

## PICTURE FUZZY LOGIC USING NODEJS IN

# UNICORN FREIGHT EXPRESS WEB APPLICATION

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**Abstract**— The shipping of parcels plays a major role in our daily routines both commercial and business purposes. It helps both the customer and business companies for the safe and secure, speed and high efficiency shipments of cargo within the security system, cannot access by the third-party service. The project Unicorn Freight Express is a web application that help various Airlines and associated companies for the importing and exporting the cargo in a efficient way. Here the customer can create and register their cargo details and trace the shipments details payment module. The daily transaction and checking done by the user. The mainly focused on the shipments and cargo management which help customers have a friendly door to door delivery service needed. Certain guidelines for their safe and secure cargo details for the weights, materials can be transferred.

**Keywords**—fuzzy neural network, RSN method, last mile delivery, Node Javascript

## I. Introduction

Cargo management has been extremely enhanced throughout the years as technology evolved. It has solved many critical issues such as reducing shipping time periods and having more control over the shipment as lack of information about

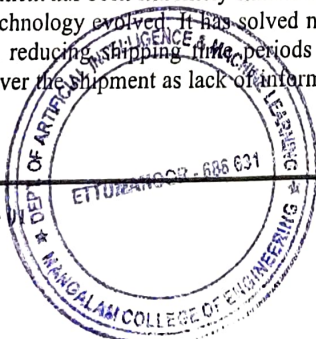
the shipment and poor tracking methods have resulted in many lost, damaged and delayed shipments.

The project entitled with "unicorn freight express" is done to build a user friendly and adaptable system for the efficient cargo managing functionality for both the commercial and business purposes. Air cargo is essential to many facets of modern life. Moving perishable goods from one side of the world. It is fully computerized system for creating, registering the cargoes details and tracing the shipment information. It provides the facilities for the users can create cargo, trace the shipments and can adopt the option for the delivery service if needed. The admin manages all the details updated by the user and provides the notification of their orders done.

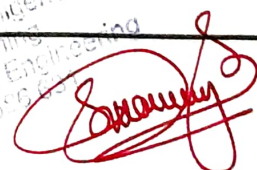
## II. Literature survey

The word "air cargo" typically refers to a good that is transported on or through an flight. Cargo shipments are now typical daily activities for corporate and commercial objectives. In order for their clients to afford the products safely and securely, many businesses import and export their goods using airlines, which makes this a common challenge for the airlines.

### A. Air Cargo Demand Modeling and Prediction



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Totamane, Amit Dasgupta, and Shrisha Rao. IEEE organisations published their work. This study put forth the idea that the air cargo transportation system is a large and intricate service system, and that demand forecasting is a crucial step in the process of master planning. Use the Potluck Problem approach to propose a multi solution for predicting the cargo demand of a specific airline in a given route, and the cargo load factor for a given flight schedule on that route. Demand forecasting is essential for evaluating existing cargo flight schedules and identifying future facility requirements of air cargo companies. In this approach, each airline is viewed as a producer, and those who utilize air cargo services are viewed as consumers.

## **B. Air cargo operations: Literature review and comparison with practices**

The writers of the suggested paper are in charge of air cargo operations, and it contrasts theoretical research with real-world issues faced by airlines, freight forwarders, and terminal service providers .In particular, we research that investigated the service processes in air cargo operations and identified the key characteristics of air cargo operations, such as the inherent distinctions from passenger operations. There is a summary of the typical models applied in earlier studies. The gaps between earlier studies and real-world situations are then shown, along with some interesting findings from an industrial interview.

## **C. A Multipurpose Mobile Application for Air CARGO Management System for Saudi Airlines**

The auother of this suggested approach implementing a number of enhancements that call for for highly secure systems that protect both the customer's information and the cargo itself, we hope to ship packages in this system with high speed and high quality. Therefore, every shipping company works hard to complete the shipping in a reliable and secure manner while giving the customer top priority This paper describes the creation of an Android application (Airpress) that will aid Saudi Airlines and affiliated businesses in the import and export of the required goods. Customers may easily and rapidly create freight using the app.A customer can register,produce cargo at any moment and track the cargo with a single click. It's a mobile device with several uses

## **D. Picture Fuzzy Decision-Making Approach for Sustainable Last-Mile Delivery**

They suggested an approach based on the growing significance of last-mile delivery (LMD) and its high prices, air pollution, and logistical difficulties. They also noted that research on sustainable LMD is extremely dynamic and trending. A new issue for decision-makers in the logistics sector is choosing a sustainable LMD method. The purpose of this research is to present an advanced decision-making strategy for sustainable LMD. First, 20 criteria for

evaluating the sustainable LMD mode are identified. Second, image fuzzy sets (PFSs) are used to assist voters in more organically expressing their choices. Thirdly, a hybrid fuzzy picture weighing approach based on direct rating and R-norm entropy is created to calculate the importance of each picture.

## **III. Related work**

The core concept of air cargo tracking is the tracking and tracing of air cargo using either the airline, the freight forwarder, the transport operator, or GPS devices.

You may be confident that you're in control of your supply chain once you create and implement a system for accurately tracking your air freight. While waiting at airports for customs clearances and other formalities, it is generally preferred that air cargo be tracked throughout all stages, from the first mile to the last mile.

Businesses rely on cargo shipping companies in the age of globalization to deliver their shipments swiftly, effectively, and on schedule. To do this, they want a capable logistics partner who can provide integrative services.

## **METHOD**

### **A. Fuzzy logic method**

Prior to being fuzzified into linguistic variables (fuzzy sets) in a fuzzy logic system, the inputs are membership function-fuzzified. The membership function converts the values passed in to a level of membership in a fuzzy set. After then, fuzzy rules—which specify the correlation between the input and output variables—are used to evaluate the fuzzy sets. Usually, the fuzzy rules are represented as "if-then" statements, such as "if input A is high and input B is low, then output C is medium.

### **B. Fuzzy Neural Network**

A fuzzy neural network (FNN) is a type of artificial neural network (ANN) that uses fuzzy logic to represent uncertainty and imprecision in the input data. FNNs combine the pattern recognition and learning capabilities of ANNs with the fuzzy inference capabilities of fuzzy logic systems.

FNNs use fuzzy sets to represent the input data and the output data, as well as the connection weights between the nodes in the network. The fuzzy sets are defined by membership functions, which map the input data to a degree of membership in the fuzzy set. The connection weights between the nodes are also represented by fuzzy sets, which capture the uncertainty in the strength of the connection.

The structure of an FNN is similar to that of a traditional ANN, with multiple layers of nodes connected by weighted connections. However, in an FNN, the nodes in the hidden and output layers use fuzzy logic to compute their output values, instead of the traditional sigmoid or RELU functions used in traditional ANNs.

The training process for an FNN involves adjusting the connection weights between the nodes using a combination of backpropagation and fuzzy inference. The fuzzy inference



component helps to improve the robustness of the network to noise and uncertainty in the input data.

Fuzzy neural networks have been used in a variety of applications, such as pattern recognition, control systems, and decision making. They are particularly useful in situations where the input data is imprecise or uncertain, and traditional ANNs may not be able to effectively model the underlying relationships in the data.

*The mathematical formula for a fuzzy neural network (FNN) depends on the specific architecture*

*The basic building block of an FNN is the fuzzy neuron, which uses fuzzy logic to compute its output value. The output of a fuzzy neuron is determined by the following equation:*

$$\text{Output} = f(W * X)$$

where 'W' is a vector of connection weights between the input and output layers, 'X' is a vector of input values, and 'f' is a fuzzy inference function that computes the output value based on the input and connection weights.

- The fuzzy inference function typically involves the following steps
- Fuzzification: The input values are mapped to fuzzy sets using membership functions, which capture the degree of membership of the input values in the fuzzy sets.
- Rule evaluation: The fuzzy rules that define the relationship between the input and output variables are evaluated using the fuzzy sets. Each rule has an associated weight, which captures the strength of the relationship between the input and output variables.
- Aggregation: The outputs of the fuzzy rules are combined using a fuzzy aggregation method, such as the weighted average or maximum.
- Defuzzification: The aggregated output value is mapped back to a crisp value using a defuzzification method, such as the centroid or mean of maximum.

The training process for an FNN typically involves adjusting the connection weights between the neurons using a combination of backpropagation and fuzzy inference. The backpropagation algorithm is used to update the connection weights based on the error between the network's output and the desired output. The fuzzy inference component helps to improve the robustness of the network to noise and uncertainty in the input data.

Overall, the mathematics of FNNs involves a combination of linear algebra, fuzzy logic, and optimization algorithm

*Picture fuzzy cososo method*

$R_{ij} = \{z_{ij} = \langle m_{zij}, n_{ij}, v_{ij} \rangle \text{ if } c_j \text{ is benefit}$

$(z_{ij})_c = \langle v_{ij}, n_{ij}, m_{ij} \rangle \text{ if } c_j \text{ is cost criterion,}$

$I = 1, \dots, m; j = 1, \dots, n$

*Decision approach*

$$K_i = (k_{\max} + (m - r_i))$$

- The following actions are often included in a fuzzy decision-making algorithm:
- 1. Clearly explain the issue at hand and list the variables that will be taken into consideration when making a decision.
- 2. Identify the fuzzy sets: Discover the fuzzy sets for every variable that is relevant to the issue. A set of values having degrees of membership ranging from 0 to 1 is referred to as a fuzzy set. A degree of membership is given to each value in a fuzzy set, indicating how well the value fits the set.
- 3. Produce a set of fuzzy rules to capture the logic of decision-making. "If-then" statements are used to define fuzzy rules, such as "if the temperature is high and the humidity is low, then the humidity is low."

#### IV. SYSTEM MODEL

The buyers are given explicit information about the prohibited products by the unicorn freight express web application system. Customers can therefore avoid all the products that the cargo manager lists. The use of digital processes, such as air freight software, ULD measuring technology, applications for declaring dangerous goods, and web-based booking and tracking platforms to track the progress of shipments in real time, has already begun by a significant number of airlines around the world. With the use of Air Cargo software, manual involvement will be significantly minimized. Airports, integrators, and freight forwarders are all increasing their use of technology for air cargo management. More and more airports demand that ground handling and service providers reserve slots on with enhanced registration, accessible via the internet booking, and tracking techniques, cargo software has simplified cargo administration at many airports. With its sophisticated ticketing, web-based booking, and tracking techniques, cargo software has made managing cargo easier at many airports. The system now calculates the billing for storage and handling fees automatically.

The samples categorized by cost criterion LMD modes of traditional delivery mode of the parcels over local area for the customer relationship and reduce the air pollution[1]

#### ARCHITECTURE



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## V. RESULT

Companies need to import and transfer products and item on a daily basis. As a result, there is a high demand for cargo businesses, particularly those that transport air freight, between cities. The goal of this project is to fulfil this need, and because of the application's simplicity of use and easy access to client information, users can simply track their shipments.

## VI. CONCLUSION

The development of an air cargo management using Node.js and Fuzzy Logic has the potential to provide significant benefits to the cargo industry. By leveraging Node.js, the system can take advantage of its scalability, speed, and flexibility to handle large volumes of cargo data efficiently. Additionally, the use of Fuzzy Logic enables the system to analyze complex and uncertain cargo-related data, making it possible to generate accurate and useful insights to support decision-making.

The system could also provide real-time visibility into cargo movement, enabling cargo managers to track shipments and respond to issues quickly. Furthermore, the system could optimize routing and scheduling, reducing delays and improving efficiency in the air cargo supply chain. Overall, the use of Node.js and Fuzzy Logic in air cargo management has the potential to provide significant improvements in cargo tracking, optimization, and decision-making, leading to increased efficiency, reduced costs, and improved customer satisfaction.

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# A Household Energy Power Consumption Meter

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**Abstract:** - This work investigates the voltage monitoring and control feature for smart meters and identifies the impact of this feature on both power distribution and communication systems. Electricity saver is an android application which aims at reduction of electricity consumption in houses. Through this project we divide each room of house into different sections. The user is provided with options to enter the rate of electricity they would like to consume per month. Electricity saver then schedules limits for each day and for each room or section. Here for convenience, the Arduino circuit is considered to be a room. As per this project whenever the limit exceeds, a warning notification is given to the user. Electricity saver provides opportunity for the user to continue usage or discontinue usage.

**Keywords:** smart energy meter, Internet of things, android application, ICT.

## I. INTRODUCTION

In our everyday lives, electricity is a crucial resource. It is best to use electricity without causing damage or pollution. Humans would not be able to take advantage of modern convenience in the absence of electricity. Thus, the significance of electricity conservation is revealed. Every home should start saving. The goal of application is to reduce electricity use in order to create a better future. With a view to conserving money, the administrator of the house suggested that this application design a daily chart for the consumption of electricity. According to the blueprints, each sector (room) is given a certain restriction that is less than the admin suggested limit. If the usage exceeds the limit assigned, a warning notification will be given to the admin and the admin can turn off the appliance or can continue usage.

Data about the operation of any asset has become precious and tremendously useful in the era of distributed assets in smart electric distribution networks. It is possible to improve the management and control of electrical distribution systems through the integration of traditional electrical networks with current advancement in modern information and communication technologies (ICT), particularly with the introduction of connected devices to the internet of things (IoT). The electrical distribution system's reliability may enhance as a result of the increased communication with linked devices, which may also minimize energy losses and increase operational efficiency.

These data are increasingly relevant and useful to system operators and energy sellers in the era of big data.

With 4.8% of the worldwide market, India surpassed China to become the third-largest electricity producer in the world. Renewable-energy made up around 28.43% of the total electricity generated while non-renewable energy made up about 71.57%. The essential element for living comfortably is electricity. It must be used and maintained properly. Currently, an electrical board employee makes a personal visit to the resident to collect energy meter readings and physically generate the bill for that month.

Energy metering has advanced significantly overtime. Thomas A Edison, a scientist and businessman, thought up the important implementation of billing the consumer for electricity consumption in the year 1881. Electric meter is a word that Edison first used in his U.S patent 25154 A. Elihu Thomson's motor meter and Aron's pendulum meter were later inventions. The "Induction-type Watt- hour meter". By Ferranti and Shallenberger, which utilized the paradise Electromagnetic Induction Principle and had a design that lasted more than a century, was the next most significant and ground-breaking electric meter.

Ferranti's rotating-disc Watt-hour meters were later replaced with meters that had no moving parts because of accuracy problems and power theft. The new meter included electrical components like a microcontroller, an analog-to-digital converter, a real-time clock, a lithium-ion battery, an LCD, and sensing tools like a current transformer (for neutral current sensing) and a shunt strip (for voltage sensing). Modern Watt-hour meters are made using high-tech techniques like "Ultrasonic Welding" of the base and cover, tamper-resistant hardware inside the meter, pressure-type tamper-proof seal on the outside of the meter, and inclusion of current-transformer between the neutral lines of supply and load to prevent power theft. The meters also adhere to the accuracy criteria established by that nation's Electricity Board.

The Internet of Things (IoT) is a network of physical devices and gadgets that are implanted with specific types of electronics that allow them to connect and communicate with one another by exchanging data. The "idea" of integrating the Internet of Things (IoT) with utility meters



dates back to 1996, when remote reading and data management systems for energy meters were combined. 'Near-Field Communication' for utility meters has now been added to the concept. This demonstrates that there are still chances for IoT to be expanded on a much greater scale. Typically, a household consumer expects the utility sector to provide a single phase AC service. Utility companies charge customers for their "energy" usage, which is measured by a unique, independent single phase AC static Watt-hour meter.

This work investigates the new voltage monitoring and control feature for smart meters, and identifies the impact of this feature on both power distribution and communication systems. Regarding the voltage monitoring, the intention work is to conserve energy by setting limits per user. Electricity saver is an android application which aims at reduction of electricity consumption in the houses. Notifications are passed to users at their exceeding usage limit and provides an option of continuing or off it. This reminder helps in the budget management of users. According to the plan, each room in the house can be set in accordance with the required limits and the admin has total control of this usage. That means, even before the usage limitation, the admin can turn off the electricity by the application. The big data is stored in an application which can be useful to revise the usage patterns. The smart meters adopt voltage and current transducers to measure energy consumption yielding an inherent voltage monitoring capacity which also allows a two-way communication, enabling sending and receiving control commands in real-time or near real-time

In India, where energy consumption is high, the IoT-based electricity monitoring system employing an android application can undoubtedly aid in the promotion of energy saving. Potentially, the proposed system may track how much energy is used in homes or workplaces and provide real-time data on energy use, enabling users to pinpoint areas where they can use less energy. This can be achieved by measuring energy consumption with sensors or smart meters, then sending the data for analysis to a central server or cloud platform. Users of the android application could have access to a user-friendly interface to examine their energy usage patterns, establish energy usage targets, and get alerts or notifications when their energy limitations are being approached or exceeded.

## II. CHALLENGES

The energy meters which are already installed at our houses are not replaced, but as a small modification on the already installed meters can change the existing meter into smart meters. Current reading with cost can be seen on application with automatic ON & OFF of meter is available. The unified approach for compressive sensing (CS) and authentication of empirically modeled signals over smart energy meter reading in advanced metering infrastructure (AMI). The wifi module used by the Arduino chip to transfer data through an android app. Therefore, an IoT-based monitoring system has the potential to improve energy efficiency, save costs, and promote sustainability in a range of contexts, including households, businesses, entire cities,

and communities.

## III. RELATED WORKS

### *A. Smart Meter Infrastructure for Smart Grid IoT Applications. (Matteo Orlando et. al., 2022)*

In this paper, a low-cost smart meter architecture and a distributed software infrastructure for AMI were developed. These systems may gather network data, interact with other entities, and provide various functions to each actor connected to the network. Utilizing well-known IoT technology makes sure that it is very compatible with other devices and outside services. The capabilities of the infrastructure and the meter have both been evaluated using a digital real-time simulator (i.e., Opal-RT). According to the results of the experimental research, the latency caused by data transmission over the Internet complies with the restrictions given by the IEC 61850 standard. As a result, our architecture has no negative effects on the smart grid's ability to function, making it a workable option to support the introduction of new services

Merits: The 3 phase meter architecture is able to run multiple software applications, either onboard or distributed over the network, and to auto-update its status when required. This ensures high compatibility with other device management tools and communication protocols, such as DLMS/COSEM, SML, and IEC 61850, which could be added and treated as any other data processing algorithm.

Demerits: the proposed distributed software platform and the 3SMA need to be integrated in a wider distributed multimodal co-simulation environment. It is needed to unlock other possible scenarios and test additional multi energy services such as optimal management of RES. In addition, further optimization of algorithms and software running on 3SMA may improve their performances when implemented on embedded systems with reduced computation power.

### *B. A Novel IoT based Smart Energy Meter for Residential Energy Management in Smart Grid Infrastructure (Gitanjali Mehta et. al., 2021)*

#### Key Concepts:

Smart Electricity Energy Meters can be considered as the basic fundamental component of the future intelligent network or smart grid, measuring the energy flow and exchanging information on energy consumption between utilities and consumers and also monitoring and controlling home appliances and devices with consumer information. In this paper, the authors propose an IoT based Smart Energy Meter with Arduino and ESP8266 Wi-Fi unit which can provide information of electricity bill by SMS or E-mail and can also provide energy monitoring usage anytime and anywhere in the world.

Merits: The idea to send email notifications when energy crosses threshold value is 15 was successfully accomplished. With this we can regulate energy consumption with ease and



that too from anywhere in the world.

Demerits: Adafruit MQTT connection with Wi-Fi Adafruit IO Key can be unreliable.

#### **C. Preserving Privacy of Smart Meter Data in a Smart Grid Environment. (Matthew B. Gough, et. al., 2021)**

##### **Key Concepts:**

In this work, a cutting-edge Differential Privacy (DP) compatible algorithm is created to guarantee the security of consumer smart meter data. Not only from the perspective of a consumer's electricity bill, but also from the perspective of power systems, the consequences of this unique algorithm on the operation of the distribution grid are thoroughly explored. The system losses, power quality difficulties, and additional expenses that such a privacy-preserving technique can cause can all be empirically investigated using this method. Additionally, a number of cost allocation techniques based on cooperative game theory are employed to make sure that the extra expenses are distributed among the players in a fair, effective, and equitable way.

Merits: The novel algorithm presented in this paper addressed the concerns related to accessing consumer smart meter data by guaranteeing the privacy of the smart meter data without losing significant value derived from the data set, which is crucial.

Demerits: The use of the innovative DP algorithm increased the system costs by a maximum of 5.61%. Even though the DP algorithm will protect against the external adversary. The internal adversary is more difficult to protect against as they may be able to make inferences about the consumer's energy usage. The energy retailer may analyze the noisy smart meter data, but the amount of information that the energy retailer may infer remains bounded by the consumer's privacy level

#### **IV. RESEARCH GAP**

The system should be designed to meet the existing standards. We now present the smart home energy consumption meter. The basic goal of a Smart Energy Meter (SEM) is to develop the necessary infrastructure for gathering data on the energy usage of home appliances, monitoring environmental indicators, and offering the necessary services to end users. Setting usage limits and interacting with customers and managing consumption across the network. Bill payment on a secured platform is also to be carefully studied. The economically friendly, safe with no compromises to the user's privacy is what is most concerning. Android application as well as alert messages helps to track the usage pattern well. Voltage controlling method has also to be considered in the hardware setting part. Every time a bill is generated by the server, it can be automatically mailed to the relevant user's email ID. To check if the system has failed or the energy meter has been tampered with, a server alert system can be set up. The server can be configured with an algorithm to track the user's energy usage.

#### **V. METHODOLOGY**

The most prominent factor of this project is to put limitations on the usage of electrical appliances. Even though the limit exceeds there is privilege of using the most crucial appliances by the permission of the Administrator. The choice of continuation of usage after limitation completely relies on the system manager. The system brings smartness in terms of bilateral communication and controlling of load. Through the website or an Android app, the user may continuously monitor their energy consumption. As a result, the system is more convincing to the users and transparent. In accordance with the user's login privilege, the software unit inserts the data into a cloud database and displays it to the customer or the electricity board. Users who have entered into their consumer accounts can read information about their daily electricity consumption as well as more detailed information shown by a listed graph. The user can track their usage by looking at the graph, which shows the variation in consumption for each month. They can therefore concentrate on cutting their electricity use based on the consumption. The Android application also allows the user to set consumption restrictions. Separate areas for showing graphs are present in both user modules. Only the relevant user who is authorized to view the details can view the views because they are made under distinct privileges. Full design in accordance with the IoT standards and protocols.

##### **A. USER CHARACTERISTICS**

- User Management
- Registration
- Scheduling
- Alert management

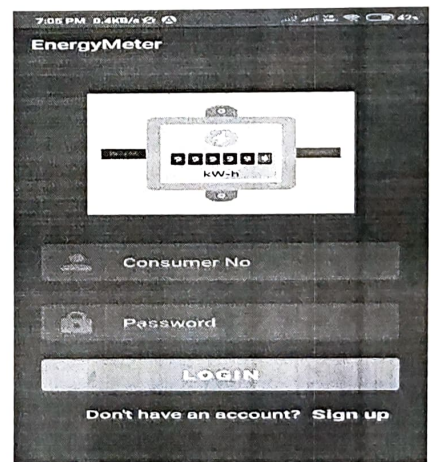


Fig.1 Login or signup account

##### **B. SCHEDULING**

- The electricity consumption for each month is scheduled as well as it can also be reset.
- Limit for the month and number of rooms is given as input.
- Scheduling can be done for each day and for each room.



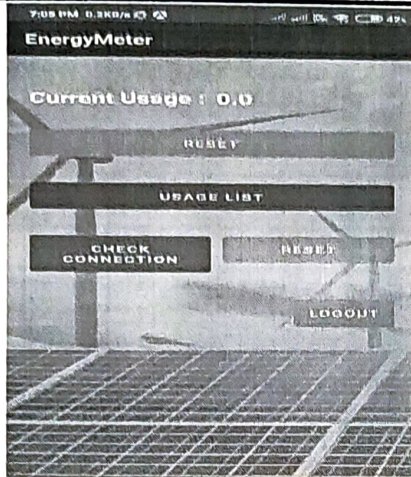


Fig.2 Limit reset option

### C. ALERT SYSTEM

- Over consumption of electricity is informed to the users.
- Increment in the usage than the limit entered by the user.
- System decides to send a warning to the user.
- User receives the notification indicating his or her over consumption.

### D. PRE-INTIMATION SHUTDOWN

The power outage is announced beforehand so that hospitals can be prepared or aware and take safety measures. Information about the power outage is transmitted via IoT from the admin web server to an Android application that has the customer's unique ID.

## VI. PROBLEM ANALYSIS AND DESIGN

The IoT real-time electricity monitoring system includes a Wi-Fi module (ESP8266), a toroidal current transformer (CT) sensor, a specialized energy meter, MySQL database, and a mobile application developed using Android Java on Android Studio.

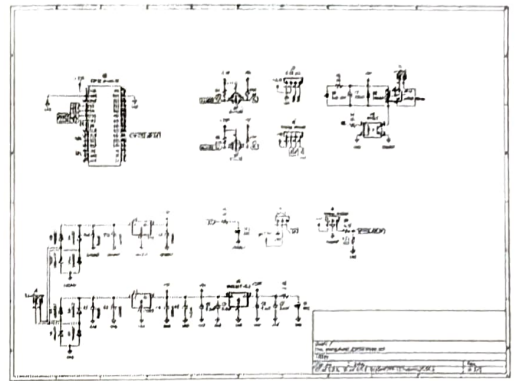


Fig.3 circuit diagram

Wi-Fi module: The ESP8266 is a great choice for a variety of IoT applications because it offers a practical and affordable method of wirelessly transmitting data to a database. The processed data is transmitted wirelessly over Wi-Fi by the ESP8266. The ESP8266 can be configured to deliver data via HTTP or MQTT protocols to a particular IP address or URL.

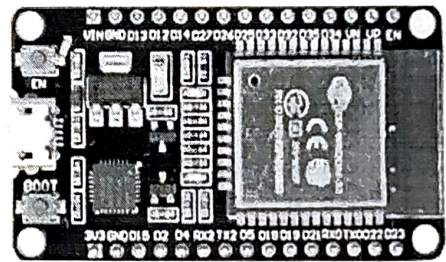


Fig.4 ESP8266

Toroidal current transformer (CT) sensor: In energy monitoring systems, the toroidal sensor is frequently utilized, connected to unique energy meters that convert the sensor's output current into a measurement of energy use in watt-hours (Wh).

## VII. RESULT AND PERFORMANCE ANALYSIS

The implementation of smart energy metering technology made it easier to assess electricity usage and to determine how much energy is used by the consumer on a daily basis once a threshold value is crossed. It is essential that the technique is economical and that the components meet all of the desired outputs in order to meet the aforementioned criteria.

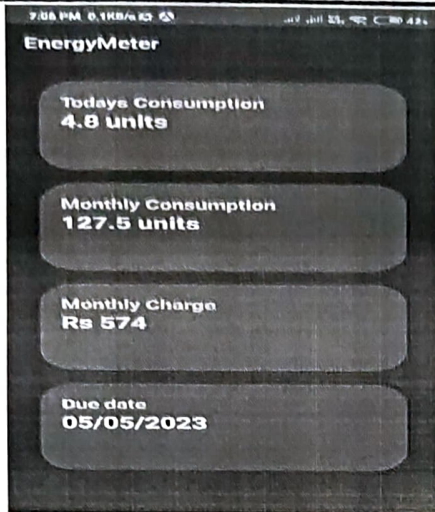


Fig.5 power consumption details

### VIII. FUTURE SCOPE

The goal of this initiative is to reveal further potential outcomes and test other multi-energy services, such as the effective management of renewable energy sources (RES). We also intend to further improve the algorithms and software that operate on our smart energy system so that they work better when used on embedded systems with less processing power. We would like to specifically emphasize that the suggested distributed software platform and the smart energy meter will be integrated in a larger distributed multimodel co-simulation environment as potential future work. The big data is stored in an application which can be useful to revise the usage patterns. The consumer can receive monthly billing information for the energy used via the web server using the same mobile application. The web server is another method of payment.

Future potential is bright for the suggested system, which uses less energy and requires less manual labor. The solution can greatly eliminate the need for manual meter reading and improve energy efficiency by merging an energy meter with a mobile app to receive monthly statistics on energy consumption.

### IX. CONCLUSION

The study has expanded and refined previous work on the use of IoT technology for real-time monitoring and protection of a residential electricity supply. By automating the process, the system can provide real-time data and insights that can help users to make informed decisions and take action to save energy and reduce costs. The setting up of usage limit and resetting of the same, which also retains some power for emergency appliances is the major output for this work.

### X. ACKNOWLEDGEMENT

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# Avoiding Phishing Attack on Online Voting System

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## Using Visual Cryptography

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**Abstract** ~ Visual cryptography is mostly used in voting systems to provide the option of casting vote for internal organizational decisions. It is adaptable enough to cast votes from a distance, places. Elections are conducted in the strictest of secrecy and are entirely private. To allow members to vote using their computers and laptops, we have suggested an online voting mechanism for the Maharashtra Carrom Association. We use CAPTCHA code and Image Share technology to protect security. The suggested solution gives voter anonymity while maintaining the privacy of votes, transparency, and security of the election.

**Keywords:** visual cryptography, phishing, CAPTCHA

## I. INTRODUCTION

Elections are the foundation of a democracy, so fairness is crucial. Voting is the only method to decide who will represent you. For people who are elderly, live far from their houses, or are in a remote area, voting in a traditional election requires them to travel to a polling place and cast their ballot. Through the internet, voters can cast their ballots for their MPs from any location. Cryptography is used in the online voting method. This guarantees an effective and secure method of counting votes. Making a voting system on the internet has many challenges to overcome. Some major issues are voting in a secure manner and accompanying many voters. There are some internet voting systems that cannot work in situations with many voters. Our proposal uses visual cryptography to overcome these issues. Everywhere there are elections, voters must cast their ballots in a polling place. The process of casting a vote is extremely complicated and involves many steps. Numerous plans need to be made. It requires a lot of manual labour. Voting in this organization requires voter presence at voting location. As a result, the goal is to ensure that voting is

efficient and secure. Voting becomes more secure thanks to visual cryptography [8]. It is crucial to implement these technologies since they will cut labour requirements and improve voting efficiency. Visual cryptography is a very safe method used for privacy that enables the encryption of secret images or data by sending it to a secure share and allows the decryption to be completed without the use of any computing devices. An image is separated into shares using visual cryptography, a secure sharing technique. Only after stacking a sufficient number of shares will the information regarding the original photocopy (Voter Password) be acknowledged. To authenticate the system in the suggested method, we employ a visual cryptographic strategy called the Internet Voting System (IVS) using 2-out-of-2 Visual Cryptography (VC). The voter's email address is shared with another password; thus the hacker cannot access it in this approach. The voting system is greatly in need of the two-way security that electronic voting offers. The voter decodes the message by piling up the shares one after another. A secret image  $S$  (voter password) is encoded into a set of shadow images called shares for  $P$  participants, with participant  $P$  receiving one share. Participants' shares must be stacked one on top of the other before the image can be retrieved. The voter's email address is shared with another password; thus the hacker cannot access it in this approach. The voting system is greatly in need of the two-way security that electronic voting offers. The voter decodes the message by piling up the shares one after another. A secret image  $S$  (voter password) is encoded into a set of shadow images called shares for  $P$  participants, with participant  $P$  receiving one share. Participants' shares must be stacked one on top of the other before the image can be retrieved.

## II. EXISTING SYSTEM

*Types of voting system*

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Three different voting systems are now accessible. We are focusing on the online voting system as a result of studying this voting system.

### A. Paper ballot system

Paper ballot system is used in old days for voting. Ballot is used by each voter and ballots are not shared. Depending on the type of voting system different ballots may be used. Ranked ballots is the type of ballot system which allow voters to rank candidates in order of preference, while ballots for first-past-the-post systems only allow voters to select one candidate for each position.

### B. Electronic voting system

The term "e-voting system" also refers to an electronic voting system. E-voting may use an electronic voting system, depending on the specific implementation. There are two primary forms of electronic voting: in-person electronic voting under the actual supervision of officials from governmental or independent electoral authority, and distant electronic voting over the Internet.

### C. Online voting system

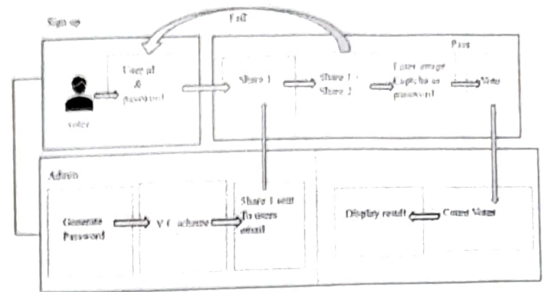
Online voting is a novel method that allows voters to cast their ballots at any time and from any location. After registering and giving the system their personal information, voters can vote by logging in to the system and undergoing verification.

## III. PROPOSED SYSTEM

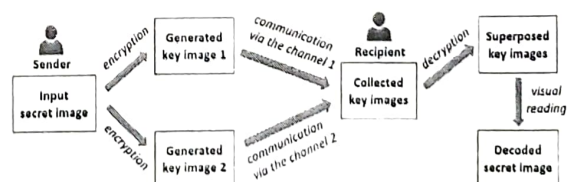
Think about using an online voting mechanism to choose the president or any other association for carrom power. All members are registered at the time of the association election by providing their personal information. Cryptography is a regularly utilized method in electronic voting because it provides a strong protection against threats. Cryptography is a regularly utilized method in electronic voting because it provides a strong protection against threats. Numerous plans have been developed and proposed in order to guarantee the integrity of an election.

Cryptography is employed in these techniques to secure the data transmission between the voter and the server, preventing data leakage to a third party. In order to protect the privacy of voters, the integrity of the ballots cast and collected, the validity of the results, and the authenticity of the voter, encryption techniques are also used in every step of the system. There are numerous cryptography techniques that can be used, including blind signature schemes, homomorphic encryption, oblivious signature schemes, bit commitment schemes, Schnorr identification schemes, mixed-net schemes, digital signature schemes, secure multi-party computation, cryptographic hash functions, etc....

As the image shown in below, the voter will share one image with the system at registration, which will then split it into two parts.



The first component (SHARE1) will then be transformed into a password using the VC technique and sent to the voter's email address. The server retains the second half of the picture (SHARE2). Voters will then enter into the system using the user ID and password provided by it, and the system will then add SHARE1 and SHARE2 to generate the CAPTCHA code. The voter will be permitted to vote if they can see the CAPTCHA code; else, they won't be able to. The system will tabulate the results after counting the votes. Then Two shares of the CAPTCHA will be distributed. Visual cryptography will be used to create these password sharing. However, the image will first be changed into a monochrome, or black and white, image, before being divided into shares. Access structure will be taken into account while forming shares as well. Access structures are employed to teach students about all the security aspects involved in cooperative resource acquisition we will be encoding the A into n number shares of transparencies. The number of pixels expands as the shares rise. Integer linear programming (ILP) will be used to prevent the modelling of enlarged pixels. This will enable the creation of a simple matrix with the fewest possible pixels. Thus, for the system that needs the fewest shares, an ideal pixel expansion will be accomplished. One share will be sent to the voter using SMTP when the two shares are established. All of the pixels will be divided into small blocks by the shares that are created, with the number of white blocks equaling the number of black blocks. The shares will be combined at the time of voting, and if the user is valid, CAPTCHA will be shown. When a voter is suspected of being malicious, they are immediately logged out of the voting system and are not permitted to cast a vote.





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# Depression Recognition Using Machine Learning

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**Abstract**— Traditionally, depression was identified through in-depth clinical interviews, during which the psychologist would analyze the subject's responses to ascertain his or her mental condition. In our model, we attempt to emulate this strategy by combining the three modalities of word context, audio, and video to forecast an outcome pertaining to the patient's mental health. To account for the subject's state of depression, the output is separated into various levels. We have developed a deep learning model that combines all three modalities, gives them the proper weights, and produces an output. The following issues are addressed by this fusion strategy:

- Control the amount of contribution from each modality;
- The presence of noise in one of the modalities.

## 1. INTRODUCTION

The current state of affairs calls for an effective, independent, and accessible method to identify depression. More and more people are becoming depressed as society creates conditions that are more and more stressful. We can only attempt to treat it if we can find it in the first place. Our motivating force is the desire to develop such a model. Clinical interviews with the individuals must be conducted in order to generate the three modalities that will be used as input in our model's testing. It has been discovered via significant research in this area that a depressed subject exhibits a variety of complex symptoms that can be detected more effectively by combining the three modalities. A shift in mental behaviour can cause a variety of physiological and physiological changes. According to research, people who are depressed tend to stutter when they speak, causing unnatural pauses to appear in their speech. Another feature that the topic emphasises is more instances of erroneous pronunciation. Other indicators, better posture, etc., can be detected using the video modality. Lexical analysis can be used to examine the subject's speech in context, which also reveals crucial details about his or her mental state. A more general model that takes into account all of these elements can be developed by merging all of these channels. As a result of the availability of more reliable components, better forecasts can be made. This model will likely face the following difficulties:

- Because our model is essentially a DL model, a sizable dataset in each of the three modalities is needed.

- Another difficulty is aligning these 3 modalities in accordance with their timing. It is crucial for our model to receive these modalities simultaneously in order to comprehend how they are correlated.

- Since video processing is required, training our model will require a lot of computing resources.

## 2. LITERATURE REVIEW

D. Huang uses a regression method based on PLS wherein a late fusion detection method is built for model prediction[1]. D.Devault has built a multimodal HCRF model which works on question-answer pairs. It analyses them for model prediction[2]. Gong et. al. use the same approach. Building on it, he combines the questionanswer based model with his multi-modal approach, taking into consideration all the 3 modalities for model prediction[3]. Similar work is also done by Sun et al. They built a single model random forest-based classifier which works on the question-answer based approach. This classifier is used for model prediction[4]. Ma et al. propose an audiobased method for depression classification using Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks for a higher-level audio representation. Ma et al. works only on the audio based modality. He inputs the audio based data into a CNN and then further uses a LSTM network for model prediction[5].

In the work done by Shivakumar et al. (6), the temporal nature of audio/ visual modalities is considered using a window-grounded representation rather of frame- position analysis. exercising reciprocal information from the textbook and audio features, J. Glass et al. proposed a model in which different LSTM branches for each modality are integrated via a feed-forward network (7). still, while this work tries to prognosticate depression grounded on late or early emulsion styles (1, 3) or the successional nature of their inputs (6, 7), learning the time-dependent connections between language, visual and audio features in detecting depression is still unexplored. The major problems that these approaches face are the different prophetic power of modalities and types of noise in the representation. In former workshop, gating medium has shown to be effective in determining the prophetic power of each modality

Another approach (10) for the same problem explores paralinguistic, head disguise and eye aspect behaviours. During the exploration phase, the authors set up out that there are numerous physical attributes changes that can be detected



through applicable detectors, when a subject is depressed. In this model, the authors try to describe features like dropped speech rate, lower articulation rate (speech features), lower eye contact, wavering eyes (eye features) and fraudulent head (head features). A aggregate of 63 statistical features were uprooted through homemade labelling, and 19 speaking rate features were uprooted using automated labelling (using PRAAT). For eye features, it was done by training a technical CV operation that's suitable to describe different attributes of the eye similar as the eye lids, pupil, and it's extremities.

Using this, it's suitable to make fine computations that lead to features similar blink time, blink frequency, aspect direction (left- right, over- down) etc. preliminarily, it was that set up slower and lower frequent head movements, increased eye contact avoidance and lower social engagement with the clinical monitor, likely to also show in other social relations. To prize head disguise and movement gesture, the face had to be detected and tracked before a 3 degrees of freedom (DOF) head disguise could be calculated (yaw, roll and pitch). A subject-specific face active appearance model was trained and erected, where 30 images per subject were named for homemade reflection, also used for the face model. These 3-DOF disguise features, as well as their haste and acceleration, were uprooted to give a aggregate of nine low- position features per frame. All of these eye and head duration features were detected when the point in question is advanced or lower than the normal of the point in question plus or disadvantage the standard divagation of that point for each subject's interview. For the system in this paper, the base of the model is an SVM classifier. It's used to classify the features into double classes i.e. Yes (Depressed) or No (Not depressed). The uprooted features are farther sifted using point birth/ Dimensionality reduction ways like Statistical Analysis using t- test algorithm and star element analysis.

For emulsion, beforehand, late and cold-blooded mixtures are explored in this paper. For early emulsion, point emulsion is explored that's principally concatenating uprooted features from the raw data. In late emulsion, results from each modality are combined after training them independently. This was done on markers (decision emulsion) and scores (score emulsion) from the classifier. In this paper, a comparatively new emulsion fashion is also explored which is cold-blooded emulsion. In cold-blooded emulsion, point emulsion of all modalities is performed first to produce a new modality, which is also treated as an fresh individual modality. The scores opinions of this new modality are also fused with the scores opinions of the individual modalities in either one or two situations. The dataset taken in this paper was fairly small due to which the results were n't conclusive.

The most recent approach [8] for this problem explores a model-based optimal fusion, that is, instead of using early fusion or late fusion technique, it focuses more on how much each modality should have an impact on the final result. Early fusion is basically concatenating the feature vectors of each modality after extraction into a single vector and feeding them to the model to learn the results. In the late fusion technique, we train individual models for each modality and then combine their results to get a final output by giving them some weights.

What both of these approaches ignore is that learned representation of one modality can be undermined by the other modalities.

### 3. DATASET

#### A. DAIC-WOZ DATASET

The DAIC-WOZ dataset [9] was collected by the University Of Southern California. It is a part of a larger DAIC (Distress Analysis Interview Corpus) that contains clinical interviews designed to support the diagnosis of psychological distress conditions such as anxiety, depression, and PTSD.

#### B. Modalities

The dataset contains audio and video recordings and extensive questionnaire responses. Additionally, the DAICWOZ dataset includes the Wizard-Of-Oz interviews, conducted by an animated virtual assistant called Ellie, who is controlled by a human interviewer in another room. The data has been transcribed and annotated for a variety of verbal and non-verbal features. Each participant's session includes a transcription of interaction, participant audio files, and facial features extracted from the recorded video.

##### 1) Video Modality

The dataset contained facial features from the videos of the participant. The facial features consisted of 68 2D points on the face, 24 AU features that measure facial activity, 68 3D points on the face, 16 features to represent the subject's gaze, and 10 features to represent the subject's pose. This made for a total of 388 video features.

##### 2) Audio Modality

The audio features are for every 10ms, thus the features are sampled at 100Hz. The features include 12 Mel-frequency cepstral coefficients (MFCCs), these are F0, VUV, NAQ, QOQ, H1H2, PSP, MDQ, peakSlope, Rd, Rdconf, MCEP024, HMPDM0-24, HMPDD0-12. Along with the MFCCs we also have features for pitch tracking, peak slope, maximal dispersion quotients, glottal source parameters. Additionally, the VUV (voiced/unvoiced) feature flags whether the current sample is voice or unvoiced. In the case where the sample is unvoiced (VUV = 0), F0, NAQ, QOQ, H1H2, PSP, MDQ, peakSlope, and Rd are set to 0.

##### 3) Text Modality

The textual modality contains the transcript for the whole conversation of the patient with the RA in csv format. Individual sentences have been timestamped and further classified on the basis of their speaker. Expressions like laughter, frown etc have been added in angular brackets as and when they occur (for e.g. Laughter). Differentiation between long/short pauses has not been made. Only word (not phenome) level segmentation has been recorded.

C. Dataset size

The dataset contains 189 sessions of interactions, ranging anywhere from 7 to 33 minutes. The dataset contains interviews with 59 depressed and 130 non-depressed subjects.

4. PROPOSED SOLUTION

In our system, we plan to first extract features and then apply some gating mechanism and hybrid fusion technique on the features extracted. For feature extraction: We have audio, visual, and textual modalities as our features that are integrated using time-stamps to learn the time-dependent interactions between them. The forced alignment will be done on a sentence level granularity. This is because we want the model to learn the context between words. This is the preprocessing part.

Now, we have aligned the textual, audio, and visual features at the sentence level. One important thing to note is that different modalities can have different impacts on the final result and there is some noise involved too while representing the features of different modalities. Now, on the extracted features, some gating mechanism will be applied to learn and control how much different modalities will be contributing to the final output. In our network, we'll use weight vectors with each modality to control and learn how much information will be transformed and carried to the next layers.

For each time step, the feature vectors from each modality will be concatenated and then passed to the word-level LSTM which comprises of the gating mechanism. Before the concatenation of the feature vectors, the audio and visual vectors will be also passed through gating mechanism to extract the important information.

The other approach that we can follow is to use a mongrel emulsion fashion, to reap the benefits of both early and late emulsion. mongrel emulsion can be performed on one position or two situations. In cold-blooded emulsion, point emulsion of all modalities is performed first to produce a new modality, which is also treated as an fresh individual modality. The scores opinions of this new modality are also fused with the scores opinions of the individual modalities in either one or two situations.

Table 1: Baseline Results

Model	Features	F1	Prec.	MAE	RMSE
<b>Baselines</b>					
DAIC Baseline [28]	Audio+Visual	-	-	5.66	7.05
Gong et al. [12]	Text+Audio+Visual	0.60	-	3.96	4.99
Alhanai et al. [18]	Text	0.66	0.70	5.09	6.11
Alhanai et al. [18]	Text+Audio	0.75	0.72	5.02	6.04
Williamson et al. [14]	Text	0.67	0.74	3.82	5.06
Williamson et al. [14]	Text+Audio+Visual	0.70	0.78	3.84	5.23
<b>Word Level Models</b>					
LSTM	Text	0.69	0.68	4.98	6.05
LSTM	Text+Audio	0.67	0.68	5.18	6.40
LSTM	Text+Audio+Visual	0.67	0.63	5.29	6.68
LSTM with Gating	Text+Audio	0.80	0.78	3.66	5.14
LSTM with Gating	Text+Audio+Visual	0.81	0.80	3.61	4.99

5. WORK DONE

The given DAIC dataset is skewed with a 7:3 ratio, of non-depressed class to depressed. To overcome the biases, the dataset was upsampled. The models were applied to the dataset;

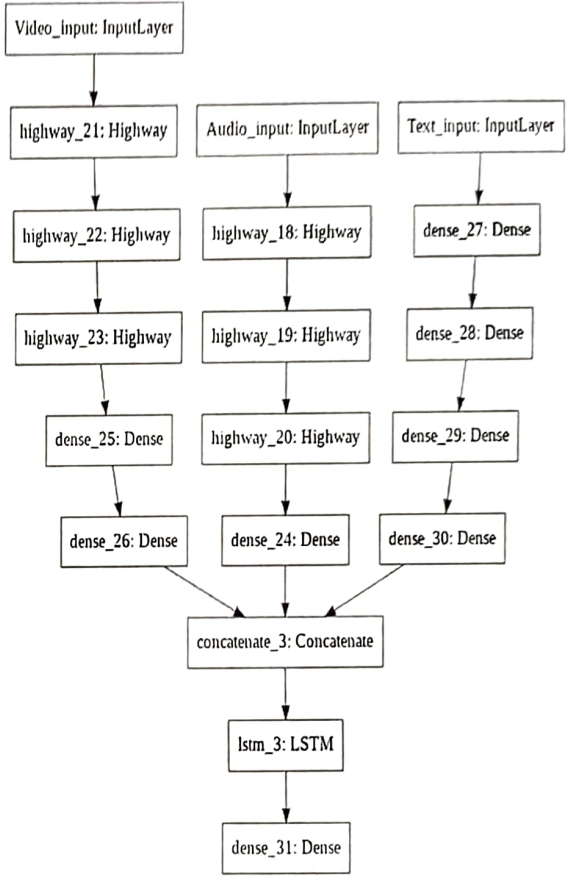


Figure 1. Model Architecture

Random Forest: Firstly, SVM (with an RBF kernel) and Random forest were applied to the three modalities separately and then another SVMmodel was trained on the decision labels from the individual modalities to perform late fusion. For this purpose, the features of the audio and video modality were averaged over all the timestamps to give a total of 74 and 388 features, respectively. For the text modality, the word2Vec model obtained from google-news-300 was applied to transform each word into a vector of size 300. Further, the 3D vector obtained (sentences x words x 300 features) was first averaged over each word and then flattened.



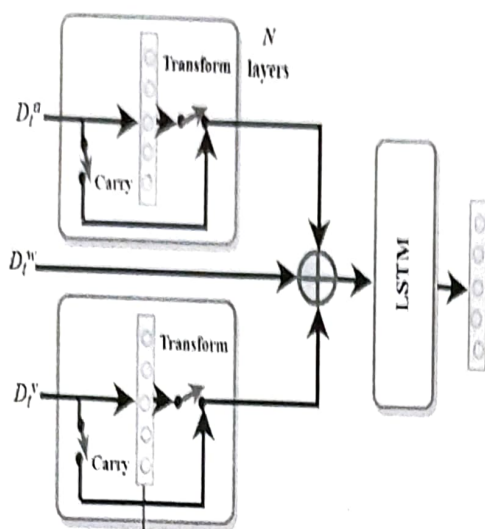


Figure 2. Sentence-level multi-modal fusion with gating

**LSTM Model with Gating (Word-Level):** Forced alignment of the data was done on a word level basis. The alignment was done using a unitary approach wherein the sentence level time stamps were converted to word-level based on the number of words (present in the sentence) and the character length present in the sentence.

Next, we used highway layers for gating the audio and video features. Each highway layer comprises two non-linear transforms: a Carry and a Transform gate which define the degree to which the output is created by transforming the input and determining how much information should move forward. After feeding the audio and video features for a sentence to highway layers individually, they're concatenated with the corresponding text feature. The concatenated vector is then passed through a (Bi)LSTM to get the final output.

**Model Architecture:** The audio and video features are first passed through 3 feedforward highway layers. Then, dense layers are used to reduce the dimensionality of both video and text features. After concatenation, (Bi)LSTM with 128 hidden nodes is used. And finally, a dense layer is applied with sigmoid activation to get the output. A learning rate of 0.0001 is used. For the number of epochs, EarlyStopping callback is used from Keras API.

## 5. RESULTS

The results have been published by taking a weighted mean of the 2 classes, i.e. class 0 (Not depressed) and class 1 (Depressed). The data provided is in the ratio 7:3:

- **SVM Model:** The model did not perform well, as can be seen from the results in table Table 1. This could be due to the fact that averaging operations were performed across

the 3 modalities. This could have led to the loss of a lot of information, leading to the model under-performing.

- **CNN Model:** This model performed better than the SVM one on the text modality because herein averaging across word vectors was not done. The audio and video modalities were still not giving satisfactory results. This could be due to the fact that the data points were too few and the features representing these modalities were too sparse.

- **LSTM with/without Gating at Sentence-Level:**

- The results clearly indicate that our model works best for Text modality. The low values of the F1 score in the video and audio modality show that these features do not represent the depression class well. This could be the reason that when audio, video and text modality are combined, the results just fall short of that of the model which only uses Text modality.

- Also, all models that use gating perform better than those models that do not. This could be because using gating, only the most important features are amplified, while the others are nullified. Thus a sort of feature extraction takes place at this level, which helps our LSTM model to learn from only the most favorable features.

- **LSTM with gating at word-level:** The results for word-level LSTM are not as good as expected. The reason could be that on a word level, the model does not get the context of the conversation as much as it does on a sentence level.

- **BiLSTM model:** This model shows clear partiality towards the 'depressed class'. The model is not able to learn much from the data.

## 6. CONCLUSION

A model was presented to detect if a person is depressed or not based on indicators from audio, video and lexical modalities. A sentence-level model with highway layers as gating mechanism was used for the task. According to our models, sentence-level seems to work best amongst other models. A mixture of early and late fusion was used to get better interpretation from each modality. For future scope, the features could be extracted on a better level. Some audio features like response time, number of pauses, silence rate can also be examined to get a better understanding about the symptoms. Interaction of bodily action sequences from motion capture data can be studied with the verbal behaviour to have a more extensive study.

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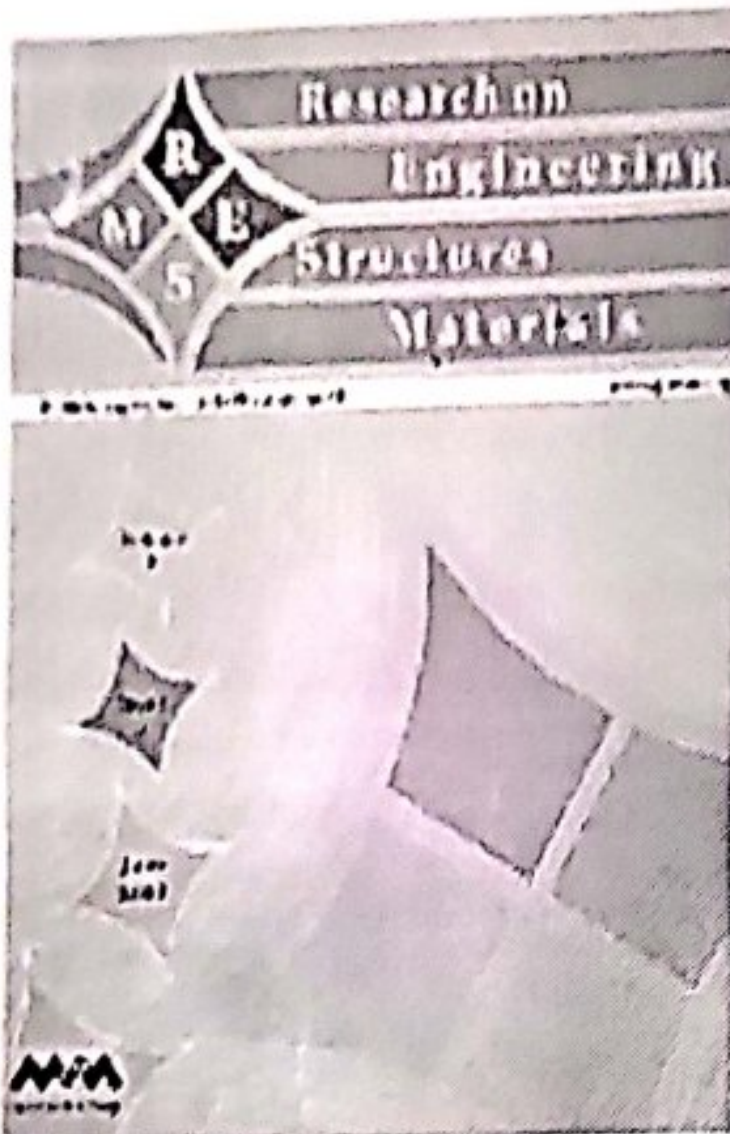
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# Research on Engineering Structures & Materials

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## Investigation on the effect of ultra fine rice husk ash over slag based geopolymer concrete

A. Chithambar Ganesh, M. Vinod Kumar, K. Mukilan, A. Suresh Kumar, K. Arun Kumar

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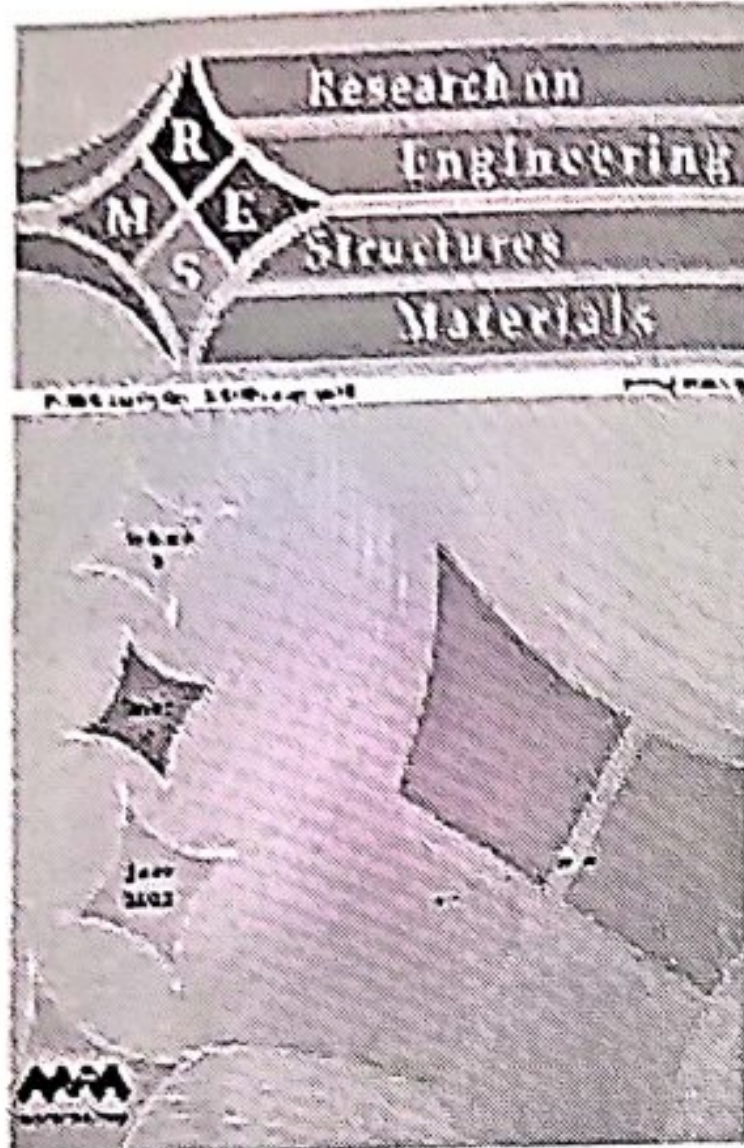
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## Optimization of hybrid fibre reinforced geopolymer concrete using hardened and durability properties

Kadarkarai Arunkumar, Arunachalam Sureshkumar, Arunasankar Chithambar Ganesh, Loganathan Parthiban, Premkumar V.

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## INFLUENCE OF HYBRID FIBRES ON THE MECHANICAL CHARACTERIZATION OF LOW CALCIUM GEOPOLYMER CONCRETE

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**Key Words:** low calcium geopolymer concrete, low calcium wood ash, polypropylene fibre, rubber fibre, hybrid fibres.

### ABSTRACT

Geopolymers are an amorphous polymer shape that lowers emissions of greenhouse gases and is also the best option for cement in construction. Compared to traditional cement concrete, geopolymers demonstrated lower energy absorption, ductility, impact energy, and brittleness. Fibres with various properties and the ability to improve the behaviour of geopolymer concrete in all aspects can be included to strengthen the aforementioned features of geopolymer concrete. This investigation added polypropylene fibre and rubber to a weight fraction of 0, 0.5, 1, 1.5, and 2 per cent. In addition, the mechanical behaviour of low calcium geopolymer has been investigated for the impacts of polypropylene and rubber fibre hybridization. In this study, the mechanical properties such as compressive strength, tensile strength, flexural strength of hybrid fibre reinforced low calcium geopolymer concrete have also been investigated. The results showed that the hybridization of 0.5 % of PP fibre and 0.5% of rubber fibre increased the compressive strength, tensile strength, flexural strength by 23.9%, 15.2%, and 13%.

### 1. INTRODUCTION

The silica and alumina were dissociated from fly ash, metakaolin, and slag using highly concentrated alkaline hydroxide and silicate solution; a form of amorphous polymer material known as geopolymer was created [1]. Production of geopolymer concrete using fly ash as an aluminosilicate source material was studied [2]. It revealed that the strength parameters of geopolymer concrete are increased by increasing the amount of alkaline solution. Fly ash-based geopolymer concrete required heat curing of 60 degrees Celsius in 24 h for strength attainment [3]. Easier dissolution of silica and alumina increased the strength parameters [4].

Geopolymer reaction was disrupted, decreasing the geopolymer strength when the molarity reached 12M [5]. Research reveals that in 2017, fly ash production was reduced to 169.25 million metric tonnes, and its utilization was increased to 107.10 million metric tonnes [6]. The demand made the research gap to identify another source of raw material. Another option for fly ash, which is rich in calcium, is ground granulated blast furnace slag [7]. While the presence of high calcium uses the alkaline solution at an early age and promotes early age strength [8]. Even so, the calcium causes the silica and alumina to remain unreactive with the alkaline solution [9]. These drawbacks imply that the alternative with lower calcium content and lower

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Article

# Fresh and Hardened Properties of Self-Compacting Concrete Comprising a Copper Slag

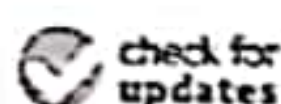
Chidambaram Prithiviraj <sup>1,\*</sup>, Packirisamy Swaminathan <sup>2</sup>, Deivasigamani Ramesh Kumar <sup>2</sup>, Gunasekaran Murali <sup>3,4,\*</sup> and Nikolai Ivanovich Vatin <sup>5</sup>

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**Abstract:** Recycling trash and protecting natural resources are two of the many benefits of using copper slag as a fine aggregate in a concrete building. However, stakeholders need proven research output to build trust and initiate or enhance the use of such industrial waste in buildings. This study evaluated self-compacting concrete's fresh and hardened characteristics (SCC) comprising a copper slag aggregate (CSA). For this purpose, six mixes were prepared by substituting river sand with CSA up to 50%, with a 10% increment. The properties of fresh SCC were evaluated using slump flow, V-funnel, and L-box tests. Several parameters of SCC were examined, including water absorption, sorptivity, chloride ion penetration, sulphate attack, and acid attack tests. Energy dispersive spectroscopy (EDS) and scanning electron microscopy (SEM) were used to investigate the concrete microstructure. The results indicated that the fresh characteristics of SCC were enhanced as the amount of CSA increased consistently. The durability properties showed a considerable enhancement in SCC mixes comprising up to 20% of CSA.

**Keywords:** concrete; copper slag; compressive strength; acid attack; microstructure

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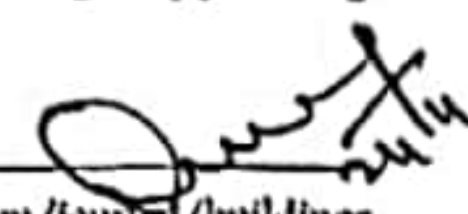


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## 1. Introduction

Massive volumes of industrial by-products are produced and disposed of worldwide, posing severe issues. Heavy metals, including arsenic, cadmium, and lead, can be found in high amounts in copper slag, causing them to be classified as hazardous wastes [1]. These metals harm human health and lead to air and water pollution. Due to a lack of landfill space and, as a result, rising costs of natural river sand, efforts have been undertaken to recycle or reuse them. One method is to utilize industrial derivatives in concrete, which will be advantageous in ecological and financial terms.

Concrete's durability may be characterized by its resistance to chemical, biological, and physical disintegration [2–5]. Chemical attack can take several forms, including sulphate resistance [6], acid resistance [7], the effect of carbonation [8], chloride ion penetration [9–11], the alkali-silica aggregate effect, and depending on the concrete exposed to the environment. The excessive loading of concrete buildings, the impact of abrasion, frost attack, and natural disasters, such as earthquakes, floods, and fires, can all cause physical disintegration [12]. Bacteria, sponges, lichens, marine borers, mosses, and boring shells are part of the biological onslaught [13,14]. Chemical attack, on the other hand, is predominantly accountable for the disintegration of concrete structures [15,16], and researchers must focus on durability [17–20]. Apart from durability, the manufacturing cost of concrete mainly depends on the constituent materials being used from natural resources. To develop durability and minimize manufacturing costs, industrial by-products can be one of the alternate solutions [21–26]. Various industrial subsidiary products, including steel slag, copper slag,







## Article

# Experimental and Statistical Investigation to Evaluate Impact Strength Variability and Reliability of Preplaced Aggregate Concrete Containing Crumpled Rubber and Fibres

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**Abstract:** The proper disposal of used rubber tires has emerged as a primary concern for the environment all over the globe. Millions of tires are thrown away, buried and discarded every year, posing a major environmental concern owing to their slow decomposition. As a result, it is advantageous to use recycled waste rubber aggregates as an additional building resource. Recycling crushed rubber would lead to a long-term solution to the problem of decreasing natural aggregate resources while conserving the environment. This study examines the impact strength variability and reliability of preplaced aggregate concrete containing crumpled rubber and fibres. Ten different mixtures were prepared by replacing natural aggregate with crumpled rubber (5, 10, 15 and 20%). The crumpled rubber was pretreated by the water with sodium hydroxide dilution for 30 min before usage. Hooked-end steel fibres were used at a dosage of 1.5%. The compressive strength, impact strength, impact ductility index and failure pattern were examined and discussed. In addition, a statistical method called Weibull distribution is used to analyze the scattered experimental results. The results showed that when the crumb rubber content was raised, the retained first cracking and failure impact numbers increased. As a result of substituting crumb rubber for 20% of the coarse aggregate in plain and fibrous mixes, the percentage development in first crack and failure was between 33% and 76% and 75% to 129%, respectively.

**Keywords:** impact strength; reliability; concrete; rubber waste; fibres; Weibull distribution

## 1. Introduction

Concrete is producing considerable use of recyclable and solid waste resources to address environmental challenges and reduce energy consumption [1]. Further research into the production of green concrete is encouraged by the increase in concrete properties and environmental advantages from the use of waste resources [2]. There are several substitutes and solid waste products, such as building debris and demolition [3], plastic wastes [4], rock waste [5], silica fume [6], flyash [7], lime sludge [8] were added to concrete to enhance their properties and minimize emissions of carbon gases while conserving



# Tricube Weighted Linear Regression and Interquartile for Cloud Infrastructural Resource Optimization

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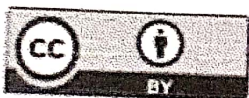
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**Abstract:** Cloud infrastructural resource optimization is the process of precisely selecting the allocating the correct resources either to a workload or application. When workload execution, accuracy, and cost are accurately stabilized in opposition to the best possible framework in real-time, efficiency is attained. In addition, every workload or application required for the framework is characteristic and these essentials change over time. But, the existing method was failed to ensure the high Quality of Service (QoS). In order to address this issue, a Tricube Weighted Linear Regression-based Inter Quartile (TWLR-IQ) for Cloud Infrastructural Resource Optimization is introduced. A Tricube Weighted Linear Regression is presented in the proposed method to estimate the resources (i.e., CPU, RAM, and network bandwidth utilization) based on the usage history in each cloud server. Then, Inter Quartile Range is applied to efficiently predict the overload hosts for ensuring a smooth migration. Experimental results show that our proposed method is better than the approach in Cloudsim under various performance metrics. The results clearly showed that the proposed method can reduce the energy consumption and provide a high level of commitment with ensuring the minimum number of Virtual Machine (VM) Migrations as compared to the state-of-the-art methods.

**Keywords:** Cloud infrastructure; tricube; weighted linear regression; inter quartile; CPU; RAM; network bandwidth utilization

## 1 Introduction

In cloud computing, resource allocation takes part in a pivotal part in deciding the performance, utilization of resources, and data center power consumption. The pertinent VM allocation in cloud data centers is also one of the main optimization issues as far as cloud computing is concerned. A load-balancing algorithm called, Priority Aware Longest Job First (PA-KJF) was proposed in [1] to enhance the VM utilization and fulfill users' requirements in cloud infrastructure. Here, the priority of tasks was first identified. VIP tasks were first executed followed by which the normal tasks were executed. Next, the heuristic-based dynamic load-balancing algorithm was employed that monitored VMs in a continuous



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# De-noising and Demosaicking of Bayer image using deep convolutional attention residual learning

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## Abstract

Nowadays, the resolution of image sensors in digital cameras is increased by minimizing the size of pixel sensors. As the size is reduced, the pixel sensor receives low light energy and becomes sensitive to thermal noise. The Color Filter Array (CFA) has a significant effect with the presence of noise, and the missing data is required to be reconstructed from the noisy data. This paper proposed a deep convolutional neural network with Honey Badger Algorithm (DCNN-HBA) for Bayer image de-noising. The deep CNN model is easily adopted and flexible for any CFA design with spatially varying color and exposures. After de-noising, attention-based deep residual learning (A-DRL) is applied to de-mosaicking the noise-free Bayer image. The channel attention is involved in which the network considers more relevant information and features. The proposed algorithm improves the quality of the image after reconstruction. The performance of the proposed work is evaluated with the performance metrics such as Peak Signal to Noise Ratio (PSNR), Color Peak Signal to Noise Ratio (CPSNR), Structural Similarity (SSIM), and Mean Structural Similarity (MSSIM) and compared with the traditional de-mosaicking approaches. By using our proposed work, the performance of PSNR, SSIM, CPSNR and MSSIM is improved by 43.23 dB, 0.997, 43.30 dB and 0.9975, respectively.

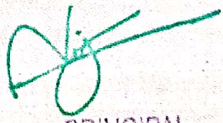
**Key words** Color Filter Array interpolation · De-noising · De-mosaicking · Deep convolutional neural network · Honey Badger Algorithm · Deep residual learning

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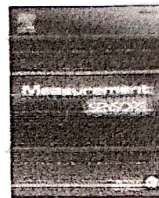
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# Analysis of optimization algorithms for stability and convergence for natural language processing using deep learning algorithms

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## ABSTRACT

A boom in applying deep learning (DL) models over the past several years has advanced the discipline of NLP. Firstly, the theoretical foundations of artificial intelligence and NLP are briefly introduced in this survey. Then, it sorts through much recent research and compiles many pertinent contributions. Lately, this article has introduced optimization theory and techniques for neural network training. First, we classify and discuss the various facets and NLP applications profiting from deep learning. Second, we review generic language modelling methods used in pre-training neural networks, such as BERT, RoBERTa, ALBERT and DeBERTa. Third, we compared the different language models in GLUE, MNLI, and SQuAD for accuracy and efficiency for best optimization.

## 1. Introduction

Various computing algorithms for the systematic analysis and depiction of human language are referred to as "natural language processing" (NLP). NLP study has progressed since the punch card days, and processing in the group when analyzing a sentence will take up to 7 min, to the age of Google and similar services, where thousands of web pages can all be analyzed in under a second [1]. NLP allows computers to execute a broad range of tasks, including natural language processing, tagging of POS (part-of-speech), parsing, and machine translations and interaction systems. Deep learning algorithms and frameworks have made significant strides in pattern identification and computer vision. In line with this trend, modern NLP study increasingly emphasizes applying fresh deep learning techniques. For many years, shallow models (like logistic regression and SVM) were trained on extremely high-dimensional and scarce features. It has been the basis for machine-learning approaches aimed at solving NLP challenges. In recent years, neural networks built using closely packed vector representations have outperformed traditional NLP methods in various applications. The popularity of using word embeddings [2,3] and deep learning

techniques [4] started this trend.

Multi-level computerized feature representation learning is made possible by deep learning. In contrast, traditional machine learning-based NLP systems rely primarily on manually created features. Such hand-made features take a lot of time to finish. A straightforward deep learning approach outperforms the majority of state-of-the-art methods in several NLP tasks, including NER (named-entity recognition), SRL (semantic role labelling), as well as tagging of POS (part-of-speech), according to Collobert et al.'s research [5]. Since then, many intricate DL-based approaches have been suggested to handle challenging NLP jobs. CNN, RNN and recursive neural structures are vital DL-related models and techniques for natural language applications. We also cover memory-augmenting techniques, attention mechanisms, and the recent use of deep generative models, unsupervised models, and reinforcement learning techniques for language-related tasks. As far as we know, this study is the beginning of its kind to thoroughly address today's most widely used deep learning techniques in NLP data analysis.

The introduction is the first of six components that make up this survey. Section 2 outlines the theoretical underpinnings of NLP and AI and examines DL as a method for tackling practical issues. A general

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# Training and Classification of PCA with LRM model for Diabetes Prediction

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**Abstract**— There are exponential increase in the number of families who are diagnosed by diabetes mellitus because of lifestyle and other non-determinable factors. Most of the patients are least bothered about the consequences they face or about the danger factor that approaches them. In this, we have established a novel model predicting the type 2 diabetes mellitus (TD2M) dependent on information digging methods. The main constraints are that we are trying to enhance the precision of the expected model and to not limit the model with just one data set. The model contains the improved NB, DT, KSTAR, LOGISTIC REGRESSION, SVM compared to the pre-processing techniques. To compare our outcome and the outcomes from different scientists we use Pima Indians diabetes data set and the Waikato environment for knowledge analysis toolbox. Apart from these, the model which we expect to implement have adequate data set quality. For more analysis, we applied it to two more diabetic datasets. These two provides satisfied outcomes. Henceforth, the model is set to be valuable for the betterment in the field of diabetology..

**Keywords**- Diabetes prediction, Logistic regression model, Support Vector Machine, KSTAR, Naïve Bayes classification.

## I. INTRODUCTION

Diabetes is the most common sickness worldwide and spreading rapidly even though they are not contagious. Diabetes is diagnosed if there is persistent hyperglycemia and is described by a term called heterogeneous aggravation of digestion. There are two reasons for this: one is inconsistent or the depleting activity of insulin or it may be both. Persistent hyperglycemia can cause various problems it may be due to brokenness issue in organs, any elements in eyes, nerves and heart. The diabetes can be classified into two classes: type 1 and type 2. Type 1 is caused due to the lack of insulin discharge. Therefore type 2 is common among the patients where it is caused either due to the lack of insulin secretion or protection from insulin activity.

A survey was taken to access the number of diabetes patients worldwide which was initiated by the six version IDF (international diabetes federation) and found to be 382 million individuals who are being diagnosed and among this, type 2 diabetes are said to be common. As a result, type 2 diabetes is considered to be a serious issue. If we could predict and analyze diabetes at right time, effective measures can be taken earlier hence not allowing to worsen the condition of the patient. This would be an exceptional innovation where it helps in the advancement of medical field industry. By demonstrating, the future could be anticipated by information mining. Lately, there are numerous computational techniques and instruments are available for information examination. For clinical exploration and mainly in clinical field, information mining has been generally applied. Hence this paper proposes a



# Hypervolume Sen Task Scheduling and Multi Objective Deep Auto Encoder based Resource Allocation in Cloud

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**Abstract**—Cloud Computing (CC) environment has restructured the Information Age by empowering on demand dispensing of resources on a pay-per-use base. Resource Scheduling and allocation is an approach of ascertaining schedule on which tasks should be carried out. Owing to the heterogeneity nature of resources, scheduling of resources in CC environment is considered as an intricate task. Allocating best resource for a cloud request remains a complicated task and the issue of identifying the best resource – task pair according to user requirements is considered as an optimization issue. Therefore the main objective of the Cloud Server remains in scheduling the tasks and allocating the resources in an optimal manner. In this work an optimized task scheduled resource allocation model is designed to effectively address large numbers of task request arriving from cloud users, while maintaining enhanced Quality of Service (QoS). The cloud user task requests are mapped in an optimal manner to cloud resources. The optimization process is carried out using the proposed Multi-objective Auto-encoder Deep Neural Network-based (MA-DNN) method which is a combination of Sen's Multi-objective functions and Auto-encoder Deep Neural Network model. First tasks scheduling is performed by applying Hypervolume-based Sen's Multi-objective programming model. With this, multi-objective optimization (i.e., optimization of cost and time during the scheduling of tasks) is performed by means of Hypervolume-based Sen's Multi-objective programming. Second, Auto-encoder Deep Neural Network-based Resource allocation is performed with the scheduled tasks that in turn allocate the resources by utilizing Jensen-Shannon divergence function. The Jensen-Shannon divergence function has the advantage of minimizing the energy consumption that only with higher divergence results, mapping is performed, therefore improving the energy consumption to a greater extent. Finally, mapping tasks with the corresponding resources using Kronecker Delta function improves the makespan significantly. To show the efficiency of Multi-objective Auto-encoder Deep Neural Network-based (MA-DNN) cloud time scheduling and optimization between tasks and resources in the CC environment, we also perform thorough experiments on the basis of realistic traces derived from Personal Cloud Datasets. The experimental results show that compared with RAA-PI-NSGAIL and DRL, MA-DNN not only significantly accelerates the task scheduling efficiency, task scheduling time but also reduces the energy usage and makespan considerably.

**Keywords**- Cloud Computing, Cloud Server, Multi-objective, Auto-encoder, Deep Neural Network

## I. INTRODUCTION

CC climate relate virtualization instrument to divide colossal actual assets into various virtual assets. A few clients use these virtual assets on a CC climate whenever and anyplace. Most existing cloud asset assignment techniques don't support the creating mode, explaining that they are deficient in endeavor the idealness and enhancement concerning asset distribution. However, clients' support more mindfulness of the practicality and advancement. In this manner, cloud specialist co-ops or cloud servers are very

restless with how to control huge assets and improve asset use. A huge asset distribution is thus urgent to show up at these targets.

A Cloud Asset Distribution Calculation in light of an Equal and Further developed Non-ruled Arranging Hereditary Calculation II (RAA-PI-NSGAIL) was proposed in [1]. To begin with, asset assignment need and it were figured out to match distances. Then, the proportion of proportion to reaction by means of multi-objective streamlining strategy for distribution the asset in CC climate was planned. Here, only minimum matching and resource proportion were employed.



## HEALTH MONITORING BASED COGNITIVE IOT USING FAST MACHINE LEARNING TECHNIQUE

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### Abstract:

Diabetic patients' pleasant of life is advanced with continuous tracking. The usage of numerous technologies like the internet of factors (IoT), embedded software program, communications generation, synthetic intelligence, along with clever devices can assist to reduce the healthcare system's monetary prices. diverse communication technologies have enabled the availability of customised and remote fitness care. to meet the demands of development of sensible e-fitness apps, we have to construct clever health care structures and boom the amount of packages connected to the community. As a result, as a way to attain important wishes such as high bandwidth and strength efficiency, the 5G community need to consist of sensible healthcare applications. the usage of device getting to know methods, this research proposes an intelligent infrastructure for tracking diabetes sufferers. clever devices, sensors, and mobile phones had been used inside the architecture to enough exposure from the body. so one can produce a analysis, the sensible machine collected statistics from the patient and classified it the use of gadget getting to know. numerous machine getting to know methods were used to check the recommended prediction system, and the simulation results showed that





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#### Abstract

The process of recognizing named things in a text document entail classifying them into specified groups like Person, Location, Organization, etc. It is a crucial stage in the processing of text written in natural language. The goal of named entity recognition systems is to extract pertinent data from the text. Different approaches are used in Malayalam for NER. In this paper, we provide a neural network-based named entity recognition system for Malayalam. For learning representations of data with various levels of abstraction, neural networks are incredibly potent tools. The suggested approach uses various properties, including embedded word and suffix representations, POS information about the word, etc. We only used a corpus of 6300 headlines for Malayalam news articles that were gathered from Malayalam news websites. The system was able to achieve the most cutting-edge performance in NER for Malayalam with fewer features.

#### 1. Introduction

The amount of information available on the internet is constantly growing. Every second, new words and images are uploaded to the internet, contributing to the issue of information overload. Furthermore, this data is accessible in an unstructured way. We are unable to search through all of these data for pertinent information. The practice of gathering pertinent material from an enormous quantity of unstructured data is known as information extraction in the field of artificial intelligence. By using information extraction (IE), unstructured content is transformed into a structured format that computers can process with ease. One of IE's subdomains is NER. In the sixth message understanding conference (MUC-6), the word "entity" is first used. Additionally, from MUC conferences are the benchmarks for various NER systems. Expressions that relate to specific people, places, organizations, etc. are known as named entities. Due to the Malayalam text's ambiguous formatting, entity extraction is a challenging operation. English, for example, has a specified and arranged shape for its text, making entity extraction in such languages a straightforward operation. It can be difficult to identify named entities in an open-domain unstructured text. Even though various solutions to this issue have been presented, the field of study is yet unexplored. The ultimate objective of named entity recognition systems is the identification and classification of named entities to classes with semantically meaningful names.

Building computational models for the analysis and creation of natural language text is the goal of natural language processing. These models can be used to create intelligent computer systems like summarizing systems, machine translation systems, and speech recognition systems, among others. Named entities make up about

60% of all search engine inquiries. Determining named entities from an open domain text is crucial for processing queries. Systems for recognizing named entities are useful in question answering software as well. Finding such entities is helpful for question-answering systems because the majority of inquiries with the keyword "who" always have an entity with the class "person" as their answer.

The task of named entity recognition in Malayalam is difficult for the reasons listed below. Languages like English have the ability to capitalize words to distinguish between named entities. However, Malayalam lacks the capitalization feature, which makes it more difficult to distinguish between named entities. Identifying named entities in Malayalam is also complicated by its rich morphology. Multiple stems and affixes are frequently combined to create words in Malayalam. Identification of named entities is additionally hampered by the case information associated with noun terms. In Malayalam, a large portion of the words are agglutinated. Agglutination produces complicated words that are frequently challenging to understand. A further challenge in creating NER systems for Malayalam is the absence of linguistic resources like standard datasets, POS taggers, morphological analyzers, dictionaries, etc.

In this paper, we provide a neural network-based named entity recognition system for Malayalam. Our ultimate goal is to raise entity recognition systems' efficiency. The main entity classes that we have taken into consideration are person, place, organization, and miscellaneous. All other types of entities fall under the miscellaneous category. The format of this essay is as follows. The paper's second half provides a brief survey of related literature. The suggested approach is explained in Section 3. The experiments and findings are described in Section 4. The paper's final part offers several directions for future research.

#### 2. Related works

One of the hot topics in NLP in recent years has been named entity recognition. Various methods for automatic named entity recognition are reported. Rule-based, machine learning-based, and hybrid technologies are the three main categories. The foundation of manually crafted rules is the foundation of rule-based systems. They are particular to the languages for which they are written and can only conduct entity recognition in constrained



# Crash Detection Using an IOT Based Sensor and Health Related Features

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**Abstract**— There are a lot of people facing a problem of unexpected death or health damage due to the lack of medical care at the right time, especially elderly people, patient with disabilities and people that are living alone who are required to be continuously under surveillance for the purpose of safety and emergency response. Most of the works done in this field imposed the restriction of fixing the smartphone in certain position on human body to easily infer the emergency case from the data of the smartphone sensors. To overcome this restriction, the proposed system incorporated a smartwatch, together with smartphone freely carried by the user, for better performance results. The use of smartwatch assisted in providing distinct separable signal variation from the smartwatch accelerometer and gyroscope sensors to recognize emergency case such as falling, car accident and heart rate failure. Immediately after cases that are mentioned previously the proposed system sends details information such as videos, location, heart rate etc. to the emergency centre and emergency contact to provide help at the right time. The system was practically tested in real simulated environment and achieved quite very good performance results. The chatbot will provide quick answers to FAQs by setting up rule-based keyword chatbots with "if/then" logic. This chatbot will use a series of well-defined rules to guide customers through a series of menu options that can help answer their questions. It will be there for customers 24/7 on their preferred channels, and simultaneously handle more queries at once.

**Keywords**—Internet of Things, Arduino.

## I. INTRODUCTION

Rema

on the Internet, especially on social media, it is becoming increasingly important to identify and potentially prevent the transmission of hate speech, i.e. fight against racism and sexism. With the vast amount of user-generated information on the Internet, especially on social media, it is becoming increasingly important to identify and potentially limit the spread of hate speech. Hate speech and defamatory comments against another person's religion, ethnic origin, or sexual orientation are prohibited by law. In many countries, anyone who incites violence or genocide is considered a criminal. In addition, many governments prohibit the use of symbols of totalitarianism and restrict freedom of assembly in the case of fascism or communism. However, not everyone has equal access to this public space and not everyone has the right to express themselves without fear. Hostile and disrespectful communication on the Internet drowns out the voices of marginalized and underrepresented groups in the public conversation. This helps us to understand this and mitigate.

Hate speech on the Internet and social media not only causes friction between groups of people, but it can also cause harm businesses and cause really important problems. For these reasons, websites such as Facebook, YouTube, and Twitter are limited hate speech. However, tracking and filtering all content always problems. For this reason, many tests have been conducted to learn how to automatically detect hate speech. Most of this hate speech detection work attempts to create dictionaries of hate phrases and expressions or categorize hate speech into two categories: "hate" and "don't hate". However, assessing whether a sentence contains hateful content is always difficult, especially when hate speech is masked under sarcasm or when hate is not clearly expressed. race or prejudice. The goal of this study was to extract hate speech from social media content in an online forum. We have proposed a hate speech visualization and recognition system based on the deep attention technique. In a study of online trends, users

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# Driver Assistance System In Stop Signal Intersection Scenarios With Live Gps Voice

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**Abstract**— The problem we address is that of failure of maps not giving adequate information about the destination that we choose. The purpose is to provide a brief description about the real time location and suggest information about the famous locations with GPS voice. The GPS module provided in the car will provide a description about the place to the drivers. This feature allows the passengers to explore and get a better knowledge about the places they visit. The driver assistance system with information provision to warn drivers that they are approaching a stop-sign intersection. The stop signals can be identified using the camera module provided in front of the car. When the system detects a stop signal, it will send an information to the driver that they are approaching an intersection.

**Keywords**— Maps, Destination, Real-Time Location, GPS, Voice Module, Driver Assistance System, Stop-Sign Intersection, Camera Module.

## I. INTRODUCTION

It is evident that there are multiple reasons for accidents occurring at intersections with stop signs. According to Figure 1, the intersection environment can be split into five sections: the approach, deceleration, entering the intersection area, preparing for a turn and executing said turn. During the first stage of this process, drivers should focus on locating and recognizing various elements such as lane arrangement, road markings and of course - the stop sign. Notably though, distraction or negligence are often main culprits in these types of incidents. In addition, trees and other things can make stop signs hard to see or they might be worn out due to age. This is especially true in bad weather or dark conditions. During the slow-down procedure, drivers must do two jobs. Firstly they need to judge the distance from the crossroads and decide when to press on the brake and let go of the accelerator; secondly they have to halt their vehicle fully at the line near it. Researching drivers' attitudes towards obeying stop signs, Pietrucha et al realized that fewer vehicles on side streets often lead people not noticing how dangerous disregarding a stop sign could be. As drivers enter intersections, their main task is coming close while searching for conflicts with other users (cyclists, pedestrians) in zebra crossings. Van Houten and Retting found that many drivers are unable to recognize potential risks at intersections and don't take the necessary precautions. While there is still a risk of collisions without stopping, it is more likely to happen if the sign isn't followed. The driver has two tasks during the preparation for a turn - stopping in an appropriate place, and observing oncoming traffic. Then during execution, they evaluate whether it's safe to carry out the maneuver without accidents. A line-of-sight blocked by something could create huge problems here. Failure to wait

for sufficient gaps in cross-traffic corresponds to a substantial increase in crash risk. Elderly drivers often estimate incorrectly the safe time margins they should allow themselves.

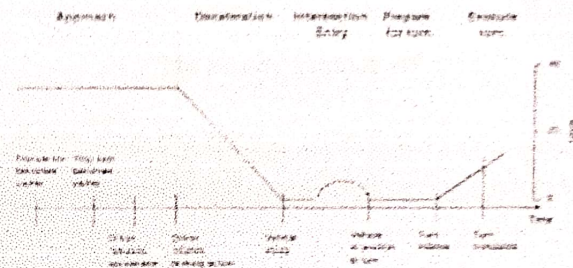


Fig 1. Rule following driver behaviour at intersections.

## II. RELATED WORK

### A. Intelligent driving system for safer Automobiles (Hideo Inoue et.al, 2017)[1]

The goal of this research is to create an Autonomous Intelligent Driving System to reduce accidents and increase safety for elderly drivers. The system uses a Risk-predictive driving intelligence model and Shared control between humans and machines. The system includes a risk-prediction mechanism to prevent accidents in difficult driving conditions, and it can recover deteriorated recognition, decision-making, and operational abilities for experienced drivers. The system aims to intervene with braking or steering actions if needed, decreasing driving workload. Shared control is used to optimize assistance levels during braking and steering maneuvers while minimizing interference with human driving behavior. The Driving Simulator and the test vehicle are used to verify the system's effectiveness.

### B. Analysis of motor vehicle crashes at stop signs in four U.S cities (R.A Retting et al. 2003)[2]

The study investigated police-documented motor vehicle crashes that occur yearly at stop signs, with around one-third of these resulting in injury, to understand the accidents and discover potential solutions. The researchers thoroughly investigated police accounts of collisions at two-way stop sign intersections from 1996 - 2000 in four US cities and found that 70% of all crashes occurred due to a violation of stopping rules, with angle impacts being the most common. In approximately two-thirds of collisions resulting from stop sign violations, the drivers reported having initially come to a halt, but the cause of the accident was typically attributed to being unable to spot oncoming traffic. Counteractive measures suggested include transforming traffic regulations and



# Realtime Drowsiness Detector & Alert System For Sleepy Commuters

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**Abstract**— In recent years, driver drowsiness and sleep are a significant causes of road accidents, especially when drivers drive for a long time on highways. Avoiding an accident can be the aim of smart systems nowadays. A robust driver detection system must be designed to alert the driver. These project detections are based on various physical-based techniques that detect features such as eyes state (closed or opened), eye blinking rate, yawning, and head movement. In the proposed project we detect drowsiness using behavioral-based techniques. We have also included face detection and various alert systems more than the existing system.

**Keywords**—Driver Fatigue,Drowsy Driving,Sleepiness Alertness Monitoring,Vehicle Safety Driver Behaviour

## I.INTRODUCTION

Drowsiness refers to the state of feeling a strong urge to sleep and being close to falling asleep, either in a routine pre-sleep state or as a chronic condition where there is no regular rhythm. However, being drowsy while engaging in activities that require constant attention, such as driving, can be dangerous. Driving while feeling sleepy increases the risk of a traffic accident. Therefore, it is crucial to detect and prevent driver drowsiness to reduce road accidents. The primary aim of this project is to create a simulation system that accurately detects whether the driver's eyes and mouth are open or closed. By monitoring eye movements, yawning, and the time the eyes are closed, it is possible to detect early signs of drowsiness and prevent potential accidents. This system could be used in various industries, including transportation and healthcare, to improve safety and diagnose sleep disorders accurately. The study focuses on localizing the eyes and mouth in facial images, which involves analyzing the entire facial image using image processing algorithms to identify eye and mouth locations. The technology then detects drowsiness by determining whether the eyes are open or closed. This project's success could prevent countless

accidents and save lives by detecting drowsiness and enabling timely intervention.

The project aims to develop a drowsiness detection system that can accurately track whether a driver's eyes and mouth are open or closed to prevent accidents caused by driver fatigue. Drowsiness refers to a person's strong desire to sleep, and it can be both a routine state just before falling asleep and a chronic condition where a person remains in that state without a regular rhythm. It can be particularly dangerous when performing activities that require continual attention, such as operating a vehicle, which increases the risk of a traffic collision. Detecting driver drowsiness is a significant challenge in the development of accident avoidance systems, and reducing the effects of drowsiness is crucial for road safety. The project will focus on developing a system that can detect yawning and ocular closure as indicators of drowsiness. The system will use a series of facial picture sequences to determine when a driver is yawning and the proportion of time their eyes are closed within a given period. The localization of the eyes and mouth will also be examined to determine whether they are open or closed using image processing algorithms. This technology has applications beyond the transportation industry, including face recognition, human identification, and security systems. The development of a reliable drowsiness detection system has the potential to save countless lives by preventing accidents caused by drowsy driving and facilitating accurate diagnosis and treatment of sleep disorders in medical facilities.

## II. RELATED WORK

*A. Camera-Based Eye Blink Detection Algorithm for Assessing Driver Drowsiness.[1]*

This paper presents a camera-based algorithm for detecting eye blinks while driving, with the goal of assessing drowsiness levels. The algorithm is designed to handle the challenges that arise when detecting eye blinks in the automotive context, such as distinguishing between eye blinks and glances at the dashboard and accounting for high inter-



# Advanced Home Automation and Security Systems Using IoT

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**Abstract**—The Home Automation System (HAS) is an expansion of the activities currently carried out inside the home. Thanks to today's powerful computing devices and wireless sensor networks (WSN), it is now possible to create an IoT-based smart bank that enables home automation with gesture detection and control. The main goal of this project is to create a home automation system utilizing an ESP32 board that can be remotely managed by any smartphone running the Android operating system. The traditional switches in modern homes are rapidly giving way to centralized control systems with remote-controlled switches. Have you ever imagined living in a world where you could just use your voice to tell your household equipment to operate as you require? In the near future, activated automated homes will be used. This project will show how to use the internet and your voice to manage household electronic items like TVs, fans, lights, and more on a tight budget. Today's Internet of Things (IOT) smart items are able to detect their own states and share them with other objects online, working together to make deft judgements on their own. Humans always look for alternatives around to do their work efficiently. Additionally, similar or alternative objects that are in line with user needs, the current situation, and prior knowledge should be able to be provided automatically by service provisioning in IOT. The rise of automated technologies has made life easier in every way. The preference today is for automatic systems over manual ones.

## I. INTRODUCTION

A system for home automation and gas leak detection combines the automation of numerous household chores with the detection of gas leaks. By automating routine household functions like lighting and temperature management and offering a gas leak early warning system, the system is intended to simplify and protect its users' lives. Any type of gas, including propane, carbon monoxide, and natural gas, can be detected by the system. The system employs sensors to find the presence of a gas, and when it does, an alarm is set off to alert the home's residents. The alarm can be a silent text message alert or a loud audio alarm. The system also offers a central control panel that the user may utilise to manage a variety of house features, including lighting, temperature control, and locking and unlocking doors. Users will be able to

operate the system using voice commands thanks to the system's ability to be integrated with voice control systems. The main goal of this project is to create a home automation system that can be remotely managed by any Android OS smartphone utilizing an Arduino board with Bluetooth. The traditional switches in modern homes are rapidly giving way to centralized control systems with remote-controlled switches. Have you ever imagined living in a world where you could just use your voice to instruct your household appliances to operate as you require? The days of needing to be a millionaire like Tony Stark in order to have an automated, voice-activated home are long gone. In this little video, I'm going to demonstrate how you can use your voice to manage a variety of electronic devices, including fans, TVs, lights, and the internet, on a budget. You don't need any prior programming or NodeMCU expertise to follow this guide. In order to understand about home automation, let's use Google Assistant and NodeMCU. Anything that makes it easier and more efficient for you to use your home's appliances, lighting, and heating is considered home automation. It might be as basic as controlling a few lights remotely or automatically, or it can be a full-fledged system that manages all the key appliances in your house, customised to suit your particular tastes. It focuses on wireless home automation technologies, which are simple to install into pre-existing homes without requiring new wiring or requiring the removal of carpets or wall-punching holes. Each technology has distinct advantages and features that make some more suitable for specific applications while others can be used for all standard installations of home automation. Providing automated control of electronic equipment in houses and other structures, as well as the detection of potential gas leaks, is the goal of the home automation and gas leakage detection system. The system's remote lighting, temperature, and ventilation controls, along with its ability to detect the presence of dangerous gases, are all designed to improve comfort, safety, and energy efficiency in the surrounding area.



# Vulnerability Deterrence System Using Web Application Firewalls- Deep Learning & Reinforcement Learning

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**Abstract**— Web Application Firewalls (WAFs) play a crucial role in securing numerous web applications from increasing sophisticated web attacks. However, as web attacks become more advanced, regular testing and updates are required to ensure the WAFs can withstand the attacks. Brute-force attacks are impractical due to the vast array of attack patterns. Therefore, black-box testing techniques have been proposed, but they are not yet mature and suffer from low efficiency and effectiveness. This paper proposes a method for vulnerability detection in web applications using a web application firewall (WAF) integrated with deep learning and reinforcement learning techniques, specifically convolutional neural networks (CNNs) and artificial neural networks (ANNs). The method aims to improve accuracy and reduce false positives by training the CNN and ANN models using a dataset of known vulnerabilities and employing reinforcement learning techniques. Experimental results show that the proposed method outperforms traditional vulnerability detection methods in terms of accuracy and reduced false positives. The proposed method has the potential to be an effective tool for enhancing the security of web applications.

**Keywords**— Vulnerability detection, SQL injection, XSS attack, Web Application Firewall, Deep Learning, Reinforcement Learning, CNN, ANN.

## 1. INTRODUCTION

In recent years, there has been a significant shift towards online businesses, such as e-commerce, online banking, and social media. This transformation has led to the accumulation of large amounts of private data belonging to both individuals and organizations in web application databases. Unfortunately, this data has made web applications an attractive target for

attackers. Recent reports indicate that web applications may experience up to 26 attacks per minute, and 76% of websites are vulnerable to several attacks, according to Symantec's security report [7][8]. This situation highlights the need for robust security measures to protect against these attacks and safeguard sensitive data.

Vulnerability detection using a web application firewall (WAF) is a proactive approach for identifying and mitigating security vulnerabilities in web applications. A WAF is a type of security solution that sits between a web application and the internet, analyzing incoming traffic and blocking any malicious requests [1]. One of the primary benefits of using a WAF for vulnerability detection is that it can provide continuous monitoring and protection against a wide range of attacks, including SQL injection and cross-site scripting (XSS). By analyzing incoming traffic in real-time, a WAF can quickly detect and block any requests that appear to be malicious or anomalous, providing an additional layer of defense against potential vulnerabilities.

In addition to providing real-time protection, many WAFs also offer reporting and analytics features that can help organizations identify trends and patterns in their web traffic, as well as detect any potential vulnerabilities that may need to be addressed. Overall, vulnerability detection using a WAF is an effective way to proactively identify and mitigate security vulnerabilities in web applications, helping to prevent cyberattacks and protect sensitive data.

WAFs are a recommended solution for protecting web applications against attacks. WAFs analyze HTTP(S) traffic to prevent malicious requests from reaching the web applications, intercepting bi-directional traffic and making decisions based on whether the traffic is malicious or benign, according to the



# Neonatal pain detection using triple CNN

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**Abstract** - Convolutional Neural Networks are used nowadays because of its successful application in medical image analysis, image recognition etc. Triplet Convolutional Neural Network which is specifically designed for neonates for the effective detection of neonatal pain. The N-CNN used here is applied on a real world dataset which contains images of the neonates at the time of pain while being hospitalized in Intensive Care Unit. It is clear from the experiments that N-CNN used here is very efficient in classifying the pain when compared to the existing standard.

**Keywords**—Convolutional neural assessment, clinical network, pain facial expression applications, analysis.

## I. INTRODUCTION

For many years Pediatricians believe that neonates do not have the ability to sense the pain. But later there exists many methods for detecting the neonatal pain. The main drawback of these methods are they are discontinuous and not consistent in determining the pain of neonates. Since neonates can't able to communicate correctly it is very important to determine the cause of pain for the proper pain management. Convolutional Neural Network were used because of its wide successful application in medical image analysis, object recognition, image recognition etc. It provides pain relevant features as they have the ability to learn and extract features at multiple levels of abstraction. Triple CNN which is introduced and designed specifically for determining the pain of neonates using facial expressions. Convolutional neural networks (CNNs) have gained much popularity in the last decades due to the wide range of its successful applications in medical image analysis, object and emotion recognition. In this paper, we investigated the use of a novel lightweight neonatal convolutional neural network as well as other popular CNN architectures for assessing neonatal pain. We experimented with various image augmentation techniques and evaluated the CNN architectures using two real-world datasets [COPE and neonatal pain assessment dataset (NPAD)] collected from neonates while being hospitalized in the intensive care unit. The experimental results demonstrate the superiority and efficiency of the novel network in assessing neonatal pain. They also suggest that the automatic recognition of neonatal pain using CNN networks is a viable and more efficient alternative to the current assessment. Triplet Convolutional Neural Network which is specifically designed for neonates for the effective detection of neonatal pain. The N-CNN used here

is applied on a real world dataset which contains images of the neonates at the time of pain while being hospitalized in Intensive Care Unit. It is clear from the experiments that N-CNN used here is very efficient in classifying the pain when compared to the existing standard.

## II. RELATED WORK

**Pain Assessment Using Handcrafted Features:** It presented a handcrafted based method to detect facial expressions of pain using different variations of Local Binary Pattern (LBP) descriptor. Specifically, Local Ternary Pattern (LTB), Elongated Local Binary Pattern (ELBP), and Elongated Local Ternary Pattern (ELTP) texture descriptors were applied to COPE infant dataset [6] to extract pain-relevant features.

In the pre-processing stage, the images were re-sized, aligned, cropped to obtain the exact facial region, and divided into blocks or cells of  $25 \times 25$ . Then, the texture descriptors listed above were applied to these blocks to extract pain-relevant features. To classify the images (204 images) of 26 subjects as pain or no-pain, an ensemble of Radial Basis SVMs was built and evaluated on a testing set.

The results showed that ELTP texture descriptor achieved the highest (approx. 0.93) Area Under the Curve of Receiver Operating Characteristic curve (AUC of ROC) as compared to other texture descriptors. In addition to LBP descriptor, Celona and Manoni applied HOG (Histogram of Oriented Gradients) descriptor to  $2 \times 2$  blocks of  $8 \times 8$  pixel cells with an overlap of half the block and histograms of 9 bins evenly spread from 0 to 180 degrees. Applying this descriptor to  $224 \times 224$  gray-scale image generates 26244-dimensions feature vector ( $729 \text{ regions} \times 4 \text{ blocks} \times 9 \text{ bins}$ ). This feature vector was reduced to 175 dimensions using Principal Component Analysis (PCA) followed by L2 normalization. Using the features extracted by HOG descriptor with SVM achieved 81.75% average accuracy (i.e., accuracies averaged across 26 subjects). Other hand crafted based methods for neonatal pain assessment can be found in [10] - [13]. The challenge of manually designing handcrafted descriptors and extracting the best set of features has motivated researchers to use Convolutional Neural Networks.

CNNs learn and extract relevant features, at multiple levels of abstraction, directly from the source data or images. These networks achieved state-of-the-art results in many applications, including clinical and emotion recognition applications.



# Breast Cancer Detection Using CLAHE-CNN Architecture

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**Abstract**— Breast cancer has evolved as the most lethal illness impacting women all over the globe. Researchers all around the world are working on breast cancer screening tools based on medical imaging. Deep learning approaches have piqued the attention of many in the medical imaging field due to their rapid growth. In this project, we have used CLAHE-CNN architecture in which the microscopic image or the biopsy image is passed through convolutional neural networks which identify various cancerous features in the image. The entire process actually covers four modules: pre-processing, segmentation, feature extraction, and classification. Pre-processing includes Contrast Limited Adaptive Histogram Equalization (CLAHE) and Laplacian filter which provides more specific images for segmentation. Feature extraction and classification of the image is achieved by employing LeNet-5, a variant of convolutional neural network (CLAHE). The resulting output will be displayed as a test result. This suggested CLAHE-CNN architecture using LeNet-5 has an accuracy of 90.3%. We believe that the suggested approach will be of tremendous value to healthcare practitioners identifying breast cancer patients early on perhaps to an immediate diagnosis.

early detection. Thus, the availability of proper screening methods is important for detecting the initial symptom of breast cancer. Various imaging techniques are used for the screening to identify this disease, the popular approaches are mammography, ultrasound, and thermography. One of the most significant methods of early detection for breast cancer is mammography. Ultrasound or diagnostic sonography methods are popularly used as mammography is not effective for solid breasts. Considering these issues, small masses can be bypassed by radiologists from radiography and thermography may be more effective than the ultrasound technique in diagnosing smaller cancerous masses.

Due to the intrinsic difficulties associated with an image, with meager contrast, noise, and lack of appreciation by the eye, instruments have been prepared to make and improve image processing. Nowadays, artificial intelligence (AI), machine learning (ML), and convolutional neural network (CNN) are the quickest-rising areas of the healthcare industry. AI and ML are found in the research arena that deals with and improves technological systems to resolve complex tasks by reducing the necessity of human intelligence. Deep learning (DL) which is part of the machine learning family depended on artificial neural networks. DL architectures, such as DNN (deep neural networks), RNN (recurrent neural networks), DBN (deep belief networks), and CNN, are generally applied to the areas like computer vision, audio recognition, speech recognition, social network filtering, natural language processing, machine translation, drug design, bioinformatics, medical image analysis, materials scrutiny, histopathological diagnosis, and board game programs. These new technologies, in particular DL algorithms, can be applied to improve the diagnostic accuracy and efficiency of cancer detection.

On the other hand, digital pathology (DP) is a way of digitalization of histology slides for producing high-resolution images. These digitized images are used for detection, segmentation, and classification through the application of image analysis techniques. Extra steps are required in deep learning (DL) using CNNs, such as digital staining, to understand patterns for image classification.

Here we use the hybrid architecture of CLAHE and deep convolutional neural network for the classification of the breast microscopic imaging. For accurate detection of cancer histopathology biopsy images are used. The characteristic of

**Keywords**— Mammography, breast cancer detection, multi-instance classification, deep convolutional neural network.

## 1. INTRODUCTION

Cancer is one of the most common diseases in India which has responsibility for maximum mortality with about 0.3 million deaths per year. The chances of getting affected by this disease are accelerated due to changes in habits in the people such as an increase in use of tobacco, deterioration of dietary habits, lack of activities, and many more. The possibility of a cure for cancer is increased due to recent combined advancements in medicine and engineering.

Breast cancer is currently the most common cancer globally, accounting for 12.5% of all new annual cancer cases worldwide. Breast cancer is also a very life-threatening disease of women after lung cancer. Breast cancer is categorized into various types according to the cell's appearance through a microscope. Breast cancer can be effectively treated through its



# A Novel Method For Data Security Using Coverless Image Steganography Using AES

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**Abstract**— We need safe solutions to protect our data as data threats grow. Techniques like cryptography and steganography can aid in preventing security threats from hostile actors. Data security can be increased by combining cryptography and cryptographic recording, and there are currently systems that do this. However, these systems frequently employ concealed hiding methods. To further strengthen data security in our proposed work, we advocate adopting encryption algorithms in conjunction with non-masking picture concealment approaches. Data encryption in our system uses a 128-bit version of the AES symmetric technique. We have opted for non-masking cloaking because image analysis technologies are particularly sensitive to conventional cloaking. In unwrapped photo steganography, hidden messages are inserted into a cover image. The combination of encryption and non-masking imaging is what we aim to do in order to increase data security. The unique idea of unwrapped image concealment, developed by A.H.S. Saad and colleagues, is used in the suggested system as an image storage technique with the highest payload capacity when compared to non-covered image storage algorithms.

**Keywords**—Information Security, Cryptography, Steganography, Advanced Encryption Standard (AES), Symmetric Cryptography, Coverless Image Steganography.

## 1. INTRODUCTION

Data security is a critical problem in the current climate, when data breaches and cyber-attacks are occurring more regularly. A hybrid approach that combines the Advanced Encryption Standard (AES) and coverless image steganography is an effective data protection technique. Steganography is a method of concealing information in an image in a way that the naked eye cannot see it.

A more sophisticated form of steganography called coverless image steganography does not need a cover image to conceal information. Instead, it conceals information using the features of the image file format itself. Data is securely encrypted using the popular encryption method AES. We can offer a two-layered solution to data security by fusing coverless image steganography with AES. The data is first encrypted with AES, making sure that even if it is intercepted, it cannot be decoded without the decryption key. Secondly, to make it even more challenging to detect and intercept, the encrypted data is cloaked inside an image using coverless image steganography. Data security benefits from the combined use of coverless image steganography with AES are numerous. Because the data is encrypted using a powerful encryption algorithm and concealed within an image, it offers a high level of security. As a result, it is challenging for hackers to intercept and interpret the data. Additionally, coverless image steganography adds an extra layer of security because there is no obvious sign of the concealed data, making it challenging to find. A method of concealing information within a picture without changing its look is called coverless image steganography. With coverless image steganography, information can be concealed without a cover image, in contrast to traditional steganography. Instead, it conceals information using the features of the image file format itself. Data is securely encrypted using the Advanced Encryption Standard (AES), a popular encryption method. Because it uses symmetric keys, the same key is used for both encryption and decryption. Data security can be effectively solved with the use of coverless image steganography and AES. Data encryption: Data is first encrypted with the AES method. To guarantee that only people with permission can decrypt and access the data, the encryption key must be kept secret. Steganography embedding Next, using coverless image steganography, the encrypted data is incorporated into the image. The image can be any image file format, such

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# SITIOS PREFERENCE BASED CARPOOLING,

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Abstract: Carpooling apps are gaining popularity as people seek cost-effective and environmentally friendly ways to commute. However, several issues continue to hinder the effectiveness of these apps. Lack of trust between users is a primary issue, which can be addressed through implementing verification and rating systems. Inefficient matching algorithms can lead to long wait times for riders or empty seats for drivers, which can be addressed through the use of advanced algorithms. Limited coverage is another issue that can be addressed through incentivizing users to join and expanding the coverage area. Payment disputes can also arise between riders and drivers, and secure payment processing systems are necessary to handle these issues effectively. Safety concerns are critical in carpooling apps, and effective safety features, such as emergency buttons, driver background checks, and real-time tracking, must be implemented. Addressing these issues can enhance the effectiveness and popularity of carpooling apps.

Keywords—Pooling, attributed network representation, and personalized ranking

## I. INTRODUCTION

User embedding is a machine learning and natural language processing approach for representing users in a high-dimensional vector space. User embedding's purpose is to build a numerical representation of users that incorporates their interests, preferences, behaviors, and other important attributes. There are several techniques to user embedding, but one of the most common relies on neural networks. A neural network is trained on a huge corpus of user-generated content, such as social media postings, reviews, or comments, in this technique. The neural network learns to map each user to a fixed-length vector containing the user's latent attributes.

Once collected, the user embedding may be utilized for a range of activities such as personalized recommendations, user categorization, and clustering. User embedding is especially effective when the user profile is insufficient or sparse, since it enables more precise and economical modelling of user behaviour[1].

The article proposes a user embedding approach based on deep learning for personalized ridesharing matching. The personalized matching is a key challenge in carpooling and ridesharing, as it involves finding the best matches between drivers and passengers based on their

preferences, schedules, and locations. To address this challenge, a neural network model that learns user embeddings from historical ridesharing data. The user embeddings are then used to measure the similarity between drivers and passengers, and to make personalized matching recommendations.

The article provides a detailed description of the proposed model, along with experimental results that demonstrate its effectiveness in improving the quality of ridesharing matching. The potential applications of user embedding in other areas of transportation, such as traffic prediction, route planning, and vehicle routing.

Overall, the article provides a valuable contribution to the field of transportation and user embedding, and it showcases the potential of deep learning techniques for improving the efficiency and sustainability of ridesharing services.

## II. EFFICIENT CARPOOLING MATCHING WITH ATTRIBUTE-BASED NETWORK EMBEDDING

### A. Background

Attributed network embedding is a technique used to represent users in a network with both their social connections and attributes. It involves mapping each user to a low-dimensional vector, which captures their social relationships and individual attributes.

### B. System Model

The system offers two critical phases for the attributed network embedding approach. First, a graph is created to represent user relationships based on their carpooling history and social connections. Then, using both social connections and individual attributes, an embedding model is trained to learn a low-dimensional representation of each user in the graph.

For this, the experts suggested a new approach called Social and Attribute Graph Convolutional Networks (SA-GCN), which combines graph topology and user characteristics into a neural network model. The SA-GCN approach employs many layers of graph convolutional neural networks (GCN) that operate on the graph, with each layer pooling information from the preceding layer as well as user data to build the embedding representation.



# SELECTIVE FEATURE BASED THYROID DISEASE CLASSIFICATION USING DEEP LEARNING

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**Abstract**— There are many thyroid diseases affecting people all over the world. Many diseases affect the thyroid gland, like hypothyroidism, hyperthyroidism, and thyroid cancer. Thyroid inefficiency can cause severe symptoms in patients. Effective classification and machine learning plays a significant role in the timely detection of thyroid diseases. This timely classification will indeed affect the timely treatment of the patients. In this study, a novel end-to-end knowledge-driven classification framework is presented. The main goal of this study is to classify thyroid disease into three categories: hyperthyroidism, hypothyroidism and normal and obtained classification results are used for the diagnosis purposes. Existing approaches often target binary classification, the used datasets are small in size and results validation is not done properly. Also, existing approaches focus less on feature engineering and model optimization. To overcome the limitations present in existing models, this work mainly concentrates on feature engineering and model optimization for deep learning. For getting better accuracy extra tree classifier based selected features are used for feature selection along with random forest classifier. As demonstrated by the results, the proposed system achieves relevant performances in terms of qualitative metrics for the thyroid nodule classification task, thus resulting in a great asset when formulating a diagnosis. K-fold validation technique along with F1 score corroborate the superior performance of the proposed

## 1. INTRODUCTION

Thyroid disease is becoming more common in recent years. One of the most important functions of the thyroid gland is to regulate metabolism. Thyroid gland irregularities can result in a variety of abnormalities, the most common of which are hyperthyroidism and hypothyroidism. Every year, a large number of people are diagnosed with thyroid diseases like hypothyroidism and hyperthyroidism. Thyroid hormones such as levothyroxine (T4) and triiodothyronine (T3) are produced by the thyroid gland, and a lack of thyroid hormones can result in hypothyroidism or hyperthyroidism. Many approaches to detecting thyroid disease diagnosis are proposed in the literature. A proactive thyroid disease prediction is required to properly treat the patient at the appropriate time, saving human lives and medical costs. Machine learning and deep learning techniques are being used to predict thyroid diagnosis in the early stages and classify thyroid disease types such as hypothyroidism, hyperthyroidism, and others as a result of technological advancements in data processing and computation. The

healthcare domain benefited from leveraging technology in many healthcare areas for human well-being due to advancements in technologies such as data mining, big data, image and video processing, and parallel computing. Data mining-based health care applications may include disease detection and diagnosis, virus outbreak prediction, drug discovery and testing, health care data management, and patient personalized medicine recommendations, among other things.

Health care professionals strive to identify diseases in their early stages so that proper treatment can be provided to patients and the disease can be cured in a short period of time and with minimal expenditure. Thyroid disease is one of the diseases that affects a large number of people worldwide. Thyroid disease affects 20 million Americans, according to the world's leading professional association (American thyroid association). A thyroid condition affects 12% of the US population at some point in their lives. These figures show that thyroid disease should not be taken lightly. The use of advanced technologies to improve health care practices for detecting and preventing thyroid diseases is highly desired. Existing research works primarily focus on binary classification problems in which subjects are classified as thyroid patients or healthy subjects, with only a few multiclass-based detection works. Even for those, there are three categories to consider: normal, hypothyroidism, and hyperthyroidism. For the most part, the emphasis is on the optimization of machine learning and deep learning models, while the feature selection component is under-studied or completely ignored in the context of a thyroid disease problem. Despite the high accuracy reporting approaches, such approaches are tested on samples with a sample size of less than 1000, and the results are not validated. The classification in terms of patient status, such as treatment condition, health condition, and general health issues, is desired in order to effectively predict and treat the patient's thyroid condition. Furthermore, no performance comparison of machine learning and deep learning models is performed. This research aims to address these issues and makes the following contributions:

- A novel machine learning-based thyroid disease prediction approach focusing on the multiclass problem is proposed. Unlike previous studies that focused on the binary or three-class problem, this study takes a five-class disease prediction problem into account.

This study investigates four feature engineering approaches to assess their efficacy for the problem at hand. Forward feature selection (FFS), backward feature elimination (BFE), bidirectional feature elimination (BiDFE), and machine

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# An Intelligent Deep-Learning based Drunk Driving Detection System

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**Abstract** — Drunk Driving accidents have been increasing rapidly, every year many people suffer due to this problem. Even though police use a breath-alcohol tester for the detection of drunk driving state of a person, but due to the residue left on the mouthpiece it may not be accurate and isn't an hygienic method. The study proposes a two-stage neural network for recognition of drunk driving. The first stage uses the simplified VGG network to determine the age range of the subject. The second stage uses the simplified Dense-Net to identify the facial features of drunk driving.

**Keywords**— Machine Learning; Drunk Driving Detection; VGG-16; DenseNet, Embedded System

## I. INTRODUCTION

Driving under the influence of alcohol is a significant problem worldwide, resulting in countless accidents, injuries, and fatalities each year. Despite efforts to increase public awareness and strengthen laws and regulations surrounding drunk driving, this dangerous behavior continues to be a serious public safety concern. In order to address this issue, there has been growing interest in developing more reliable and accurate methods for detecting signs of intoxication in drivers.

Breath alcohol detectors, commonly used by police officers to detect signs of intoxication in drivers, have been found to pose potential hygiene risks. The devices are typically designed to be used multiple times by different individuals, and the mouthpiece can become contaminated with saliva, bacteria, and other substances over time. This can lead to the spread of infectious diseases, and may also cause discomfort or reluctance among individuals who are required to use the device.

One approach to detecting drunk driving that has shown promise in recent years is the use of deep learning models. Deep learning is a subfield of machine learning that utilizes neural networks to automatically learn representations of data, and has been applied successfully to a wide range of tasks in computer vision, natural language processing, and other domains. In the context of drunk driving detection, deep learning models can be trained to recognize subtle changes in facial expression, speech patterns, and other features that are indicative of intoxication.

In this research paper, we propose a novel approach to drunk driving detection using deep learning models, specifically VGG for age detection and DenseNet for detecting signs of intoxication. VGG is a popular deep convolutional neural network architecture that has been

widely used for image classification tasks, while DenseNet is a more recent architecture that is designed to improve the flow of information between layers in the network.

Despite the potential benefits of deep learning models for detecting drunk driving, there are several challenges that must be addressed in order to develop a reliable and effective system. These challenges include variations in the ways that different people show signs of intoxication, the need to process large amounts of data quickly, and the ethical considerations surrounding the use of facial recognition technology for public safety purposes.

Nevertheless, the potential benefits of a more reliable and accurate system for detecting drunk driving are substantial, both in terms of reducing the number of accidents, injuries, and fatalities caused by this dangerous behavior, and in promoting responsible behavior and accountability among drivers. This research paper represents a step forward in the development of such a system, and contributes to the growing body of work aimed at leveraging the power of deep learning to improve public safety and the well-being of communities around the world.

## II. RELATED WORK

- A. Deep expectation of real and apparent age from a single image without facial landmarks (R. Rothe et. al, 2018) [2]

Age estimation from a single face image is an important task in human and computer vision which has many applications such as in forensics or social media. It is closely related to the prediction of other biometrics and facial attributes tasks such as gender, ethnicity, hair color and expressions. A large amount of research has been devoted to age estimation from a face image under its most known form - the real, biological, age estimation. This paper proposes a deep learning solution to age estimation from a single face image without the use of facial landmarks and introduces the IMDB-WIKI dataset, the largest public dataset of face images with age and gender labels. If the real age estimation research spans over decades, the study of apparent age estimation or the age as perceived by other humans from a face image is a recent endeavor. We tackle



# Virtual Mouse for Physically Disabled Using MediaPipe and PyAutoGUI

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**Abstract**— The Eye Blink Detection System focuses on the interaction between people and computers, it provides an interface between them. The main goal of our paper is to design a software that helps the people with physical disabilities to interact with computers in an easier and more convenient way. The main components are image processing to detect the eyes, and eye-blinking, face movements and opening and closing of the mouth. An eye blink is used as the click on the mouse. All the functions of the mouse can be performed by the proposed system. OpenCV is used for image processing after the image is captured from the webcam. Blazeface model of the MediaPipe is used for creating face mesh and feature extraction of the captured image. PyAutoGUI is a library provided by python for programmatically controlling mouse and keyboard.

**Keywords**—Eye blink, Head Tracking, Face Mesh

## 1. INTRODUCTION

In today's world each and every day different innovations are happening in the field of computer and technology. But the people with physical disabilities are unable to make use of these computer technologies due to the absence of a convenient way for allowing them to use computers. The existing system for the physically disabled to interact with the computers is a virtual keyboard [1] that allows them to type characters. This system uses the computers camera to capture the images for eyeblink. There is a virtual keyboard that highlights each character in the keyboard sequentially and the user have to blink their eye when the desired character is highlighted to perform the enter function and print that character on the screen.

The existing system is too much time consuming for typing each character as the user have to wait until the desired character is highlighted. Then only the user will blink his eye to enter the character on the screen. And this system can only be used for typing purpose no other functions can be performed using this existing system.

Brain-computer interface (BCI) technology works on signals from the brain. The electrical activity of the brain is determined by an electroencephalogram (EEG). A special cap sensor is placed on the scalp to read the signals, which are then transmitted to the computer. Next, the electrical activity of the brain is translated into a command to perform the action required by the BCI. A study in implemented a virtual keyboard based on BCI components with an eMotiv EPOC Neural Headset. The current implementation of the proposed virtual keyboard still needs some improvements to expand the accuracy and selection rate. Another virtual keyboard was introduced that used a brainwave sensor to connect and write. However, current systems might not have enough control precise for gaze, good control provides the ability to use available commercial eye-tracking based systems. Therefore, some studies and experiments have been built based on the rapid serial visual presentation (RSVP) model, which does not require exact gaze control to differentiate between different characters. The paradigm is called an RSVP Keyboard™, an EEG-based BCI typing system. The RSVP Keyboard™ gives the user the capability to sequentially scan the options until the



# RIDE SHARING

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**Abstract**— Over the past decade, problems related to traffic congestion have severely aggravated in city centers across the globe. This has occurred due to a wide variety of factors such as concentration of population in major cities, inadequate public transport facilities, increase in the quantity of private vehicles brought about by an improvement in standard of living, etc. In such densely populated cities, carpooling or ride-sharing serves as the perfect alternative to taking your car out daily. Along with being a relatively cost-effective and frugal way of commuting, carpooling also benefits the environment by reducing the carbon footprint generated by every individual commuter.

Despite, its numerous benefits, finding people to carpool with often proves to be quite a tedious affair. Due to this, effective execution of carpool proves to be a challenge. This Android carpooling system has been developed to help encourage carpooling by helping users "offer a ride" in their vehicle or "find a ride" with other users.

**Keywords**—ride-sharing, Vehicle-pooling, cost -sharing mechanism

## I. INTRODUCTION

Population growth and increasing population density, particularly in metropolitan areas, have brought about an increase in the number of vehicles on the roads, by a few percentage points per year. The cumulative effect of this phenomenon is staggering. This abstract presents the design and implementation of a ride sharing application.

Rideshare help connect people to travel together to the same or similar destinations. Ride sharing is a form of shared vehicle ownership to provide members with vehicles for

personal use without the costs and commitment of individual car ownership.

It will enable users to share car and bike rides in an efficient and simple way. Use of this system should reduce significantly the number of private cars on road. The application is designed for web application, thus enabling implementation of the sharing in real time, from anywhere, anytime.

## II. RELATED WORKS

Research on ride-sharing is included in a sizable corpus of literature. Ride-sharing among commuters or between drivers and passengers can take many different forms. Finding suitable drivers for the requested passengers, or the matching process that matches commuters to share a ride, is one of the crucial elements in ride-sharing. The research in [1], [12] in particular looked at how ride-sharing and vehicle pooling can cut down on delays in transportation. In order to obtain the desired benefits, these articles typically assume that ride-sharing and car-pooling are organized by centralized institutions. The self-interested nature of commuters, who do not always adhere to centralized arrangements, is not taken into account. On the other hand, recent articles [5]–[7] have looked upon stable matching in ride-sharing. Although it is not always related to cost-sharing of transportation costs, the motivation for stable matching in these papers is related to arbitrary passenger or driver preferences about one another. Although [8]–[11] take into account stable matching between drivers and passengers, they do not take into account the passengers sharing the cost of transportation. These publications also did not compare stable matching with socially optimal ride-sharing arrangements when it came to splitting passengers' transportation costs.

Our research on equitable cost-sharing systems for ride-sharing falls under the umbrella of issues with network cost-



# HUMAN DISEASE PREDICTION AND DOCTOR BOOKING SYSTEM

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**Abstract**—Today, data mining is more important than ever in the healthcare and medical industries. When specific data mining techniques are applied correctly, important information can be obtained from large databases, enabling medical professionals to make quicker decisions and enhance patient care. The idea is to help the doctor by using the classification. Understanding how to correctly diagnose patients through clinical examination and assessment is essential. The health care industry generates a lot of information about clinical evaluation, patient reports, treatments, follow-up meetings, medications, and other topics. It takes careful orchestration to execute it well. Due to poor information management, the quality of the data association has been impacted. A legal method must be found to focus and process information in a viable and effective manner as data volumes increase. A classifier that can divide the data into groups based on attributes is built using one of the various machine learning applications. The data set is divided into at least two classes. These classifiers are used to analyse medical data and forecast diseases. This project aims to develop a portal for predicting disease according to the symptoms which is given by the user and an option for consulting doctor.

## I. INTRODUCTION

The creation and use of a number of well-known data mining techniques in a variety of real-world application fields (such as industry, healthcare, and bioscience) has resulted in the use of these techniques in machine learning environments to extract useful information from the target data in healthcare communities, biomedical fields, etc. The accurate analysis of medical databases aids in the early diagnosis of illnesses, patient treatment, and social services. There are numerous applications where machine learning techniques have been successfully used, including the forecast of disease. The goal of creating a classifier system utilising machine learning algorithms is to significantly aid in the resolution of health-related problems by supporting doctors in early disease prediction and diagnosis. But for a doctor, making an accurate forecast based on symptoms is too challenging. The hardest task is making an accurate diagnosis of a condition. Data mining is crucial in predicting the sickness in order to solve this issue.

The annual data increase in the medical sciences is substantial. The accuracy of medical data analysis, which has benefited from early patient care, has increased as a result of the rise of data in the medical and healthcare fields. Data mining uses disease data to uncover patterns that are hidden in

the vast volume of medical data. The most prevalent health conditions frequently have certain fundamental signs that people typically display. For instance, a person with a headache may also display a number of other disease symptoms. We rely on doctors in situations where we demand an immediate diagnosis. Based on the symptoms, a machine learning model can be created to predict the disease's type. Early disease identification and quicker diagnosis may be made possible by the model's predictions. Malaria, dengue, impetigo, diabetes, migraines, jaundice, chicken pox, and other ailments have a substantial impact on a person's health and can even be fatal if left untreated. The healthcare sector can make smart decisions by "mining" the massive database they already have or by identifying its hidden links and patterns. This problem can be solved using data mining methods like decision trees, random forests, and naive bayes. Therefore, using the rule set of the appropriate algorithms, we can create an automated system that can find and extract secret information about diseases from a history (diseases-symptoms) database.

## II. LITERATURE SURVEY

Disease prediction by machine learning over big data from healthcare communities, in this paper, they streamline machine learning methods to accurately forecast the onset of chronic diseases in areas with a high incidence of those diseases. They tested the updated prediction models using actual hospital data from central China that was gathered between 2013 and 2015. They use a latent component model to fill in the gaps in the data to overcome the challenge of incomplete data. They test various treatments for a localised, persistent cerebral infarction. They suggest a fresh multimodal illness risk prediction algorithm based on convolutional neural networks (CNNs), which uses organised and unstructured hospital data.

A relative similarity based method for interactive patient risk prediction, this study examines the patient risk prediction issue within the framework of active learning, with comparatively similar results. Active learning has been thoroughly investigated and successfully used to address practical issues. Active learning techniques are typically used to explore absolute questions.

Disease and symptoms dataset, this study identifies diseases based on symptoms and provides more information about the most frequently occurring diseases, including treatment

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# Personality Trait Classification Using CNN-LSTM Model

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**Abstract**—Cognitive base sentiment analysis for understanding the behaviour of the user on the basis of tweets posted by them in their social media has become a common technique nowadays. These techniques are not showing accurate result. In our paper we come forward with a hybrid based deep learning model called convolution neural network with LSTM to improve the efficiency of current technique. We classify the personality trait into 8 types they are introversion, extroversion, intuition, sensing, thinking, feeling, judging, perceiving. This type of method have shown better result in comparison with the existing system. This technology is helpful in recruiting people for various jobs. We also introduce the concept of audio to text conversion where user give their audio to the system and our system will tell the emotions based on given audio.

**Keywords**—Personality Trait, CNN, LSTM, Keras, Tokenizer, Deep Learning

## I. INTRODUCTION

Cognitive science deals with various emotions of the people on the basis of their tweets. Personality plays an important role in determining the individual. Personality of an individual can be judged from various parameters such as text, audio, video. CNN extracts the basic features of the sentences without storing the previous information. We introduce a technique which uses both CNN and LSTM technology to enhance the feature of existing system. The present system aims to classify user behaviour based on various deep learning models. We also introduce the concept of audio to text using the same CNN-LSTM model to improvise the existing system.

## A. RESEARCH STUDY MOTIVATION

Various studies have been conducted by the research scientist for personality detection. The personality trait is a classification problem where the user gives the input tweet as text and he gets the various emotions corresponding to the text he has given. The aim of this paper is to build a strong model for personality trait detection. We have categorized the various emotions as a pair like I-E, N-S, T-F, J-P. We classify the various tweets into this category. There is also provision for user to give their tweets in the form of audio and our system will detect the personality of individual based on the audio.

## B. PROBLEM BACKGROUND

Cognitive-based SA applications have gained popularity in recent years among online communities as a way to learn about people's attitudes and personality traits towards various topics, laws, and other

things. However, because it takes a lot of time to analyze text using the present techniques to find personality traits at such a speed because of the diversity of social media information. Therefore, it has become essential to automatically classify personality traits for use in social media content extraction and analysis. We have all seen a lot of research in the fields of text-based SA, lexicon generation, cognition, aspect-based SA, and visual SA. However, further study on cognitive-based social media is needed, with an emphasis on extracting and classifying personality features. Our suggested method can resolve both issues, but the current system cannot handle both audio and text transformation.

## C. RESEARCH PROBLEM

The present system for personality trait classification has limited number of models. These techniques uses old models and they need to be improved for improving the accuracy of the system. We treat personality trait as a classification problem and which need to be resolved for future. Furthermore we include the concept of speech to text where user will give his tweet in the form of audio and our training model will identify the emotion from that audio. Through this we show that our model is self sufficient to solve all kinds of transformation.

## D. CONTRIBUTION

1. Exploring LSTM model and capturing information from text and training it using CNN and storing it using LSTM.
2. We used SVM and conducted various test like logistic regression, decision tree, k nearest neighbour.
3. Our proposed system has showed very good performance and result in against of the existing system models.
4. The proposed system can help various companies to analyse the personality of their employees.
5. Furthermore we provide both speech to text as well as audio to text so there would be added benefit for users to use our system.

## II. REVIEW OF LITERATURE

In this section, a comprehensive study of personality trait classification. The study discusses various practices and approaches that have address the problem of personality prediction, and the methods that have been used for this purpose. Specifically, the literature focuses on machine learning approaches to personality recognition, and the following studies are reviewed in detail:



# HUMAN DETECTION SYSTEM USING IoT

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**Abstract** – Natural calamities do occur and they are unstoppable. Thousands of people killed as a cause of disaster like earthquake. These words aren't the headlines of the newspaper but such news come after the disaster destroyed the field. The disaster in the New York City at 'World Trade Center' claimed lives of more than 5000 people. It was said if survivors has been found and rescue earlier the numbers of victims have been lower. There is no end to the number of lives lost as the result of such disasters as landslides, collapsed tunnels and avalanches. This project aims to give a practical design to build the first and simplified version of a rescue robot which has to be active within disaster areas like collapsed buildings where rescue teams cannot operate due to a lot of technical difficulties, which is connected by a smartphone via IoT. It will better to utilize some technically efficient equipment to achieve such mission rapidly and effectively. Microwave radar sensor is used for the search and rescue of victims trapped under the rubble of collapsed building during the earthquake or other disasters. By advent of this system the world death rate as a cause of an earthquake may decrease to greater extent.

## 1. INTRODUCTION

Nowadays disasters are unpredictable. Natural disasters like floods, earthquakes and other geologic processes and manmade situations like bomb explosion, building collapse occur regularly and they cannot be predicted in advance to take necessary precautions. The change in atmospheric conditions and climatic changes are occurring in a rapid fluctuating manner. A disaster is a serious problem occurring over a short or long period of time that causes widespread human, material, economic or environmental loss which exceeds the ability of the affected people or community to cope using its own resources. Disaster risk management activities are designed to increase the resilience of people, communities, society and systems to resist, absorb, accommodate and to recover from and improve well-being in the face of multiple hazards. Activities for reducing and managing risks can therefore provide a way for building resilience to other risks. Most of the victims of earthquakes or other natural disasters in the world are trapped or locked under obstacles or rubbles or even under soil. There are systems which is used in disaster areas including detection of human presence using different radars. In the case of a disaster like earthquake the rescue operation is over a wide area under most

difficulties. In the proposed system a life sensor, which sensor is used in the field to detect human presence. The robot is controlled by a computer or remote control and it should move with substantial speed in all directions that the user desires. By using this system we can reduce the operation to the possible areas of human presence, detect of early, wasting time. Time is the fact that the survival life truly depends on. How much time can be reduced for an operation is an important factor of lives. Once a human target is located the system has to give an buzzer as well as a notification which may help to identify and localize the victim location as soon as possible.

## II. LITERATURE SURVEY

IoT based live human detecting robot for earthquake rescue operation, in this is paper they used the micro controller PIR, DC GEAR MOTOR, INTERNET OF THINGS (IoT), MAX 232 IC, this robot mainly built for the save sensor disaster here they have been connected PIR sensor to detect the presence of human or not they had used microcontroller pic 16f877a to make automation. Easy to the control with Bluetooth module were installed in it. From this they will get information.

Unmanned Vehicle to Detect Alive Human During Calamity, this is the paper they used ARM7 controller with a highly efficient low cost camera to capture image and detects human body through MATLAB Software using the Viola-Jones algorithm and a set of sensors like Pulse sensor and Temperature sensor will give the information regarding an alive human presence will give the information regarding an alive human presence. IR sensor is used in this project to avoid obstacles in its navigation path. An Unmanned vehicle navigates through the debris automatically to check the presence of human life and it display it through a Zigbee.

Human Detection Robot For Disaster Management, In this paper they used Arduino Uno Microcontroller, Robot Chassis, PIR (Passive Infrared) sensor for detecting the human presence and controlling the robot. In this they used a buzzer for alerting the presence It is a simple, yet efficient equipment to indicate casualties and help them with immediate access to first aid.

A Modern Microwave Life Detection System For Human Being Buried Under Rubble, in this paper the system utilizes L - Band frequency which is able to detect respiratory and heart fluctuations. The main operation principle is based on Doppler frequency of the electromagnetic wave it will be reflected from buried body.

In this paper titled, "IoT Based Rescue Robot for Alive Human Detection and Health Monitoring System" In this paper they used Arduino mega 2560 the main aim of the





# FACIAL RECOGNITION ATTENDANCE SYSTEM USING FLASK AND OPEN - CV

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**Abstract** Based on a person's distinctive facial traits, face recognition technology employs computer algorithms to identify and confirm them. The device employs a camera to take pictures of people, identifies them using facial recognition software, and records their attendance. Python and the free computer vision package Open CV are used to implement the technique. Face identification and feature extraction are only two of the many techniques for image and video processing that are available in Open CV. Python is a well-liked machine learning programming language that is frequently used to develop and apply facial recognition models.

## I. INTRODUCTION

This project's major goal is to develop a facial recognition-based attendance monitoring system for educational institutions in order to improve and modernize the current attendance system and make it more effective and efficient than it was previously. The existing outdated system is very ambiguous, which results in erroneous and ineffective attendance taking. When the authority is unable to enforce the rules that are present under the previous system, many issues occur. The face recognition system will be the technology at work. One of the natural characteristics that can be used to specifically identify a person is their face. The system uses facial recognition technology to correctly and swiftly identify pupils and mark their attendance, which is an improvement over the time-consuming and error-prone old techniques.

This project's major goal is to replicate a brand-new, cutting-edge smart system that can benefit the institution while resolving the problems with the outdated attendance system. In this project, a program will be created that can recognize each person's identification and eventually save the information in a database system. In addition, an excel file is made that lists the students' attendance and is sent right away to the esteemed teachers.

## II. LITERATURE SURVEY

Face recognition: A convolutional neural-network approach, IEEE Trans. Neural Networks, vol. 8, pp. 98-113, 1997. 2.1 S. Lawrence, C.L. Giles, A.C. Tsoi, and A.D. Back[1]. In this study, a face recognition system is created that is insensitive to significant variations in lighting. Histogram truncation was utilised as a pre-processing step before the implementation of the homomorphic filter in the second step of the normalisation

process. The fundamental tenet is that establishing illumination invariance leads to a feature extraction module that is simpler and has a higher recognition rate. Then, we used Fuzzy Linear Discriminant Analysis (FLDA) in the feature extraction stage, which demonstrated good discriminating ability in comparison to other methods and Feed forward Neural Network (FFNN) for classification. The ORL (Olivetti Research Laboratory) face picture database was the subject of the studies, and the findings indicate that the current method is superior to other techniques used on the same database and described in the literature.

"Face recognition based on fitting a 3D morphable model," V. Blanz and T. Vetter, IEEE Trans. on Pattern Analysis and Machine Intelligence, vol. 25, no. 9, September 2003 [2].

This study proposes a method for face recognition under a variety of lighting conditions, such as cast shadows and specular reflections, and in poses ranging from frontal to profile views. The method, which estimates 3D shape and texture of faces from single photos, replicates the process of image production in 3D space using computer graphics in order to take these differences into account. A statistical, morphable model of 3D faces is fitted to the photos to provide the estimate. A collection of textured 3D head scans is used to train the model. We go over how the morphable model is made, an approach for fitting the model to images, and a framework for face recognition. Faces are represented in this framework by model parameters for 3D shape and texture.

"RFID-based Student Attendance System" established by Hussain, Dugar, Deka, Hannan in 2013 [3]. This paper describes the use of open-source software in a multi-user environment to construct a student attendance management system based on radio frequency identification. Python serves as the system's back-end for reading tags. The python program is run, the lecturers are authenticated, and tags are recorded in an XML file using a desktop Java application. The XML file is then uploaded to the server to be processed and used to interpret student attendance. By using the web portal, users can view attendance.

The phrase "Fingerprint Based Attendance System Using Micro-controller and Lab-view" (2015) Kumar Yadav, Singh, Pujari, and Mishra [4]. In this context, research prospects are outlined together with an automated system for recognizing fingerprints and the identification of major problems. This report's description of an RTOS (Real time operating system) implementation in the context of an embedded system reads like a product design. Despite being very common, fingerprint recognition is a challenging pattern recognition problem. It is quite challenging to create precise algorithms that can extract



# The Paw Project

## A Mobile Application for Identifying Stray Dogs

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**Abstract:** The PAW PROJECT is a veterinary and pet care android application intended for pet lovers and owners. Now a days pet owners are increasing abundantly. This app will help us to find whether a dog is vaccinated or not and thus by identifying this a dog can easily get vaccinated with the help of nearby pet clinics both private or government named. Another important feature of this app is to get the locations of stray dogs which connects with those who love to adopt and also with pet caretakers. THE PAW PROJECT, as described above, creates an error-free, secure, reliable, and fast system. It can assist the user to concentrate on their activities rather than concentrate on record keeping. Thus, it will help organizations in better utilization of resources. The organization can maintain computerized records without redundant entries. The project is executed in three modules (1) Admin module (2) User module (3) Database. The admin module manages the entire content of the system.

**Index Terms** – stray dogs, rabies, mobile application, sterilization

### I. INTRODUCTION

At present the number of stray dogs in India is increasing at a continuous rate as per the current record of animal welfare organizations. The overpopulation of stray dogs has become one of the major threats to the citizens of India. It has been reported that around 92-97% of death due to dog bites have been reported in India. Zoonotic pathogens which are usually found in dogs are mainly transmitted by stray dogs.

A stray dog is defined as any dog that roam around in a public area that had no human control over it. These are dogs that are either owned in the past or never be owned. According to a recent estimate, there are over 17.14 million stray dogs in India [6].

A recent study has shown that people are less bothered about the available applications and 90% of the people never

used it once [1]. There are so many functions that are available nowadays to track stray dog and their attack patterns such as GPS, Surveillance Camera, and video surveillance algorithms. Our approach is based on existing infrastructure to make the manual process easier by making it a computerized system for uploading pictures and details of the dog. Providing the facility to the users that can upload pictures and get details of the dogs and also adopt them. This process is computerized and the details of the user who uploads the pictures of stray dogs are stored in the system. The user can view the details about the dogs in the Android app.

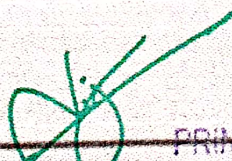
There has been a rapid growth in the number of people who own pet dogs due to the low birth rates, the increasing aging population, and the increasing number of single-person households. As we know there is a wide range of pet care applications available in the marketplace.

Pet tech includes not only robotized litter boxes, automatic food dispensers, and remote-control toys to play with your pets. Here our project focuses more on stray dogs as they are increasing rapidly in our society day by day. The paw projects a unique initiative about which a true passionate animal lover would have certainly dreamt while trying to save/help an injured/helpless stray dog in need. This platform will connect you to a relevant person/resource in real-time.

### II. BACKGROUND AND RELATED WORK

#### A. STRAY DOGS IN THE COMMUNITY

As we know stray dogs are increasing day by day in our society. The free-ranging and roaming dogs are called stray dogs. They are found in most of the cities, especially in developing cities. Stray dogs are increasing because of the abandonment nature of the owner. They are of different classifications such as pure breeds, true mixed-breed dogs, or unbreed. The major problem caused by stray dogs is Rabies and Dog Bites both affect the quality of living.



PRINCIPAL





# Human Pose Estimation Using AI/Machine Learning Algorithms

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**Abstract** - Human pose estimation localizes body points to accurately identify individual poses given an image. This step is a prerequisite for many tasks in computer vision, including human recognition. This article contains an overview of the Human pose estimation techniques using machine learning and also proposed an AI-based system which can work as a personal fitness advisor. It is based on an algorithm that looks at your exercise chart in real time and tells you what's right and what's wrong! The methods used in human estimation are briefly described before listing some of the applications and problems encountered in estimation. Next, focus on briefly discussing the research that has had a major impact on human prediction, and examine each new model, motivation, architecture, process (policy work) and its advantages and disadvantages, the data used, and the methods used for evaluation. metrics for the model. This review serves as a foundation for novices and guides researchers to discover new trends by examining methods and architectural flaws in current research.

**Keywords**— *sklearn library, convolution neural network (CNN), machine learning.*

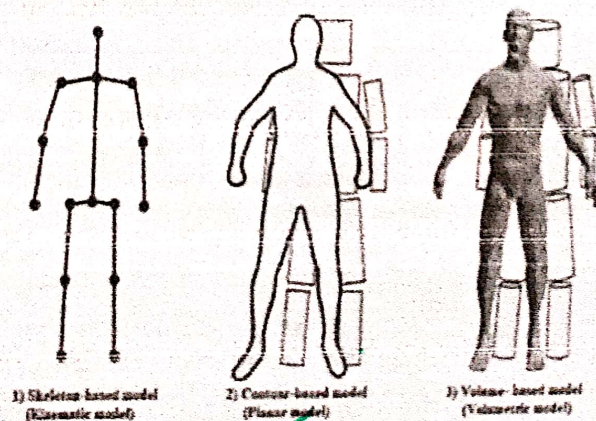
## I. INTRODUCTION

Human Pose Estimation (HPE) is a technique used to identify and classify the joints in the human body. HPE is a computer vision technique to capture a set of coordinates for each joint (head, neck, arm, limbs, torso, etc.,) and these coordinates are referred to as a **keypoint** that can be used to describe a pose of a person. The connection between these key points is termed as a **pair**.

Exposure detection is an active area of research in computer vision. Exposure estimation is a computer vision method used to track the movement of a person or object. Finding keywords for a product usually does this. Based on these key points, we can compare various actions and form and draw predictions. HPE is often used in augmented reality (AR and VR), animation, games, healthcare, Online coaching/training, surveillance and robotics.

The aim of Human Pose Estimation is to form a skeleton-like representation of a human body. There are three models of Human pose estimation and are used to represent the human body using computer vision.

1. Skeleton-based model or Kinematic model
2. Contour-based model or Planar model
3. Volume-based model or Volumetric model





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**Abstract**— Mobile phones have become a very important aspect of human life. From making cellular calls to money transactions, nowadays, people mostly use smart phones, which work very efficiently in the sense of network connectivity such as 4G, 5G, Bluetooth connectivity, WIFI, etc. Around 70% of people use android-supported systems. Whereas Android is vulnerable to attacks, viruses, and other malicious contents compared to other OS's such as Apple's iOS, smartphones are vulnerable nowadays. "security is a myth" in networks. Security is thus essential for android systems. The proposed system is an SMS-based remote mobile recovery system. The system proposes an Android-based application that allows the client to retrieve contacts, locate the system that is misplaced, change the sound profile of the system, lock the system if it is misplaced. This could be done using other cell phone, which does not require an internet connection.

**Keywords**—SMS, recovery, smartphone, retrieval

## 1. INTRODUCTION

Nowadays, smartphones play an important role in one's life, as they control the most important aspects of a human being's life. It has multiple access points to one's daily life categories, such as personal life and banking aspects. So there are many important contents for a person stored in it, such as his or her banking credentials, valuable documents, etc. So it is very important to protect these users information. The proposed system is an SMS-based recovery system. That is, the system is an application for Android users. Most people use Android, as it has a much simpler interface and is also affordable also. But when it's compared with other OSes such as Apple's iOS, the security features of Android are pretty weak and

  
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# *Road Accident Prediction using Deep learning*

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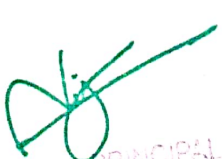
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**Abstract**—A database of the traffic accidents was organized and analyzed, and an intersection accident risk prediction model based on different mechanical learning methods was created to estimate the possible high accident risk locations for traffic management departments to use in planning countermeasures to reduce accident risk. Using Bayes' theorem to identify environmental variables at intersections that affect accident risk levels, this study found that road width, speed limit and roadside markings are the significant risk factors for traffic accidents. Meanwhile, Naïve Bayes, Decision tree C4.5, Bayesian Network, Multi-layer perceptron (MLP), Deep Neural Networks (DNN), Deep Belief Network (DBN) and Convolution Neural Network (CNN) were used to develop an accident risk prediction model. This model can also identify the key factors that affect the occurrence of high-risk intersections, and provide traffic management departments with a better basis for decision-making for intersection improvement.

**Keywords**— Byes' theorem, Deep Neural Network (DNN) and Convolution Neural Network (CNN)

I. INTRODUCTION (Heading 1)

A high accident risk prediction model is developed to analyze traffic accident data and identify them priority intersections for improvement. A traffic accident database was organized analyzed. An Intersection Crash Risk Prediction Model Based on Different Machine Learning methods for estimating potential high accident risk locations for traffic management have been developed department to use in planning countermeasures to reduce the risk of accidents. Using Bayes theorem identify environmental variables at intersections that influence the level of crash risk, this study found that the width of the road, the speed limit and the markings along the road are significant risk factors for traffic accidents. Meanwhile, Naïve Bayes (NBD), Deep Neural Networks (DNN) and Convolutional Neural Networks (CNN) were used to develop the accident risk prediction model.

This model can also identify key factors that influence the occurrence of high-risk intersections, and provide operations management departments with a better basis for decision-making intersection improvement. Using the same environmental characteristics as high risk intersections for model inputs to estimate the level of risk that may occur in the future, which can be used to prevent traffic accidents in the future. In addition, it can also be used as a reference for future intersection design and environmental improvements. In practical applications, our proposed model can be used to predict probability (or "risk") accidents at different intersections by identifying similar environmental variables, ie it enables authorities to take practical steps to effectively reduce incidence and severity accidents together with the costs associated with such accidents. In addition, research results identify important environmental factors that influence the occurrence of traffic accidents. To effectively reduce the risk of accidents, in recent years traffic accident management agencies in countries around the world not only have established standards and operating procedures for road surveys, but also sought to develop accident risk analysis and forecasting methods. The it hoped that longitudinal crash data would be used to identify and classify high-risk ones intersections, allowing efficient prioritization of scarce resources to minimize frequency and severity of traffic accidents.

II. LITERATURE SURVEY

	data mining techniques	R. Bhuvaneshwari, R.	traffic injury	ISSN: 2278-0181
			Expensive	Conference Proceedings
2	Accident avoidance system using IR transmitter	Adnan Bin Faiz, Ahmed Imteaj, Mahfuzulhoq Chowdhury	Uses the alarm pulses and vibration system as the first level of safety	The smartphone's sensors could provide false data sometimes
3	Android application for automatic Accident detection	Dnyanesh Dalvi, Vinit Agrawal, Sagar Bansod, Apurv Jadhav, Prof. Minal Shahakar	It is integrated with multimodal alert dissemination	Slow in responding
4	Accident detection and reporting system using GPS,GPRS and GSM technology	Md. Syedul Amin, Jubayer Jalil, M. B. I. Reaz	Capture the location of vehicle accident	Limited rate of data transfer
5	Real time traffic accident detection system using wireless sensor network	Hossam M. Sherif, Hossam M. Sherif, Samah A. Senbel	Long distance data collection and transmission	It cannot be used for high speed

Table 1: Literature survey of accident prediction model

III. RELATED WORKS

The rapid development and wide application of computer technologies, computer network technologies, multimedia and communication technologies, and the Internet of Things fields [1], has driven the recent development of intelligent road traffic management systems [2]. Li et al. The Internet of Things allows for the collection of various kinds of information through sensors [3], each of which represents an independent information source [4] from which data is collected at a certain frequency for categorization and analysis. Each independent information source would sense, measure, capture and transmit information anytime and anywhere. The development of advanced chip design and new materials have also increased the utility and longevity of such sensors [5], while also allowing for anti-interference, multi-mode, and self-adapting features [6].

These developments provide the technological basis for intelligent expressway management systems, integrating Internet of Things applications due to the introduction of mass information compatibility. High-speed wired and wireless networks have been integrated to create three-dimensional connections, ensuring the accuracy of data information, wider transmission bandwidth, higher spectrum utilization, more intelligent access, and more efficient network management [7]. The development of these advanced technologies mainly depends on NGN (Next Generation Network) communication network technologies and new wireless communication networks (3G, 4G, ZIGBEE) [8]. Expressway construction and traffic is rapidly growing around the world, and the demand for social development is growing synchronously [9].

Improving the efficiency of existing expressway traffic infrastructure requires the effective collection and analysis of usage data [10]. As cars and individual drivers are increasingly linked to wireless transmissions, drivers demand increasingly sophisticated traffic information, allowing them to assess current local traffic and driving conditions, predict future conditions, and identify optimal driving routes [11]. Expressway traffic management agencies also need to effectively monitor highway conditions and coordinate timely emergency response including police, rescue and repair units [12].

The data to drive such coordination is sourced from sensor networks that monitor traffic and environmental conditions throughout the highway network. Such monitoring data can be used to improve and simplify signal control algorithms and traffic efficiency. Wireless sensor networks can be applied to control subsystems and guidance the execution subsystem and to improve signal



# Mask and Helmet Recognition based on Machine Learning for ATM Security

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**Abstract**— ATM plays an important role in modern economic activity. Unfortunately, it provides a convenient way for criminals to get illegal money. For safety reasons, each ATM is equipped with a surveillance system to record customer's face information. When criminals use the ATM to withdraw illegal money, they usually hide their faces with something to avoid the surveillance system recording their face information. Due to this the efficiency of the surveillance system is decreased. In this project the process of ATM transaction will be finetuned so that a person can't proceed in the transaction without removing the mask and helmet. With each transaction the image of the person along with the transaction details will be stored.

**Keywords**—Helmet; mask; Machine learning; Image processing

## I. INTRODUCTION

According to today's world, pollution, infectious diseases, and climate change are all having an impact on humans. Wearing a mask in public places has become a need for people to avoid these issues. Thieves and intruders may use circumstances to their advantage so they can commit crimes without being seen on cameras and CCTV. Many people use ATMs to withdraw cash while hiding their faces. These actions lead to miscommunication between the customer and the bank. The proposed approach uses machine learning, and OpenCV used to detect face masks, which is resource efficient and can be used in embedded devices. The technique has an accuracy score of 0.9264 and an F1 score of 0.93, which can be used for further advanced models. Face recognition is a biometric technology used to authenticate individual identities. It involves two phases: face detection and recognition. Face detection and recognition technology has become increasingly important in our lives, making life easier and faster and adding a touch of technology fun. Sensors can be combined with many technologies to form smart sensors, but early vision measurement technology is expensive, has low performance indicators, and has high failure rates. Processing efficiency is not high. Face Detection is a part of computer technology and AI. It determines the positions and sizes of human faces in arbitrary video and images. It is used in a variety of application that identifies the human face with the help of regular web camera, human face by identifying the face location identifies by matching digital images present in Database. It is a simple technology for face perception and Human Machine

interaction. This can be seen in technical foresight. So, we have to be securing, to catch thief, to find someone who loses, and more. It has become a popular subject of lookup due to demand for protection and the rapid improvement of cellular devices. It can be used to gain access to control, identity verify, security surveillance systems like atm. To solve the Atm security problem, it is important to show the person's face in the bank ATM camera when they conduct an ATM transaction. Image processing will be used to accomplish this, and the system will be able to distinguish between those wearing masks and helmet.

The basic idea behind the paper is to develop a system which is automated and provides the most advanced security features in places like ATM. The paper aims to give access to ATM's for only those who follow the rules of the ATM usage that is preventing access to ATM for those wearing helmet. Background Subtraction Algorithm is used for identification like carrying any weapon, wearing helmet and mask identifications. To solve this problem, we try to promote cameras in atm that gives an alarm if they detect someone with helmet or mask. They can only enter the ATM after removing their helmet and masks. This way we can easily read the faces of people and store in our database. This atm camera also makes sure that the transaction is not carried out until the person removes the helmet or mask.

## II. RELATED WORK

Use a technique like TensorFlow and Open CV to detect face masks on humans. When a face is found, a bounding box is drawn around it to determine whether the person is wearing a mask or not. The name of the person who is not wearing a mask will be discovered if their face is saved in the database, and an email warning will be sent and images will be stored in cloud [1]. A face detection technique utilizes a single shot multibox detector and a mobile device called MobileV2 that is small and can be integrated to detect real-time masks. The entire procedure is referred to as SSDMNv2. This method is used to evaluate the accuracy, which is 0.9264, and the F1 score, which is 0.93[2].

The model is separated into two phases: the first phase detects faces, with the exception of situations where the item is held at a distance, and the second phase detects faces as individuals. The procedure is repeated with assistance from the face model utilized in biometric technologies today [3].



# Credit Card Fraud Detection using Machine Learning

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**Abstract**—The usage of credit cards for online purchases has grown significantly as a result of the E-Commerce sector's explosive growth, and as a result, there has been an increase in fraud associated to it. In recent years, it has become exceedingly challenging for banks to identify credit card system fraud. For transactions to be free of credit card fraud, machine learning is essential. Banks utilise a variety of machine learning approaches to forecast these transactions. Past data has been gathered, and new elements have been added to increase the predictive power. The choice of variables, sampling strategy for the data set, and detection methods all have a significant impact on the effectiveness of fraud detection in credit card transactions. The study examines the effectiveness of decision trees, random forests, and logistic regression for detecting credit card fraud. 2,84,808 credit card transactions from a European bank are included in the dataset of credit card transactions that was obtained from Kaggle. It views fraudulent transactions as belonging to the "positive class" whereas legitimate ones are in the "negative class." Based on sensitivity, specificity, accuracy, and error rate, the performance of the approaches is assessed for a variety of factors.

**Keywords:** Fraud detection, Credit card, Logistic regression, Decision tree, Random forest.

## 1. INTRODUCTION

To provide e-commerce, information, and communication services to their clients more effectively and more conveniently, businesses and organisations are shifting some or all of their operations online. Worldwide, there is a significant issue with payment card fraud. Annual losses from fraud are enormous for businesses and institutions, and criminals are always looking for new ways to engage in unethical behaviour. We'll strive to spot any fraudulent activity here. When a credit card is cloned, stolen, lost, and found by fraudsters, it is typically utilised up to its available credit limit. Therefore, a solution that reduces the total available limit on cards susceptible to fraud is more important than the quantity of correctly classified transactions. It uses a genetic algorithm to minimise false alarms by optimising a collection of interval-valued parameters. Generally speaking, fraud is unapproved conduct that occurs in electronic payment systems; this activity ought to be prohibited by law and is treated as unlawful. In many diverse fields, including financial systems, telecommunications, and public and private services, fraud can occur. It is focused on identifying fraudulent credit card transactions and is concerned with financial scams. The

classification challenge of fraud detection has been addressed by numerous data mining algorithms using some statistical techniques, more common among decision trees. Fraud detection has typically been a part of data mining and e-commerce. It optimises a group of interval-valued parameters using a genetic algorithm to reduce false alarms. In general, fraud is unapproved behaviour that takes place in electronic payment systems; this behaviour should be illegal and outlawed by law. Fraud can happen in many different industries, such as financial systems, telecommunications, and public and private services. It is concerned with financial fraud and focuses on recognising fraudulent credit card transactions. Numerous data mining algorithms that employ some statistical techniques have been developed to address the classification challenge of fraud detection, more prevalent in decision trees. Data mining and e-commerce have traditionally included fraud detection.

## 2. LITERATURE REVIEW

Fraud is defined as an illegal or criminal deception meant to produce a monetary or personal profit. It is an intentional action that violates a rule, legislation, or policy with the intention of obtaining unrecognised pecuniary benefit. There is a wealth of publicly accessible material on the topic of anomaly or fraud detection in this field that has already been published. Data mining applications, automated fraud detection, and adversarial detection are among the strategies used in this field, according to a thorough review undertaken by Clifton Phua and his coworkers. Suman, a research scholar with GJUS&T at Hisar HCE, discussed methods for detecting credit card fraud, such as supervised and unsupervised learning, in a different study. Even though some of these techniques and algorithms achieved unexpected success, they were unable to offer a reliable, long-lasting answer to fraud detection. Wen-Fang YU and Na Wang presented a similar area of research in which they employed distance sum algorithms, outlier mining, outlier detection mining, and outlier detection mining to precisely forecast fraudulent transactions in an experiment simulating credit card transaction data from a particular commercial bank. Data mining's field of outlier mining is primarily utilised in the financial and internet sectors. It focuses on identifying detached objects from the main system, or transactions that aren't real. The distance between the observed value of an



# Sign Language Translator: A hand gesture recognition device using Arduino

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**Abstract**— The sign language translator explores an innovative solution for conveying one's thoughts where individuals are incapable of speaking, specifically by translating hand gestures into voice. This approach is primarily intended to assist individuals who are deaf or have difficulty speaking, and is accomplished through the use of gloves fitted with flex sensors that capture data on finger and hand movements. This data is then processed by a microcontroller to generate voice feedback. Existing systems used for sign language translation involve devices with high energy consumption and less mobility. Although these systems allow for sign recognition with high accuracy they cannot be accessed by most people and the receiving end should be independent such that any user is able to get voice feedback.

**Keywords**—Arduino, Hand Gesture, Voice Feedback, C++

## I. INTRODUCTION

Speech-impaired and hearing-impaired people only use the sign language as their principal means of communication. However, this becomes problematic to people who are not familiar with the different gestures of the sign language, thus creating a communication barrier between the impaired and not. Sign language doesn't use acoustic sounds but visually transmitted sign patterns.

By simultaneously combining hand shapes, orientation, movement, and facial expressions, this can be used to express the speaker's thoughts and it carries as much information developed and researched by various scholars globally. Despite these, there hasn't been a solid and concrete process in which the translation is from text or speech to the ASL gestures thus suggesting a one-sided approach on the matter. Many other existing gesture recognition solutions rely on cameras, microphones, radio frequency (RF), or special body sensors such as Electromyography (SEMG), Electrical Impedance Tomography (EIT) sensors, and electrocardiogram (ECG) sensors. However, these methods have various limitations. For example, camera-based approaches may face occlusion and privacy issues, while microphones are susceptible to ambient acoustic noise. RF-based methods are known to be device-free, but they can be sensitive to indoor multipath effects or RF interference. On the other hand, special body sensors for gesture recognition are more robust to environmental noise, but they require additional cost and manpower for installation. Sign language gestures are particularly challenging to detect as they often involve finger-level movements without significant wrist or arm motion.



# VISA PROCESSING SYSTEM USING NODE JS

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**Abstract**—The objective of this study is to evaluate the chance of visa approval based on the information that has been given. Visa processing is a time-consuming and complicated procedure that includes several steps such as verification of documents, criminal record investigations, and risk evaluation. Technology has been extensively used in recent years to automate and simplify visa processing, leading to more rapid, precise, and more affordable processing.

**Keywords**—H1B Visa, Machine Learning, Classifier, Node.js

## I. INTRODUCTION

Visa processing with Node.js involves using the popular JavaScript runtime environment to develop software applications that can automate and streamline visa processing tasks. Node.js is known for its fast and scalable nature, which makes it well-suited for handling large volumes of data and traffic, making it an excellent choice for visa processing.

Node.js can be used to develop server-side applications that handle various visa processing tasks, such as document verification, background checks, and risk assessment. Node.js can also be used to build user interfaces and frontend applications that interact with visa processing APIs, making it easier to create and manage visa applications.

One of the primary advantages of using Node.js for visa processing is its ability to handle multiple concurrent requests in real-time, making it possible to process visa applications quickly and efficiently. Additionally, Node.js has a rich library of modules and packages that can be leveraged to build robust and reliable visa processing applications.

Overall, Node.js provides a powerful and flexible platform for developing visa processing applications that can improve the efficiency and accuracy of the visa application process. With its ability to handle large volumes of data and traffic, Node.js is an excellent choice for governments and immigration authorities looking to modernize and streamline their visa processing systems.

## II. RELATED WORKS

There are several related works and projects that have been developed using Node.js for visa processing. Here are a few examples:

A. VisaHQ: VisaHQ is a leading visa processing company that has developed a Node.js-based platform to automate visa processing for individuals and businesses. The platform leverages the strengths of Node.js to provide a fast and reliable visa processing experience.



PRINCIPAL





# VOICE BASED INTELLIGENT VIRTUAL ASSISTANT FOR WINDOWS USING PYTHON

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**Abstract**—In this paper, Voice intelligent Assistance tool is used for searching purposes, summary extraction, setting reminders just by using voice commands. Voice recognition technology allows us to access any document or file we desire. If the user spells out the word it automatically types in the required field. It recognizes the speech and searches the appropriate content in the database and retrieves it. The audio from the microphone will be collected by this voice assistant, which will subsequently translate it into text. To ensure that the virtual assistant can comprehend them, the user should choose the proper language. If any wrong or invalid communication happens it invokes some messages in dialog box. It is a software application which performs tasks and events based on commands. Voice-Command and speech synthesis are enhancing the level of user-interaction in applications. This intelligent personal assistant (IPA) can interact with the user by opening a report, providing a brief summary via speech-to-text, and outlining the most crucial details in the appropriate context. Here, an attempt is made to build an intelligent voice personal assistant using Python, which offers the ability to control voice-activated devices and speech-activated smart devices for information extraction. NLP (Natural Language Processing) helps the virtual assistant to understand and respond to human speech and based on the voice commands the tasks are performed. BERT is designed for the computers to understand the meaning of ambiguous language.

**Keywords**—Virtual Assistant, Speech Recognition, Extractive summarization, BERT

## I. INTRODUCTION

The virtual assistants have become an essential component of our life nowadays as a result of all the functions and simplicity they provide. They can also automate some routine duties so that a user can concentrate on what is most important to them. A voice assistant is a digital assistant that uses speech synthesis, voice recognition and natural language processing (NLP). The software that can identify human voices and respond using an integrated speech system is known as a desktop-based voice assistant. A voice-based personal assistant is a helpful tool for searching, setting reminders, and

taking notes just by speaking. Therefore, making use of these virtual assistant capabilities will enable one to save a lot of time and work. Everyone wants an assistant these days that will listen to their calls, anticipate their requirements, and take the appropriate action when necessary. The command open can be used by the user to launch any other application. The voice assistant records vocal input through a microphone and converts it into understandable computer language to give the user the information and answers they require. Keeping track of test dates, birthdays, or anniversaries is another challenging endeavor for most of the people. To solve this problem, the voice based virtual assistant helps to generate reminders. Therefore, making use of these virtual assistant capabilities will enable one to save a lot of time and work.

## II. LITERATURE SURVEY

[1] A multi-functional Smart Home Automation System (SHAS) that can adapt to a user voice and recognize spoken instructions regardless of the speaker individual features, such as accent, was proposed by Yash Mittal. This system is affordable since processing and control are handled by an Arduino microcontroller board. Thus, the Smart Home Automation System (SHAS) prototype can be utilized to transform current homes into smart homes. [2] Home Automation Using Voice Commands in the Hindi Language. The voice recognition module and dedicated hardware, the Arduino Uno, were used in the planned home automation in Hindi language project to increase the system robustness and cost-effectiveness. The system can operate with several linked devices, such a lamp, fan, air conditioner, etc. With the use of voice assistants, this technology enables users to make decisions and control their home equipment. [3] In recent years, due to the progress of information technologies, the homes are built to smart homes. Smart home style can bring benefits to user, the technology becomes unavoidable in these years. Even enterprises still cannot integrate the functional divisions of smart home. Consumers struggle to find the products they require. In this paper, it builds a tailor-made function for users without their attempt; it makes use of Google Voice recognition in the house using machine learning to demonstrate the viability of a smart home pattern in order to meet user needs. This enabled user to interact with Google Home's voice recognition system while controlling devices by sending a Bluetooth signal to the Raspberry Pi. [4] Recent



# VEHICLE LICENSE PLATE RECOGNITION USING DARK CHANNEL PRIOR ALGORITHM

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**Abstract**—Automatic license plate recognition and its use in many automotive applications make this process very easy. However, it can be very difficult to verify the vehicle license number, especially in some foggy areas. This is because the lines and symbols on the plate are deformed due to bad weather conditions and the plate becomes unreadable. To this end, this study provides a method for verifying license plates in the dark (LPRFH). A dark based method has been used in the past to remove blurry images for license recognition purposes. After additional de-blurring of the image, the license area is detected using a combination of de-blurring and area subtraction models based on known convolutional neural networks. Use a convolution-rich, super resolution convolutional neural network to generate a high resolution image and make it easier to distinguish license plates. The results are 95% accurate and up to date. Many studies have proven that these plates can be trusted to read plates even in the most extreme weather, weather and atmospheric conditions.

**Keywords**—Object Detection Convolutional Neural Network (ODCNN), License Plate Recognition Method for Fog Haze, Dark channel prior algorithm

## INTRODUCTION

Due to the rapid growth of the economy and the further expansion of cities, transportation has become an essential part of modern civilization. Intelligent Transportation Systems (ITS) claims to provide traffic management and transportation related services to easily manage large vehicles. Every vehicle in the world has a vehicle license number as an identifier and important steps for ITS. This license verification method is fully automatic. Therefore, in a foggy environment, a smart transportation vehicle cannot recognize a vehicle license. License Plate Recognition (LPR) technology allows automatic vehicle identification. It is important to remember that certain environmental conditions (such as weather, lighting levels) can affect the visibility of the vehicle's license photo from the security cameras. Fog really distorts the lettering and framing of the license, making it difficult to see and recognize the license, especially when the fog is more severe. Most current license plate authentication algorithms rely on removing features. Due to the effects of smoke and blur on the image, the vehicle plate cannot be recognized based on these events. Cognitive behavior also affected by the fog effect.



Fig 1: Vehicle license plate in fog environment

The frame provided by LPRFH technology includes resolution technology and image de-blurring technology. Object Detection Convolutional Neural Network (ODCNN) is the basis of the image hazing technique. Super resolution convolutional neural network is the basis of super resolution technology. The first is the dark channel before the process based on local estimation of atmospheric light. This value is initially used to de-blur the image. To reduce image backup distortion caused by the accumulation of many errors, images are further de-blurred and then license plate is extracted from these enhanced images using an object detection convolutional neural network. Finally, the improved SRCNN technique with six layer convolution for super resolution images improves the accuracy of license plate identification. Note that the detection Conv Nets in our study were trained on real and synthetic images, but SRCNN was trained on synthetic images as it collects invisible images of vehicles in motion from the environment.

## CHALLENGE

S

There are still various problems with automatic license plate recognition systems. The most common challenge they face is the non-uniformity of license plate number models for different cities and countries. Their length may also vary. That's why the software must be customized to the place it's being used in.

## RELATED WORKS

It was discovered that there are fewer accurate methods in the area based on the many strategies employed over the years.



# Enhancing Security of Industrial Internet of Things Against Botnet Attacks through Hybrid Deep Learning Methodology

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**Abstract**—The Industrial Internet of Things (IIoT) has transformed the manufacturing industry by enabling intelligent inter-connected devices and driving digital innovation. However, the distributed nature of IIoT, Industrial IoT sensing devices, IIoT convergence, Edge Computing, and Time sensitive Networking also make it a prime target for cyber-attacks. Multi-variant and persistent bot attacks are particularly devastating for IIoT systems, and detecting them is both complex and critical. To address this challenge, I propose a hybrid intelligent mechanism that leverages Deep Learning (DL) to protect IIoT infrastructure from sophisticated botnet attacks. The proposed solution has been rigorously evaluated using the latest datasets, performance metrics, and DL benchmark algorithms, achieving a detection rate of 99.94 and an impressive speed efficiency of 0.0066/ms. The results demonstrate the effectiveness of our approach in accurately identifying and mitigating multi-variant bot attacks, providing much-needed security for IIoT systems. To ensure the security of heterogeneous IIoT devices and generated traffic, existing solutions for identifying cyber threats and attacks predominantly rely on pre-defined signature vectors for pattern matching, also known as signature-based detection.

**Index Terms**—IIoT botnet detection, deep learning (DL), Internet-of-thing (IoT), network security.

## I. INTRODUCTION

The Industrial Internet of Things (IIoT) is rapidly growing and becoming integral to our daily lives. It is revolutionizing various industries, generating massive amounts of data for analytics and decision-making. By 2025, it is estimated that around 75 billion IoT devices will be connected. However, the heterogeneity of devices and data transmission, along with resource constraints, make IIoT vulnerable to cyber threats. Attacks like phishing, DoS, MITM, and Botnet can compromise the entire system, with Botnets being particularly dangerous. Current solutions rely on signature-based detection, which is insufficient for dynamic IoT infrastructure and zero-day threats. A hybrid DL-driven intelligent threat detection mechanism is proposed to address these challenges, combining deep learning algorithms with signature-based detection for real-time detection of unseen threats. This approach aims to provide a comprehensive solution to the security concerns of IIoT systems.

## II. RELATED WORK

### A. Reinforcement learning in blockchain-enabled IIoT networks

Reinforcement learning (RL) techniques have shown great potential in addressing some of the major issues faced by blockchain-enabled IIoT networks, such as block time minimization and transaction throughput enhancement. However, there are several challenges and open research questions that need to be addressed, such as the energy-constrained nature of IIoT devices, scalability paradox, and anonymous data sharing. Additionally, there is a need for further research to explore the applicability of Reinforcement learning techniques in blockchain-enabled IIoT networks, and to develop novel solutions that can improve the performance, security, and efficiency of these networks. Overall, the insights and results provided in this work could pave the way for the rapid adoption of blockchain technology in IIoT networks, but more research is needed to fully realize its potential.

[1].

### B. A secure industrial internet of things (IIoT) framework for resource management in smart manufacturing

The SoftMax-DNN algorithm is used to optimize resource scheduling and to make efficient use of available resources in the IIoT framework. Improved RSA techniques are applied to ensure secure transmission of data between devices. The algorithm aims to reduce process delays and improve the use of resources to achieve optimal planning goals. The proposed algorithm achieves the lowest latency, the lowest energy consumption, and the highest network lifetime. Overall, this work presents an efficient and secure approach for IIoT resource scheduling and data transmission. [2].

### C. An ensemble deep learning-based cyber-attack detection in industrial control system

The proposed attack detection model utilizes a deep learning approach with a combination of DNN and DT classifiers to detect cyber-attacks. The model also includes a deep representation learning component, which constructs new balanced



# Security Model for the privacy of Big Data in Health Care Cloud using Fog Computing

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**Abstract**—E-medicine is one of the new areas of e-health study. It is the distribution of health-related services and information via electronic information and telecommunication technologies. Electronic medical records, including medical big data, MBD, pictures, and interactive medical records, are relayed through insecure Online communications, as advised by distant doctors, in the E-medicine. Electronic Medical Records (EMR) must be stored with large amounts of data on the Medical Data cloud to provide effective access and facilitate mobility between health advisors and patients. Clinical-service Edge computing has various issues related to its security. As a result, we have put forth an approach that employs DMBD to safeguard Medical Big Data in the healthcare cloud. This method involves utilizing edge networking device plus pairing PKCs depending on cryptanalysis. Utilizing Pairing Based Cryptography(PBC)s for the storage and retrieval of MBD in the cloud, session keys will be created to ensure secure communication between participants. The use of a fog computing facility has focused on the secure storage of healthcare private data in the cloud.

**Index Terms**—Medical Big Data, Fog Computing, Pairing Based Cryptography

## I. INTRODUCTION

Telemedicine includes the use of communication networks and digital solutions in providing health services and its popularity is increasing nowadays. Telecare aims to deliver healthcare services that are on par with in-person treatment in terms of quality. Its primary goal is to provide cost-effective medical services while also alleviating the pressure on healthcare systems. The ease of managing and tracking patient information is a benefit of healthcare cloud computing. However, this technology also poses security concerns that must be dealt with. Lack of transparency is also a consumer issue, which may come to light when consumers do not know where their data are physically kept or what will happen to them. Moreover, cyber security also poses a cloud security problem. Information input, information, and command output, sharing of property and physical infrastructure have all been identified as cyber security challenges. Therefore, we proposed a method to ensure that the MBDs are secured in healthcare cloud using DM BD and relying upon a combination of fog computing technology and paired cryptographically based encryption codes.

The large size and intricacy of these data sets make it challenging, and in some cases, not feasible to manage them

using traditional software and hardware. The healthcare cloud infrastructure offers the advantage of seamlessly consolidating a patient's healthcare information, even as they transfer between different hospitals or healthcare providers. This feature simplifies the regulation and observation of a patient's wellness data. Data theft attacks are the most serious security breaches of medical data in the Health Care cloud. The objective of this summary shall be to protect healthcare private information from cloud computing using fog computation technology. To notice the vulnerability concerns at healthcare cloud, Tripartite One Round Certificated Key Agreement Rule has contemplated. This protocol uses additive coupling cryptology to generate secure interaction keys for participants to communicate with each other in a safe and protected manner. Finally, implementation of a decoy technique will enable access and secure storage of private healthcare data.

## II. RELATED WORK

### A. A 5G Cognitive System for Healthcare

This paper introduces a new system of healthcare based on 5G cognitive systems. Data Based on medical big data analysis, it is possible to control patient physiological and psychological status using cognitive intelligence. The 5G Tactile Internet technology is expected to revolutionize the healthcare industry by enabling real-time remote patient monitoring and diagnosis, as well as facilitating surgical procedures through haptic feedback. The technology is capable of providing high-speed, low-latency, and reliable connectivity, which is critical for applications such as telemedicine, remote surgery, and virtual and augmented reality (VR/AR) in healthcare. Moreover, the integration of machine learning and deep learning algorithms in the data cognitive engine can enhance the system's ability to analyze and interpret large volumes of healthcare data, including speech and emotion recognition. This can help improve the accuracy of medical diagnosis and treatment plans, as well as enable more personalized and efficient healthcare services. [1].

### B. Healthcare Big Data Voice Pathology Assessment Framework



# Brain Tumor Detection & Classification Using Machine Learning

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## ABSTRACT

The phrase "brain tumor" simply refers to the growth of aberrant brain tissues. The quickest and most common method of locating a brain tumor is through Magnetic Resonance Imaging (MRI) scans. A brain tumor may be lethal if it is not detected in the early stages of growth. As a result, it is essential to spot and diagnose tumors while looking at brain imaging. The challenge of identifying tumors from MRI scans is one that takes a lot of effort, money, and time. This study suggests a deep learning-based approach that may identify brain tumors from MRI images considerably more quickly and accurately, enabling doctors to treat patients right away. Additionally, radiologists can make decisions regarding the best therapeutic approaches to use more quickly. The trained model will also be used to predict the presence of brain tumors, automating the process, and saving time and labor.

**Keywords:** Brain Tumor; Machine Learning; MRI Images; Convolutional Neural Network.

## I. INTRODUCTION

Brain tumor detection using machine learning is a relatively new field of study that is gaining more attention as time goes on. This type of technology is being used to detect, diagnose, and treat various types of tumors in the brain. A type of artificial intelligence called machine learning analyses data to forecast outcomes and make judgements. The use of diverse algorithms and approaches to recognize and categorize various tumor forms is necessary for the use of machine learning to the identification of brain tumors.

This type of technology can provide more accurate results and a better understanding of the underlying causes of brain tumors. Additionally, it can help doctors and researchers better understand the progression of the disease.

Supervised and unsupervised learning are two forms of machine learning algorithms utilized for brain tumor identification. Supervised learning systems use tagged data, such as medical images, to identify and classify different types of cancer. On the other hand, unsupervised learning algorithms employ unlabeled data to find patterns

and trends in the data. Convolutional neural networks (CNNs) are one of the most used supervised learning techniques for finding brain tumors. This type of algorithm is used to detect tumors by analyzing medical images. CNNs are trained using labeled data, such as MRI scans, to identify and classify different types of tumors. These methods can also be used to track the evolution of tumor size and morphology over time.

Unsupervised learning algorithms can also be used for brain tumor detection. These algorithms are used to identify patterns and trends in the data without the use of labels. Common unsupervised learning algorithms used in brain tumor detection include clustering algorithms, such as k-means, and anomaly detection algorithms. Clustering algorithms are used to group similar tumors together, while anomaly detection algorithms are used to identify outliers or anomalies in the data.

Deep learning can be utilized for brain tumor identification in addition to supervised and unsupervised learning. These algorithms are designed to find patterns and trends in data that may be difficult to find using conventional machine learning methods. Because doing so tracks the progression of the disease, deep learning algorithms can be used to discover and classify different tumor types.

Overall, machine learning has become an important tool for brain tumor detection. This type of technology can provide more accurate diagnosis and treatment of tumors, as a better understanding of the underlying causes of brain tumors. Additionally, machine learning algorithms can be used to detect changes in tumor size and shape over time. With the help of machine learning, doctors and researchers can make better decisions when it comes to diagnosing and treating brain tumors.

## II. RELATED WORKS

The Fuzzy segmentation technique (FCM) was used in [1] to distinguish between brain areas with tumors and those without them. A multilevel discrete wavelet transform (DWT) was also used to extract wavelet characteristics. Deep neural networks (DNNs) were

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# File Encryption and Decryption Using Cryptanalysis

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## Abstract

The process of converting the initial text communication into an ambiguous form, as well as in reverse, is known as cryptography. It is the process of concealing data and transmitting it in an appropriate format so that only authorized individuals may access and use it. Data security for consumers is mostly achieved through the use of cryptographic processes, which protect data against theft or transformation. This paper defends the use of Sequences of DNA (Deoxyribonucleic Acid) used for encryption and decryption. To encrypt the communication, two intermediary steps in this procedure are used: perception of binary-coded form and generation of arbitrary keys. For the purposes of encryption and decryption, the sender and receiver should establish a shared key. The sequence is more secure thanks to the shared key. This paper examines both the process. And also we have included three level of security. We have added image steganography with encryption using RSA before DNA encryption which makes the data more secured from the hijackers.

**Keywords—** DNA Encryption and Decryption techniques, Image Steganography, RSA encryption and Decryption

## Introduction

Due to the effective expansion of transmission applications, data security has become increasingly important in communication systems. The process of converting the initial text message into an ambiguous form is known as encryption. Decryption is the process of returning encrypted data to its initial condition. The process of encrypting and decrypting data is known as cryptography, commonly referred to as cryptology. Data is encrypted on the sender side and decrypted on the receiver side before being sent over the network. Based on the key-value pair and the cryptographic method that is used to encrypt and decrypt the provided results, the current cryptographic technique can safely encrypt the data. The numerical key that is employed for both encryption and decryption.

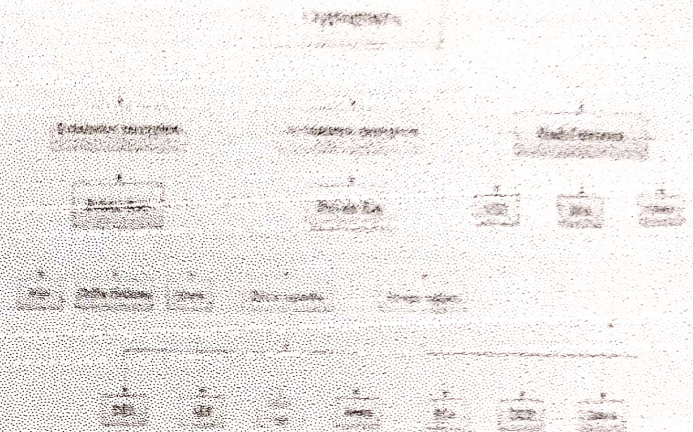


Fig. 1. Different Types of Cryptography

We have used three different techniques to make the data more secured and confidential. The RSA Technique make the data more secured using a key. And hiding the text in image makes the hackers more complicated from hijacking. Above all these, For a third level of security, we have used DNA encryption technique also.

## CHALLENGES

Nowadays data access has been easier but more challenges occur in the acquisition and processing of data. Longer DNA might be encrypted for greater security. Sequencing takes longer. Security is entirely dependent on the key. Due to the length of the keys, asymmetric cryptography is much slower than symmetric key encryption. All these are the current challenges in the published papers. One time padding is also another method in which the decrypt message uses a codebook which may not be possible for all messages.

## RELATED WORKS

Based on the different techniques used along the past years it was found an accurate method is less in the field. So combination of different techniques together can make the data more secured.

In [1], Pushpa. Introduced a DNA synthesis, using DNA digital coding and PCR amplification. Prevent attack from a possible word as PCR primers. The complexity of Biological scheme and cryptography computing provide a double security safeguards for the scheme. Cost of encryption scheme was low. In [2], Pushpa. Introduced a DNA synthesis, using DNA digital coding and PCR amplification. Prevent attack from a possible word as PCR primers. The complexity of Biological scheme and cryptography computing provide a double security safeguards for the scheme. Cost of encryption scheme was low. In [3], Pushpa. Introduced a DNA synthesis, using DNA digital coding and PCR amplification. Prevent attack from a possible word as PCR primers. The complexity of Biological scheme and cryptography computing provide a double security safeguards for the scheme. Cost of encryption scheme was low.



# An Intelligent Application for Detecting and Alerting on Dangerous Driving Behaviors

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**Abstract**—Worldwide, traffic accidents are a major source of fatalities and injuries, resulting in financial losses and societal expenses. One of the main factors contributing to traffic accidents is human error, which includes driver weariness, distraction, and other risky driving practices. AI and computer vision developments have created new possibilities for tracking driver behavior and warning of risky driving practices. Numerous academics have investigated the use of computer vision algorithms to identify and categorize driving behaviour, including detecting attention and sleepiness. These issues have also been addressed by machine learning algorithms, enabling the creation of systems that can recognise and categorise various driving behaviours. Some existing systems use sensors, such as cameras and accelerometers, to monitor driver behavior and provide feedback. However, these systems can be limited in their effectiveness and may require significant calibration and maintenance. The proposed application to monitor driver visual analytic using AI aims to overcome some of these limitations by using advanced computer vision algorithms and machine learning techniques to provide real-time feedback to the driver.

**Index Terms**—Artificial Intelligence, Visual Analytic, Computer Vision

## I. INTRODUCTION

Road safety is a pressing concern worldwide, as road accidents are a major cause of fatalities, injuries, and economic losses. One of the primary causes of road accidents is human error, particularly unsafe driving habits such as driver fatigue, distraction, and other forms of impaired driving. According to the WHO, around 1.35 million people die each year globally due to road accidents, with driver fatigue, distraction, and other unsafe driving habits being primary contributing factors. While various technologies exist to monitor driver behavior and provide feedback, such as sensors and cameras, these systems can be limited in their effectiveness and may require significant calibration and maintenance. Advances in computer vision and machine learning techniques have opened up new opportunities to monitor driver behavior and alert them to unsafe driving habits in real time. This study suggests a driver visual analytics program that employs artificial intelligence (AI) to analyze a driver's visual behavior and notify them if they display indicators of fatigue, distraction, or other risky driving practices. A camera that is positioned on the dashboard steering wheel of the car is used to implement the system. It records the driver's face and eye movements. If the driver

is found to be drowsy or distracted, the application could alert them with a sound, vibration, or message to encourage them to take a break or refocus their attention on the road. The proposed system has the potential to improve road safety by lowering the number of collisions brought on by driver inattention, weariness, and other risky driving practices. The proposed application also aims to improve the resiliency of existing systems and focus on detecting bad driving behaviors while introducing an alarming system to prevent accidents while driving. The proposed system holds the potential to make a substantial contribution to road safety and decrease the frequency of accidents due to human error by tackling these crucial concerns.

## II. RELATED WORK

### A. An HMI Concept to Improve Driver's Visual Behavior and Situation Awareness in Automated Vehicle

This paper introduces a concise HMI (Human Machine Interface) concept that utilizes an LED ambient light located at the bottom of the windscreen to convey critical information such as the status and intention of the automation, detected potential hazards, and warning for a take-over request (TOR) by altering the color, frequency, lighting position, and animation of the LED. The primary aim is to enhance situational awareness (SA) during automated driving, improve the take-over quality, and enable the driver to perform non-driving related tasks (NDRTs) without distraction or annoyance. The effectiveness of the new HMI was evaluated in a between-subject-design experiment using a static driving simulator with 50 participants, who performed a visual motoric task on a smartphone during a 45-minute automated drive with or without the new HMI [1].

### B. Dynamic Human Behaviour Pattern Detection and Classification

The focus of this study is on analyzing and classifying four types of detailed human behaviors - walking, standing, running, and sitting - through videos. To achieve this, the study proposes the use of a Convolutional Long Short-Term Networks (CLSTM) model that combines the CNN and LSTM models to facilitate the learning, detection, and classification

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# SOUND TRIGGERED PATROLLING AND SURVEILLANCE ROBOT USING DEEP LEARNING

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**Abstract** — Technology plays an inevitable role in human lives. The development of various technologies has altered the way we live and work. The advent of computer systems and internet has introduced a modern alternative to satisfy our day-to-day requirements. In present and future scenario robots have largest research area in different fields. In Present generation, an autonomous robot has been a popular technology which is widely used in many areas. Robots are used to share the work and act more autonomously in performing the jobs faster than humans. Usually, Robots are more intelligent with endless energy levels and more precise in handling the jobs perfectly. Surveillance is the term which is as old as human civilization, only its mode and technology has changed and evolved. The kind of surveillance adopt here is a patrolling robot which It has the ability to monitor sound in the premises. The robotic vehicle moves at particular intervals and is equipped with night vision camera and sound sensors and it starts moving towards the sound on its predefined path. It then scans the area using its camera to detect any human faces detected. It captures and starts transmitting the images of the situation immediately.

**Keywords** — autonomous robot, night vision, sound sensor

## I. INTRODUCTION

Technology plays an inevitable role in human lives. The development of various technologies has altered the way we live and work. The advent of computer systems and internet has introduced a modern alternative to satisfy our day-to-day requirements. Majority of people rely on internet and computers to perform certain task, most significantly technology altered our way of life while also making it more comfortable. As the world slowly moves towards modernization, peoples are looking for innovative ways to make life easier and more efficient. The security sector has made progress in the development of existing technology but has yet to take full advantage of the technology. When societies first began developing, nearly all productions and efforts were the result of human labors. With technological advances machines were slowly developed. For the last

decades, many researches had been done to develop the autonomous robot in order to perform risky, dangerous and continued task and hence replace human in certain jobs. Throughout the time, the autonomous robot has been developed according to the progress in different ability such as self-maintenance, task performance, sensing the environment, outdoor autonomous position-sensing and navigation, and indoor position sensing and navigation. Today, the security monitoring job is required and important for the most of place due to safety issues. The monitoring job generally needs to be done in 24 hours' time to ensure that any unwanted incident will not happen and because of that, the autonomous robot is needed to be design so that it can replaced the human work which is currently doing the security monitoring manually by checking around the area continuously. The concept of integrating robotics into security sector is relatively new trend, and is mostly efficient. The robot is an autonomous rover, fitted with ultrasound sensor. The ultrasound sensors are what helps the robot in becoming autonomous, detecting obstacles, and avoiding them according to the algorithms set through the raspberry pi, which is the brain of the robot. The robot has the advantage of using a smart camera, having the functionality of human detection, tracking and night vision, which can be controlled wirelessly via an IOT website, making it easy to use and monitor. The emergence of security robots is a milestone in the evolution of security systems-an emerging stage of technological development that brings the entire industry to new standards of best practices expected in the profession of securing people and property. Autonomous mobile robots designed for outdoor use can reduce and overtime, completely eliminate the need for human workers to ensure the safety of large facilities.

## II. LITERATURE REVIEW

In the paper titled "Decentralized Control of a Heterogeneous Human- Robot team for Exploration and Patrolling" presents a decentralized connectivity-maintenance control framework for a heterogeneous human-robot team. The algorithm is able to manage teams of an arbitrary number of mobile robots and humans to

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# An Intelligent Hate Speech Detection System For Safetalk Using Bidirectional LSTM

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**Abstract**— Hate speech is clearly directed at social tensions and violence. Recognition becomes increasingly difficult when emotions overlap. However, there are still some unsolved problems with informal and indirect targeting of negative communication, such as sarcasm, misrepresentation, and glorification of immoral behavior of the target audience or society. In this study, we proposed a case selection method based on the visualization of attention networks. The purpose is to classify, modify, and scale the number of training instances. To do this, we first used hate speech dictionaries and online forums to practice embedding using transfer learning. We then used synonym expansion of the semantic vector. An active learning approach was used to train the task using pairs of outcome labels. Entropy-based selection and visualization techniques help select unlabeled text for each active learning cycle. To improve model accuracy, the approach is improved and the number of training instances is increased. The active learning cycle repeats until all unlabeled text is converted to labeled text. Semantic embedding and lexicon expansion improve the receiver operating characteristic (ROC) of the model from 0.89 to 0.91. A bidirectional LSTM with attention and active learning scored 0.90 on Precision – Recall. A trained model can visualize position-weighted terms to explain why hate speech is classified

**Keywords**—Deep learning, ethnic hate, explainable machine learning (ML), hate speech detection.

## 1. INTRODUCTION

With the advent of new communication technologies, the communication process has become very easy for internet and social network users all over the world. Remarkable advances in technology are driving the adoption of new media. With the increasing use of social media, the phenomenon of online hate speech is also gaining attention. In recent years, social media platforms, such as Twitter and Facebook, have gained popularity among the masses. They are filled with user-generated content, including text, social media data, photos,

and videos. Given the large amount of user-generated content on the Internet, especially on social media, it is becoming increasingly important to identify and potentially prevent the transmission of hate speech, i.e. fight against racism and sexism. With the vast amount of user-generated information on the Internet, especially on social media, it is becoming increasingly important to identify and potentially limit the spread of hate speech. Hate speech and defamatory comments against another person's religion, ethnic origin, or sexual orientation are prohibited by law. In many countries, anyone who incites violence or genocide is considered a criminal. In addition, many governments prohibit the use of symbols of totalitarianism and restrict freedom of assembly in the case of fascism or communism. However, not everyone has equal access to this public space and not everyone has the right to express themselves without fear. Hostile and disrespectful communication on the Internet drowns out the voices of marginalized and underrepresented groups in the public conversation. This helps us to understand this and mitigate.

Hate speech on the Internet and social media not only causes friction between groups of people, but it can also cause harm to businesses and cause really important problems. For these reasons, websites such as Facebook, YouTube, and Twitter are limited hate speech. However, tracking and filtering all content always problems. For this reason, many tests have been conducted to learn how to automatically detect hate speech. Most of this hate speech detection work attempts to create dictionaries of hate phrases and expressions or categorize hate speech into two categories: "hate" and "don't hate". However, assessing whether a sentence contains hateful content is always difficult, especially when hate speech is masked under sarcasm or when hate is not clearly expressed, race or prejudice. The goal of this study was to extract hate speech from social media content in an online forum. We have proposed a hate speech visualization and recognition system based on the deep attention technique. In a study of online trends, users communicated hate speech in response in the



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**Abstract** To significantly minimize the effort required to seek in new environments, it is critical to choose an effective search strategy. In mobile robotics, random search is the main search method due to the lower processing capabilities of mobile robots, which result in the detection of only local features. If you are looking for random-walking techniques that emulate social insects self-organized behaviour, then Levy's struggle approach is very popular. Robot searches are often ineffective since the suggested methodology is very restricted. This article offers an enhanced random walking technique in which each robot's stride size is adjusted to minimize the amount of repeated searches. To find out if the suggested approach was successful and whether it performed as an intelligent exploratory strategy, simulation tests and experiments with real robots were undertaken. The research found that the suggested approach was more successful over a wider area.

**Keywords** Mobile robot · Exploration strategy · Random walk method · Repeated search · Unknown environment

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## 1 Introduction

Across the last ten years, in a number of areas, autonomous mobile robots have grown increasingly common. In the industrial sector, collaborative robots are being utilized, and mobility fleets are swarming logistically. But their usage in civil applications presents extra difficulty (Deng et al. 2018; Ingrand and Ghallab 2017; Shakhathreh et al. 2019), owing to their interaction with people and their deployment in possibly unexpected contexts. Search and rescue (SAR) are a major scenario in which mobile robots may save lives by allowing for quicker responding times (Mehmood et al. 2018) and (Roberts et al. 2016), supporting dangerous environments (Luk et al. 2005; Lunghi et al. 2019; Sung 2019) or offering, among other opportunities, real-time mapping and monitoring in an event area (Merino et al. 2005) and (Brenner et al. 2017). In this paper, we are doing a literature evaluation of SAR scenarios multi-robot systems.

In everyday life, it is a practical issue to locate a permanent object of interest in a recognized or new setting

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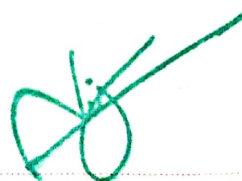
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# Multi-objective load balancing in cloud infrastructure through fuzzy based decision making and genetic algorithm based optimization

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## ABSTRACT

Cloud computing became a popular technology which influence not only product development but also made technology business easy. The services like infrastructure, platform and software can reduce the complexity of technology requirement for any ecosystem. As the users of cloud-based services increases the complexity of back-end technologies also increased. The heterogeneous requirement of users in terms for various configurations creates different unbalancing issues related to load. Hence effective load balancing in a cloud system with reference to time and space become crucial as it adversely affect system performance. Since the user requirement and expected performance is multi-objective use of decision-making tools like fuzzy logic will yield good results as it uses human procedure knowledge in decision making. The overall system performance can be further improved by dynamic resource scheduling using optimization technique like genetic algorithm.

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## 1. INTRODUCTION

Cloud computing can be explained as on-demand availability of services like cloud servers, resources, storage and computing power, which is managed remotely in internet. The term is usually used to define data centers accessible to consumers over the Internet. The service models of cloud computing [1]–[10] are platform as a service (PaaS), infrastructure as a service (IaaS) and software as a service (SaaS) [8], [9]. Hence any user they like to use the above-mentioned services can avail the services after paying the service cost but user always enjoys the uninterrupted services without facing the difficulty of maintaining the same.

Amazon web service (AWS), Microsoft Azure, Server Space, Google Cloud Platform, Adobe Creative Cloud, IBM Cloud Services, and VMware are the major cloud service providers. When the multiple users have multi objective requirement the cloud infrastructure operation is difficult as it will not be able to provide good QoS to all the clients. Service migration amid data servers may reduce the network overhead in a cloud infrastructure and improve QoS to the clients but it will create serious load balancing problems which ultimately degrade the performance of the system. Figure 1 shows basic cloud architecture with various services like infrastructure, applications and platform which can be accessed by multiple users in multiple configurations through internet. Infrastructure services contain services like server, computing power and data storage.



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## One-Step Effective Sonochemical Technique for *Insitu* Coating of $\text{Ag}_3\text{PO}_4$ Nanoparticles on Glass and Polymer Substrates

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The green technology clubbed with the ultrasound irradiation allows one to produce the products and to reduce the number of production stages without increasing the cost and also devoid of toxic effects. A novel sonochemical method is demonstrated for the preparation of four samples of  $\text{Ag}_3\text{PO}_4$  nanoparticles by using  $\text{AgNO}_3$ ,  $\text{KH}_2\text{PO}_4$  and D-Glucose. The synthesized products were systematically characterized by X-ray powder diffraction, and scanning electron microscopy (SEM). XRD pattern revealed a face-centered cubic structured  $\text{Ag}_3\text{PO}_4$  phase. We recognized the optical properties of  $\text{Ag}_3\text{PO}_4$  nanoparticles and found that  $\text{Ag}_3\text{PO}_4$  nanocrystals show emission in the photoluminescence (PL) spectrum. In addition, we also discuss the possible formation mechanism of  $\text{Ag}_3\text{PO}_4$  nanocrystals.

**Keywords:**  $\text{Ag}_3\text{PO}_4$  spinel; ultrasonic synthesis; photoluminescence and mechanism.

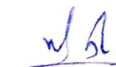
### 1. Introduction

Nanotechnology is an improved technology that can bring revolution to different scientific fields. Nanomaterials have wide range applications due to their size and morphology, and have been an important subject in the fields of basic and applied sciences. In the recent years, there has been a great focus on nano-sized semiconductors because of their novel properties which have applications in optoelectronic.<sup>1-6</sup> Among various nanoparticles, silver phosphate nanoparticles ( $\text{Ag}_3\text{PO}_4$  NPs) are

versatile semiconductors that display significant optical transparency and luminescent properties in UV-Visible (UV-Vis) regions. These nanoparticles have become important in recent years, due to their excellent chemical and thermal stability. Various approaches for the preparation of  $\text{Ag}_3\text{PO}_4$  NPs have been developed such as sol-gel, hydrothermal, spray pyrolysis, microwave-assisted techniques, chemical vapor deposition and precipitation methods.<sup>7-17,28</sup> Nevertheless, these procedures are quite expensive, very complex,

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## Revamping E-Learning among Professional Students: The Pandemic Effect

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### Abstract

The impact of pandemic COVID-19 is observed in every sector around the world. The educational sector of India, as well as the world, is badly affected. It enforced the worldwide lockdown creating a very bad effect on the students' life. Around 32 crore learners stopped moving schools/colleges, all educational activities halted in India. The outbreak of COVID-19 proved that change is inevitable. It worked as a catalyst for educational institutions to grow and opt for new platforms and techniques. The educational sector has been fighting to survive the crisis with a different approach by digitalizing the pedagogy through online platforms. The present study is designed to understand the student's perspective about factors influencing online classes conducted at the university level. And to find out general challenges faced by the students in E-learning. The data were collected from 98 professional students from different engineering colleges in the Malabar region. Career Development Programs and Social problems are the major problems faced by the students.

### 1. Introduction

According to Huang et al. (2020)<sup>i</sup>, a novel coronavirus, known as Covid-19, was discovered in the last month of the year 2019, in a seafood market in Wuhan. The virus's clinical analysis results showed person-to-person transmission (Wang, Zheng, et al., 2020)<sup>ii</sup>. The COVID-19 outbreak has had a profound impact on the world's education system and closed the doors of many schools and universities. Undoubtedly, the spread of COVID-19 created huge challenges for the world's educational systems that nobody has seen since the development of technology and distance instruction. This pandemic has forced the global physical closure of businesses, sports activities, and schools by pushing all institutions to migrate to online platforms (Lugori et al, 2020)<sup>iii</sup>. Online learning is the use of the internet and some other important technologies to develop materials for educational purposes, instructional delivery, and management of the programs (Fry, 2001)<sup>iv</sup>. The education systems faced challenges that shift them toward using online learning while they were not prepared for that. Early March 2020 the spread of the COVID-19 caused all

universities and schools to be closed following the health protocols and presidential directive. It continued after the new year holidays, in the middle of April 2020, from elementary, secondary, high school education to universities. As a result of the new situation, administrators of schools and universities had no option except to instruct teaching staff to use various applications for online teaching. Indeed, given the problems caused by COVID-19 in the world, online education is the best method to teach various courses: since this type of training has been growing for years, and it has provided new opportunities for students, professors, and educational planners and institutes (AF Mayadas, 2009)<sup>v</sup>. The need of this study is to understand the challenges faced by the students during the COVID-19 pandemic situation. As the online teaching-learning process has become more prevalent in India due to COVID 19 pandemic, it becomes particularly important to know the factors that influence E-Learning among professional students. The present study was therefore designed to understand the student's perspective, attitudes, and readiness about online classes being conducted at the university level.





# A STUDY ON POWER SYSTEM IMPACTS AND VALUE OF WIND POWER IN INDIA

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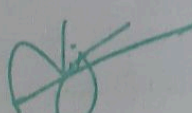
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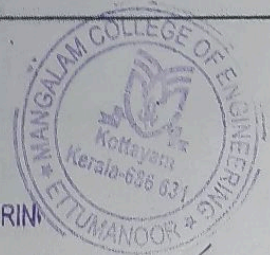
## Abstract

Current electrical systems are mostly thermal (coal, gas), hydro, and nuclear in nature. Hydro-thermal scheduling and merit order dispatch are two aspects of traditional power planning. Modern renewables (wind, solar, and biomass) are expected to play a substantial role in the electricity sector in the future. This study describes a method for analyzing the effects of wind power on the electrical system. The short- and long-term implications of wind power on the grid are discussed. A method based on duration curves has been devised. Wind energy was regarded as a negative load to generate a modified load duration curve from which capacity savings in terms of base and peak load generation could be calculated. The approach is demonstrated for Tamil Nadu (an Indian state). Scenarios for 2021-22 have been developed. Constructed to illustrate the methodology proposed. This technique can be useful for power planners for an analysis of renewables in future electricity grids.

**Keywords:** Electricity generation, Global electricity consumption, Conventional power planning, Ecographical area of interest.

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## Introduction

The present share of renewables in most electric grids is marginal. Electricity generation from renewables is assuming increasing importance in the context of rapid and accelerated growth in energy demand and negative environmental externalities due to predominance of fossil fuels in the generation mix. The share of renewables in electricity generation is around 18%, with 15% of global electricity coming from hydroelectricity and 3.4% from new renewables (Global Status Report, 2007). In particular, the wind and solar photovoltaic markets show yearly growth rates between 20-30% in the last few years (Waldau and Ossenbrink, 2004). At the end of 2008, worldwide wind farm capacity was 120,791 megawatts (MW), representing an increase of 28.8 percent during the year, and wind power produced 1.3% of global electricity consumption. Wind power accounts for approximately 19% of electricity use in Denmark, 9% in Spain and Portugal, and 6% in Germany and the Republic of Ireland (WWEA, 2009). The National Solar Mission is a major initiative of the Government of India and targets the deployment of 20,000 MW of solar power by 2022 (MNRE, 2009).

However, regardless of the kind of renewable energy source, its adoption in the present centralized conventional distribution system faces challenges. The methods of analysis for determining optimum decisions for conventional generation are well understood, but intermittent non-traditional sources provide unique challenges. Techniques for fossil fuel and water power plants are available in conventional power planning. Using mathematical methodologies, these techniques deal with optimal hydro-thermal scheduling with variable loads. A traditional generation system can be controlled to follow the load, however non-schedulable renewable power producing methods cannot. The production of a wind power plant varies daily and seasonally, depending on the wind regime at the location and the machine/device parameters. As the amount of variable renewable energy grows in importance, challenges connected to capacity expansion planning and dispatch become important.

This paper illustrates an approach based on the duration curve analysis for generation expansion planning with higher penetration of renewable power. Future scenarios for Tamil Nadu state in India for 2021-



22 have been illustrated using this methodology.

### Effects of wind energy on the power system

The power system requirements of wind power depend mainly on the power system configuration, installed wind power capacity and variation of wind power production. Wind resource variation on time scales of seconds to years affect the power system. An analysis of this impact will be based on the geographical area of interest. The impact of wind energy in the grid has been generally represented in literature in terms of the capacity credit. The capacity credit of wind power has been defined as fraction of installed renewable capacity by which conventional capacity can be reduced without a loss in security of supply (Giebel, 2006). It has been shown that calculating the capacity factor of the resource over a relevant time period usually provides a good estimate of capacity credit (Milligan and Parsons, 1997; Milligan and Porter, 2005). Another method is to compute the wind power generation for time periods corresponding to high systems risk hours or approximate the system LOLP (Loss of Load Probability) curve so that high risk hours receive more weight than other hours. Most methods to assess the capacity credit of a wind power plant are based on a related reliability measure called the Loss of Load Expectation (LOLE) (Milligan and Parsons, 1997; Wijk et al., 1992). However, the total amount of energy generated by a specific technology does not by itself indicate the full value of that technology. The contribution is intermittent and its value is dependent on the correspondence with the major part of the demand. For seasonal wind/solar regimes like India, neither the capacity factor, nor the capacity credit reflects the monthly variation in the renewable energy generation (George and Banerjee, 2009).

Power from renewable sources (predominantly considered here as wind power) introduces more uncertainty in operating a power system: it is variable and partly unpredictable. To meet this challenge, there will be need for more flexibility in the power system. How much extra flexibility is needed depends on the one hand on how much wind power there is and on the other hand on how much flexibility there exists in the power system (IEA, 2007). The impacts of wind power on the system can be categorised as short-term or long-term. The short term effects involve the cost of balancing the system on the operational



time (from several minutes to several hours) and are primarily due to fluctuations in power output generated from wind. The short-term effects include voltage management issues, impacts on production efficiency of hydro and thermal units, positive or negative impacts on transmission or distribution efficiency, primary and secondary reserve control and loss of energy from wind (if wind power exceeds the amount the system can absorb). Other impacts include those on fuel consumed and emissions from the thermal power units.

The long-term effects pertain to adequacy of power capacity. The variable power output from renewables will have an impact on power system reliability and efficiency. These impacts may be positive or negative. The reliability of the power system includes the analyses for ensuring sufficient electricity production within the system to meet the load demand or constraints within the transmission and distribution system. System adequacy is associated with static conditions of the system, and studied either by a simple generation load model or by an extended bulk transmission system model consisting of generation, transmission, distribution and load. The criteria that are used for the adequacy evaluation include the loss of load expectation (LOLE) and the loss of load probability (LOLP), for instance (Holtinen, 2008).

Many studies with respect to the effects of grid integration of wind power in European countries (IEA, 2007; Holtinen, 2008; Holtinen et al, 2007; Gross et al, 2006; Akhmatov and Knudsen, 2007) have reported that the major challenges include impacts on power system operating costs, power quality, imbalances and transmission and scheduling planning. The reported results indicate that wind power impacts are small at low penetrations (about 5% or less) and the effects remain moderate with penetrations approaching 20%. Georgilakis (2008) states that as penetration of renewables increases, they become progressively less valuable for saving thermal capacity. However, no values have been cited. Also, there still are no concrete results with respect to much higher penetrations of wind power. A consolidated research project between major European countries along with the IEA is still reviewing these aspects (IEA, 2007). With respect to the India, the results from a simulation by Hossain (1993) for Tamil Nadu indicate reliable penetration levels of 25-30% of the conventional power system.

Very little is known about the realizable levels of penetration for countries like India. More importantly, unlike the developed countries, the capacity expansion and evolution of generation system is continuing in



India. The opportunity to plan and control the evolution of the system with a reasonable component of renewables is still open. Despite the large potential of renewables and the need for such studies, no attempts have so far been made to address the issues of integration of significant amounts of renewable energy within the Indian power system. Conventional power planning offers techniques for fossil fuel power and hydropower plants. The output of a wind power plant has daily and seasonal variations, depending on the site wind regime and machine characteristics. As the share of wind energy increases and becomes significant, issues related to capacity expansion planning and dispatch become important.

### Wind energy impact assessment framework

#### Proposed methodology

This paper outlines a method which can be used to quantify the savings achieved under higher penetration of renewables in the grid. Here, we propose a methodology based on the annual Load Duration Curve (LDC) to assess impacts of wind power on the power system.

The model is developed in a sequential manner, as described below:

- ❖ Major sites for wind energy generation are reconsidered.
- ❖ Long period (over 10 year) average hourly wind speed data for each representative site is obtained.
- ❖ Using the existing installed capacity values and the equipment characteristics, the hourly output from a generator is computed.
- ❖ The output powers for each site are summed up and weighted based on installed capacity at each site to obtain the total hourly wind energy generation for the state.
- ❖ The hourly generation data for wind is compared with the actual hourly load demand. The annual load duration curve with and without wind energy is drawn and savings obtained are calculated. The flowchart for the micro model is shown in Figure 1.
- ❖ The energy replaced is estimated from the area between the two load duration curves. The capacity savings are calculated considering the load savings from wind power at 6000 hours (considered as base load savings) and at 15% of peak load hours (considered as peak load savings). The exercise is repeated for different penetration of renewables.
- ❖ The method is extended to future scenario modelling by including a capacity



expansion model, which is calculated from the Gross Domestic Product (GDP) growth rate and elasticity. New load duration curves are drawn by extrapolating the existing LDC with the energy growth rate.

Different hypothetical renewable energy capacities may be used for the simulations and savings for a ch can be obtained.

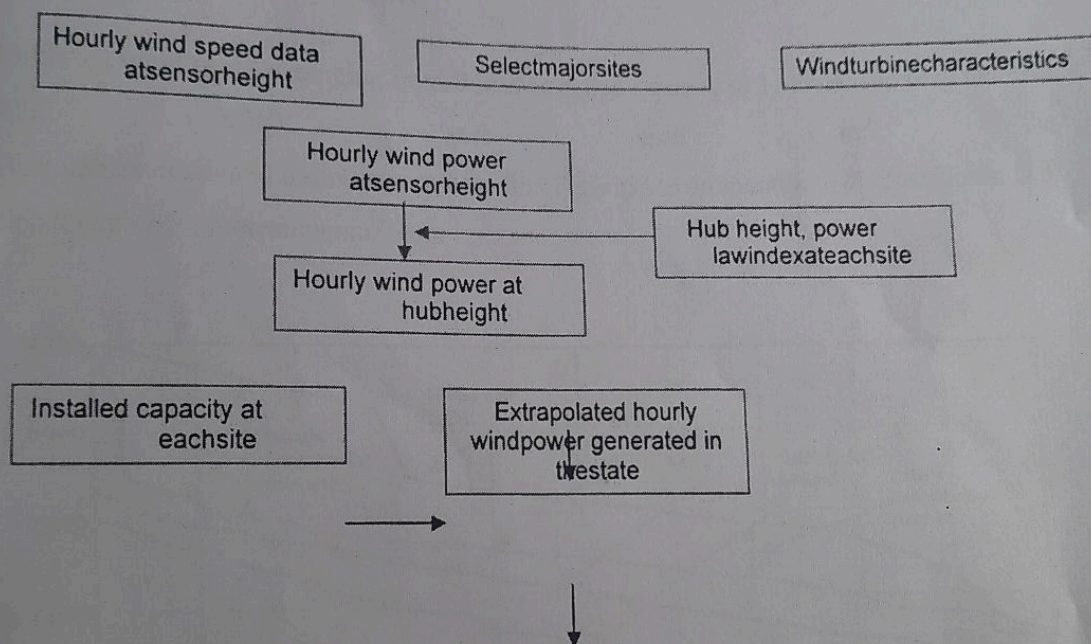


Figure 1: Micro model for wind power output

### Illustration

A Load Duration Curve (LDC) is used to illustrate the relationship between generation capacity requirements and capacity utilisation. It is similar to a load curve but the demand data is ordered in descending order of magnitude, rather than chronologically. The LDC shows the capacity utilization requirements for each increment of load. The height of each slice is a measure of capacity, and the width of each slice is a measure of the utilization rate or capacity factor. The product of the two is



a measure of electrical energy (e.g. kWh). Load duration curves are constructed by dividing the chronological loads into different time periods. The smaller the steps, more is the chronological information retained.

The effect of adding intermittent renewable resources into the system can be modelled as a negative demand (Wijk et al, 1992; Castro et al, 1996; Fsadni and Mallia, 2006) which accounts for the inherent fluctuations of the produced power. The LDC methodology identifies the same trends as hour-by-hour simulations.

### *Capacity saving impacts of wind power*

Different wind profiles ranging from 0 MW installed capacity to 100% of the peak demand (9000 MW) were used and the effect on the annual load duration curve was studied. The impacts of some of these wind profiles on the load duration curve are shown in Figure

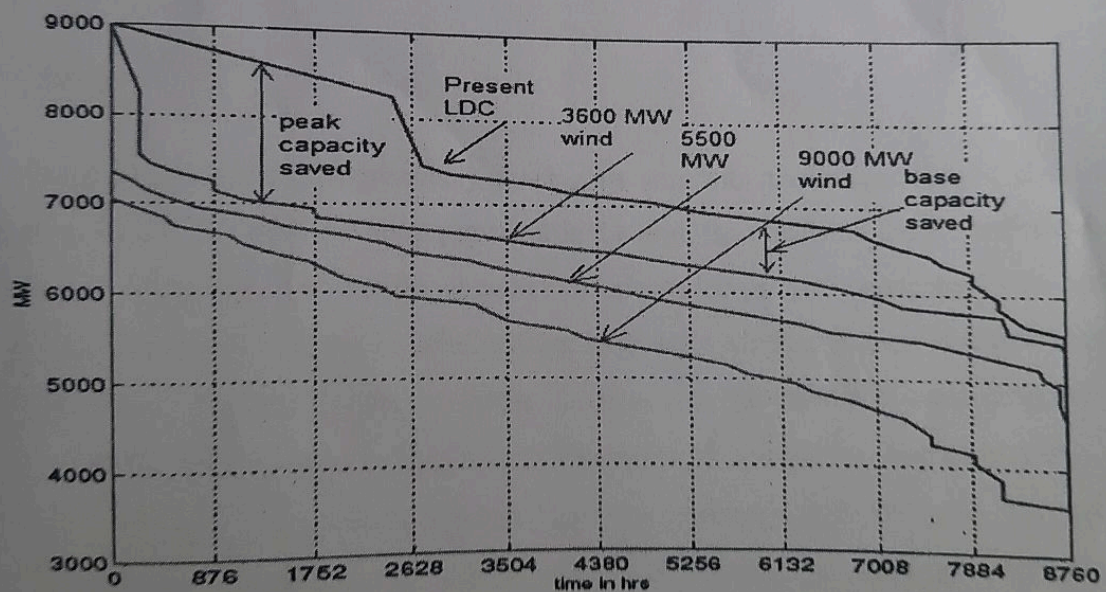


Figure 11: Annual load duration curves for Tamil Nadu under different wind power scenarios

### *Future projections and scenarios*

The load duration profile for the state system in 2021, (when the installed capacity of



wind power is expected to reach the estimated potential for the state) was developed using historical data and the projections of the 17<sup>th</sup> Electric Power Survey (CEA, 2007) and has been shown in Figure 12. The report projects a growth rate of 9% p.a. in GDP and an elasticity of 0.8, giving an annual average load growth of 7.2%. Here, it is assumed that the load shape will remain the same, but the method can still incorporate a change in the future load profile. Many wind experts (Winrock, 2009; IWEA, 2009) believe that the potential has been underestimated and the actual potential is double the estimated value. Hence, we a scenario with 11,000 MW of wind has also been shown.

The average additional peak demand to be supplied then would be about 3,600 MW and additional peak energy to be supplied is 7,877 MU in the absence of wind power (curve A). Also, an additional 11,300 MW would be required to be added to the base load capacity by 2021. However, in the presence of 5,500 MW of wind power, the base load capacity addition required would be about 10,200 MW and additional peaking energy to be supplied reduces to 4670 MU. Thus, wind power of 5,500 MW in 2021 can lead to savings of about 1,100 MW of base power capacity and about 3,207 MU of peak energy requirement or 2,400 MW in the average peak. Such analysis can be extended to higher wind power penetrations using this method.

## Conclusions

Renewable energy is progressively making its way into the mainstream of electricity generating. As they become more prevalent in the grid, the effects on the electricity system must be investigated. The traditional power techniques are primarily concerned with hydro-thermal coordination. Many countries still see large-scale wind generation as a viable option in the future. Long-term patterns can have an impact on the impact of wind power on the system. If the system has a significant proportion of intermittent energy sources, new capacity with lower investment costs (but higher fuel prices) will be preferred. The trend of expanding dispersed generation from flexible gas turbines, as well as increased load management, is favorable for wind power integration. Wind power will have an influence on both power system reserves and losses in generation and transmission or distribution. It will also contribute to a reduction in fuel usage and emissions. Regarding the power system, the drawbacks of wind power are that wind power production is variable, difficult to predict and cannot be taken as given. However, integration of variable sources is much less complicated if they are connected to large power systems, which can take advantage of the



natural diversity of variable sources. A large geographical spreading of wind power will reduce variability, increase predictability and decrease occasions of near-zero or peak output. The power system has flexible mechanisms to follow the varying load that cannot always be accurately predicted. As no production unit is 100% reliable, part of the production can come from variable sources, with a similar risk level for the power system. Power system size, generation capacity mix (inherent flexibility) and load variations have an effect on how intermittent production is assimilated into the system. If the proportion of intermittent power production is small, and if wind power production is well dispersed over a large area and correlates with the load then wind power is easier to integrate into the system.

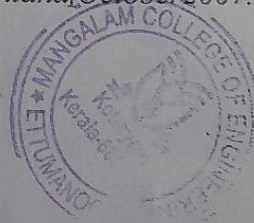
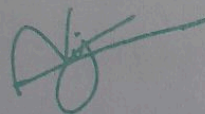
In this paper, a simple load duration curve methodology with detailed micro-level modelling has been proposed to study the impacts of renewable energy systems in electric utility systems. This approach has been used in the Indian state of Tamil Nadu. The potential savings have been evaluated in terms of base and peak capacity replaced. The approach was used to create future hybrid wind power scenarios for 2021-22. For many nations, large-scale wind power is still in the future, and there are long-term trends that can influence the impact wind power has on the system, such as the usage of energy for cars. An ideal system may necessitate adjustments to the standard capacity mix at high penetration levels. The suggested technique will allow power planners to analyse the future consequences of expanding renewable energy capacity in different networks and create suitable capacity expansion plans.

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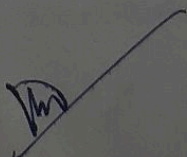
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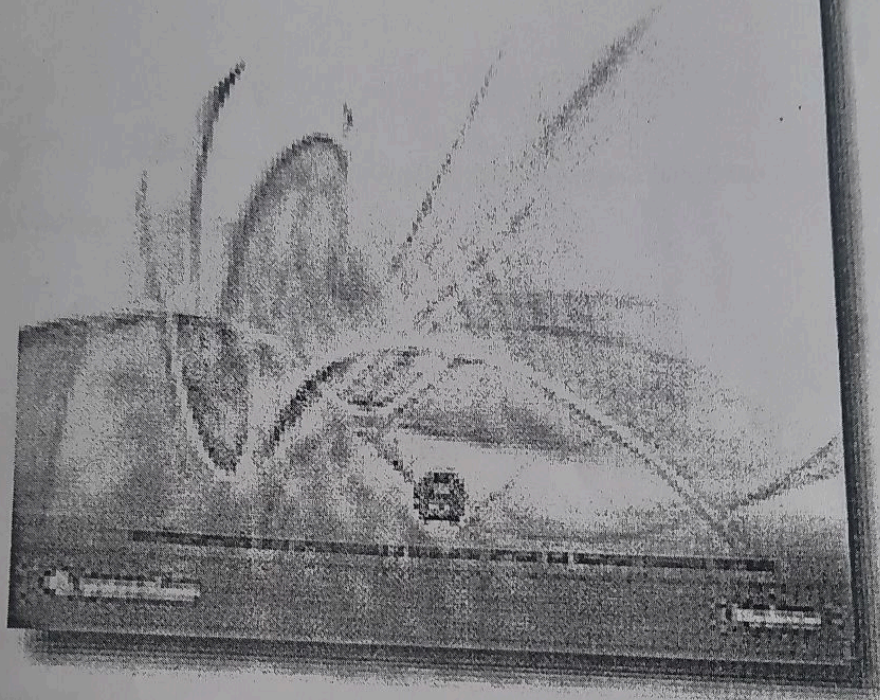
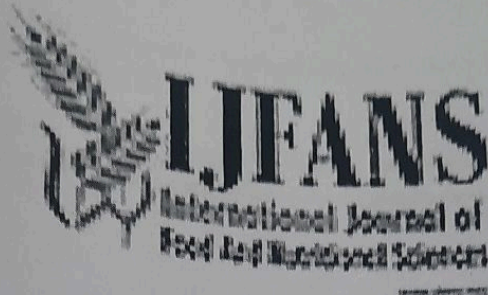


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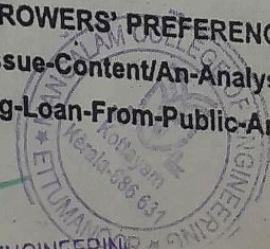
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## Assessment of Wind Energy Development in Tamil Nadu and Kerala: Challenges and Preferences

PDF (<https://www.ijfans.org/uploads/paper/0395ef48d216480e4460d1809a4518fe.pdf>)

### Keywords:

wind energy, sustainable development, climate change, bio energy, welfare

Bose Tom, M Rajeswari

### Abstract

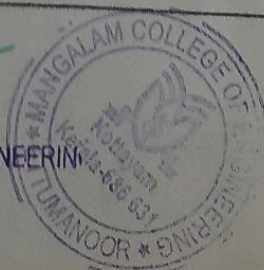
This study conducts a comprehensive examination of the present state of wind energy advancement in the regions of Tamil Nadu and Kerala, situated in India. The primary objective of this research is to assess the current status of the wind energy industry, including the challenges faced and the overall advancements made. Moreover, this study offers efficacious measures to address these challenges and promote the progress of sustainable development within the industry. To optimise wind power generation in Tamil Nadu and Kerala, it is crucial for policymakers to establish a favourable regulatory framework that incorporates various incentives such as feed-in tariffs and tax benefits. Additionally, prioritising long-term power purchase agreements is essential.

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## Assessment of Wind Energy Development in Tamil Nadu and Kerala: Challenges and Preferences

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### Abstract

This study conducts a comprehensive examination of the present state of wind energy advancement in the regions of Tamil Nadu and Kerala, situated in India. The primary objective of this research is to assess the current status of the wind energy industry, including the challenges faced and the overall advancements made. Moreover, this study offers efficacious measures to address these challenges and promote the progress of sustainable development within the industry. To optimise wind power generation in Tamil Nadu and Kerala, it is crucial for policymakers to establish a favourable regulatory framework that incorporates various incentives such as feed-in tariffs and tax benefits. Additionally, prioritising long-term power purchase agreements is essential.

**Keywords:** wind energy, sustainable development, climate change, bio energy, welfare

### Introduction

The relationship between energy and economic development is of paramount importance, since the two are intricately interconnected. The impact of energy source accessibility, affordability, and reliability on several aspects of the economy, such as output, consumption, employment, and general welfare, is substantial. Energy is an essential and indispensable factor in all production processes, enabling companies to engage in the manufacturing of goods, provision of services, and creation of job opportunities. Nations endowed with ample and readily available energy resources tend to exhibit accelerated rates of economic expansion. As civilisations undergo expansion, there is a general tendency for their energy consumption to increase. The escalation of energy demand is driven by the growth of industrial output, commercial activities, transportation, and household energy usage. Decreases in energy usage might serve as potential indicators of economic downturns or enhanced energy efficiency. Elevated energy prices have the potential to augment the operational expenses of enterprises, hence potentially diminishing their profitability and resulting in escalated prices for consumers. Fluctuations in energy prices have the potential to create uncertainty and have an impact on investment choices within energy-intensive sectors. The provision of advanced energy services plays a vital role in mitigating poverty and promoting societal progress. The absence of stable energy supplies is a significant obstacle to economic possibilities, education, healthcare services, and general human development in many developing countries. The pursuit of economical and sustainable methods



to expand energy access has the potential to foster economic empowerment and improve living circumstances.

The investigation into the significant role of energy in the context of economic development and its correlation with economic growth has been the focus of intense academic research (Stern, 2019). Energy is widely acknowledged as a significant driver of economic development in all nations. According to Rafindadi and Ozturk (2021), it has been observed that economic growth has a favourable impact on energy use, hence presenting difficulties in terms of price and economic progress as a result of resource constraints.

Economists commonly acknowledge the correlation between energy usage and economic development. Nevertheless, the widespread use of conventional energy sources presents ongoing difficulties in ensuring their availability. The substantial demand for conventional energy in contemporary consumption has significant implications on price and production, as well as environmental contamination, heightened infrastructure and administration expenses, and the worsening of traditional energy source shortages. As a consequence, several nations depend on the importation of energy resources, a circumstance that may lead to the reduction of foreign direct investment. The current energy crisis embodies a fundamental clash between inadequate energy resources and an overwhelming surge in energy use.

The global community is now seeing a notable proliferation of renewable energy sources, driven by nations' acknowledgement of the need to mitigate glasshouse gas emissions, address the challenges of climate change, and shift towards more environmentally friendly energy systems. Presented below is a comprehensive analysis of the current worldwide landscape pertaining to renewable energy. The objective of this study is to perform a thorough analysis of the developmental landscape of wind energy in the states of Tamil Nadu and Kerala. Specifically, the study aims to evaluate the cost and revenue structure of wind energy units, assess the profitability of wind mill units, and identify key challenges associated with this sector.

## Review of literature

### World scenario of renewable energy

According to the 2020 report by the International Renewable Energy Agency (IRENA), the proportion of renewable energy in the global power generation capacity was around 29.3% (Hasanuzzaman et al., 2017). The use of solar and wind energy for power production has seen substantial growth. Numerous countries have made substantial investments in utility-scale solar generating installations and distributed solar systems (Zhang et al., 2022). The establishment of onshore and offshore wind farms is being facilitated by advancements in wind turbine technology, decreasing costs, and favourable wind resources. Offshore wind power is gaining momentum, especially in countries such as the United Kingdom, China, India, and the United States. There is a growing focus on smaller-scale hydropower installations, such as run-of-river projects, in order to mitigate environmental impacts (Akuru et al., 2017). This is noteworthy considering the longstanding presence of large-scale hydropower facilities. Biomass resources are used in several sectors, including transportation, energy generation, and heating (Celebi et al.,



Research paper

2019). In order to ensure that the production of bioenergy does not have a negative environmental effect, it is essential to prioritise sustainable practises and the use of waste resources.

In the contemporary global context, the use of wind energy for power generation has emerged as a feasible and environmentally beneficial alternative. The economic aspects of wind energy play a crucial role in facilitating its broader acceptance, particularly in light of escalating concerns over climate change and energy security (Stigka et al., 2014). This article explores the primary economic aspects of wind energy, including its cost-competitiveness, potential for generating money, and other factors that contribute to its financial viability.

One notable advantage of wind energy is its increasing affordability relative to other forms of energy. The capital expenditures associated with wind energy initiatives have seen a significant decline due to advancements in technology, economies of scale, and expedited project development processes. Moreover, the levelized cost of electricity (LCOE) associated with wind energy has seen a consistent downward trend, hence enhancing its economic attractiveness. As a result, wind power has emerged as a very cost-effective option for the establishment of new power facilities (Shields et al., 2021).

By the 19th century, both Denmark and Holland had a significant number of functioning windmills, exceeding 7,000 in each country. Between the years 1850 and 1970, a substantial quantity of miniature wind turbines with multiple blades was constructed in the United States, surpassing a total of 6 million units (Pachauri et al., 2014). Presently, it is approximated that around one million of these wind turbines remain functional. Fabric and wood windmills, which are affordable, continue to be used. The use of windmills is still seen in Thailand and the Valley of 10,000 Windmills located on the island of Create (Bili & Vagiona, 2018). The Danish government initiated a programme during the early 2000s aimed at establishing a series of wind-powered electricity generation facilities. Several European countries, such as the United Kingdom, France, Germany, and the United States, have initiated such projects (Wang et al., 2021). Nevertheless, the utilisation of wind energy had a decline and garnered little attention until the early 1970s, partly due to the widespread availability of inexpensive oil throughout the 20th century.

## Methodology

### Sampling strategy

The sampling strategy used in this research involves the selection of a sample consisting of 46 wind turbines for investigation. Specifically, 21 turbines were picked from the region of Kerala. The selection criteria for these turbines may be determined by several aspects, including but not limited to age, capacity, location, and operating history.

The study methodology includes the acquisition of primary and secondary data to assess the operational effectiveness and status of the chosen wind turbines.

### The data collecting techniques

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1. Field Visits and Inspections: Researchers undertake site visits to wind turbine installations in order to do visual inspections, gather empirical data, and evaluate the operational status of the turbines. The components under examination include rotor blades, towers, nacelles, electrical systems, and control systems.

2. Data Collection Methods: The research employs interviews and surveys as primary data collection techniques. Interviews are done with key stakeholders, such as wind farm operators, maintenance employees, and specialists in the wind energy field. Surveys may also be used as a means of collecting data pertaining to maintenance practises, operational difficulties, and the experiences encountered when turbines achieve their intended lifespan.

3. Utilisation of Secondary Data: This study makes use of secondary data obtained from a range of reputable sources, such as publications from the Tamil Nadu and Kerala Electricity Boards, KSE Regulatory Commission, Centre for Monitoring Indian Economy, ANERT (Agency for Non-Conventional Energy and Rural Technology), Energy Management Centre, Kerala State Planning Board, Tamil Nadu State Planning Board, U.N. Environment Programme, Energy Audit Centre, TRAC (Technical Research Assistance Centre), IEA (International Energy Agency), and OECD (Organisation for Economic Co-operation and Development).

By including data sourced from esteemed publications, this research guarantees the dependability and authenticity of the material used for the examination and assessment of the wind energy industry in Tamil Nadu and Kerala.

## Results

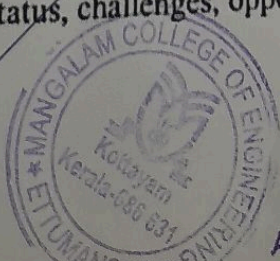
The term "installed capacity" pertains to the highest power output that wind farms are capable of generating under optimal circumstances. This metric denotes the aggregate power generation potential of the wind turbines situated at various locations. Wind farms are a kind of renewable energy infrastructure that harnesses the power of wind turbines to transform the kinetic energy of wind into electrical energy. The Muppandal wind farm, located in Tamil Nadu, has a total installed capacity of 1,500,000 kilowatts, equivalent to 1.5 gigawatts. The Thoothukudi wind farm, located in Tamil Nadu, has a total installed capacity of 50,400 kilowatts, equivalent to 50.4 megawatts. The Tirunelveli wind farm, located in the state of Tamil Nadu, has a total installed capacity of 51,000 kilowatts, equivalent to 51 megawatts. The Kanjikode KINFRA industrial park in Kerala is home to a wind farm with an installed capacity of 22,000 kilowatts, equivalent to 22 megawatts. The Muppandal wind farm, located in Tamil Nadu, has a total of 1,622 turbines and has a capacity to produce 1,500,000 kilowatts, equivalent to 1.5 gigawatts, of electrical energy. The Thoothukudi wind farm, located in Tamil Nadu, consists of 54 turbines that together provide an energy output of 50,400 kilowatts, equivalent to 50.4 megawatts. The Tirunelveli wind farm, located in the state of Tamil Nadu, has a total of 55 turbines and has the capacity to produce 51,000 kilowatts, equivalent to 51 megawatts, of electrical energy.

Table 1. State wise Wind farms and installed capacity

State	Wind farm	Electricity generated	
Tamil Nadu	Muppandal wind farm	1500MW (93.8%)	0.0003% of total



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# Selecting the Optimum Tool for Driving Performance Evaluation by Assessing the Ergonomic Methods—An Overview



Arun Chand , H. Mannikandan , and A. B. Bhasi

**Abstract** Ergonomic analysis of the driving environment is very essential for enhancing productivity and reducing musculoskeletal disorders (MSDs) of drivers. The proposed driver distraction model for heavy vehicles examines the influence of environmental, psychological, and vehicle design factors on driver performance. The main ergonomic risk factors include long driving hours, poor human-machine interface, incorrect driving posture, vibration due to bad road conditions, driver sleepiness and age. To evaluate the effect of these factors on driving performance which leads to MSDs, different ergonomic methods/techniques are available. Selecting a single tool from these methods is quite difficult due to the heterogeneity of driver ergonomic parameters. To find the optimum tool, different features of the ergonomic methods were identified and compared. Integration of these tools used for ergonomic analysis was an outcome of the advancements in machine learning technology which resulted in digital human modelling (DHM). DHM combines computer-aided design, human factors management, and risk evaluation.

**Keywords** Human factors · Musculoskeletal disorders · Driver fatigue · Ergonomic tools · Digital human modelling

## 1 Introduction

Subsequent paragraphs, however, are indented. Driver ergonomics have been identified as a source of concern that contributes significantly to traffic accidents. Driver fatigue is a function of ergonomic issues related to driving. Fatigue is a state of exhaustion caused by extended periods of driving, tedious road conditions, and a poor environment or the driver's features [1]. Driver fatigue caused by ergonomic issues also leads to a reluctance to drive and a complete withdrawal of attention

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227

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from traffic and road conditions [2]. Although previous researchers have debated the matter in numerous domains, they have still come up with the importance of driver ergonomics and its effects on driving performance.

One of the most critical safety concerns in reducing road transport accidents is the management of heavy-truck driver ergonomic issues. Heavy vehicle drivers are responsible for 25% of traffic accident deaths on highways, worldwide [3]. It is found that personal fatalities are more than any other type of vehicle accident, in each heavy-duty accident [4]. Driver associated factors are determined to be significant causes in most accidents. Major health problems like musculoskeletal disorders (MSDs) are a common health concern and a major source of occupational illness of heavy-duty drivers [5]. Many researchers have examined heavy-duty driver fatigue, its roots and effects, as well as solutions for reducing the frequency of accidents caused by it [6–8]. The best technique to evaluate driver ergonomic issues has been a long history of incoherence in the transportation sector even though it is critical for the health and safety of heavy-duty drivers. It is critical to accurately assess a driver's exposure to ergonomic factors that may lead to the growth of MSDs. Various methods and mechanisms for evaluating exposure to ergonomic risk factors for driving-related MSDs have been developed. According to the measurement technique, they can be grouped into self-report, direct measurement, and observational methods [9]. However, these three divisions have their pros and cons when dealing with the assessment settings.

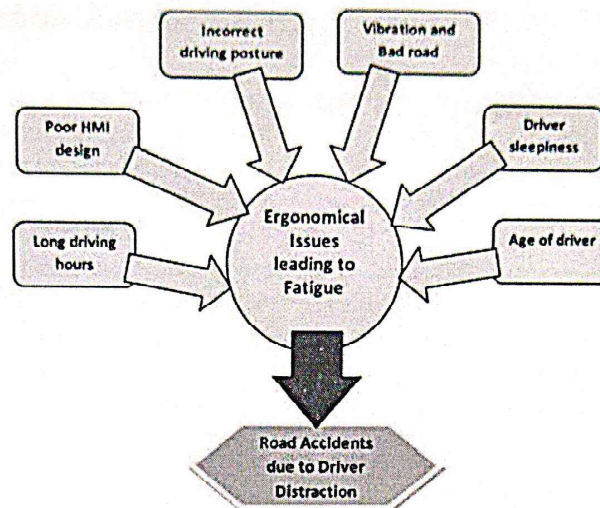
Most of the countries have spent decades attempting to understand the issues and reasons underlying driver ergonomic health impacts. There is a dearth of study on ergonomic impacts on driving performance in developing countries, especially India [10, 11]. Limited data is available to address the ergonomic concerns of heavy-duty drivers, indicating a significant gap in the literature that needs to be addressed. This study paves the way for the inquiry into the impacts of factors affecting driver ergonomics and discusses the issues that should be considered when selecting and using an assessment instrument. The significance of developing the optimal tool for resolving ergonomic challenges of heavy-duty drivers is also presented.

## 2 Human Factors in Heavy-Duty Vehicle Driving

The importance of human factors in safe driving identifies that a combination of environmental, psychological, and vehicle design factors influence driver performance [12]. In contrast to normal, drivers of heavy vehicles are more exposed to the road because of the lengthy travel schedules and distances [13]. Driver ergonomics and fatigue management is tough issue, especially if the aim is to preserve public safety on the road. But a little data is available which could reveal the influence of ergonomic factors on the heavy-duty vehicle driver's safety, especially in developing countries like India. This is because multiple aspects have to be examined and understood simultaneously for recording the effect of the driver ergonomic scenario. A driver distraction model for heavy vehicles is developed from the literature survey, and it focuses on the research gaps connected to driver ergonomics and regulations



Fig. 1 Factors affecting the driver ergonomics



impacting driver fatigue. This model is divided into six major areas: long driving hours, poor human-machine interface, incorrect driving posture, vibration due to bad road, driver sleepiness, and age of the driver (Fig. 1).

## 2.1 Long Driving Hours

Abledu et al. [14] used a Nordic-musculoskeletal semistructured questionnaire to inspect the frequency and consequences of long driving hours related MSDs among 148 commercial bus drivers in Ghana. The results showed that 116 (78.4%) participants had experienced MSDs in the past twelve months. Neck pain (25%), low back pain (59%), shoulder pain (18%), upper back pain (22%), ankle pain (10%), knee pain (15%), elbow pain (5%), thigh pain (3%), and wrist pain (7%) were the most predominant MSD areas. Multiple-logistic regression investigation adjusted for probable confounders exhibited that fewer physical movements ( $OR = 4.9$ ; 95%  $CI = 1.5-16.5$ ;  $P = 0.010$ ), driving over 12 h in a day ( $OR = 2.9$ ; 95%  $CI = 1.1-7.8$ ;  $P = 0.037$ ), and driving not less than 5 days in a week ( $OR = 3.7$ ; 95%  $CI = 1.4-9.4$ ;  $P = 0.007$ ) were particularly related with MSDs amongst the group of bus drivers. Wise et al. [15] found from their concept analysis research that long-distance heavy-truck drivers are at risk of cognitive, psychological, and physical fatigue. This influences the safe travelling of long-distance heavy-truck drivers and other stakeholders of roadways also.



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## 2.2 *Poor Human–Machine Interface (HMI)*

Pickering et al. [16] developed a test environment to ascertain driver preferences regarding dashboard and console designs, as well as attention performance and appropriate real-time responses for various driver demographics. The test environment was capable of providing speed, position, acceleration, and rear proximity sensing, in a 25-min test drive route. The most prevalent cause found was an operational error, such as a failure to grasp or act on information presented on the vehicle console, or an inability to handle the vehicle properly. The driver's abilities could be showcased from the test data results. Additionally, the platform features driver-selectable instrument clusters and LCD panel configurations. The findings demonstrated the critical role of HMI design in promoting physical ergonomics and reducing musculoskeletal diseases.

## 2.3 *Incorrect Driving Posture*

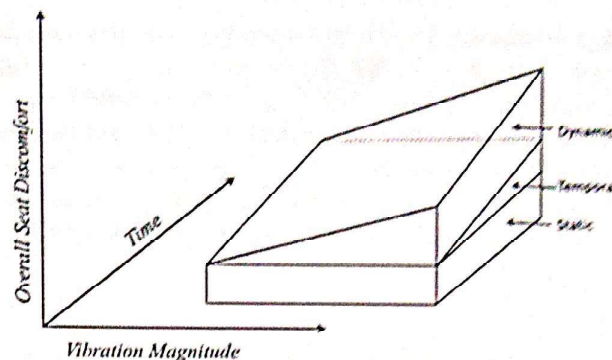
In a year, truck drivers spend nearly 2400 h on the road [17]. Physical injuries and the development of MSDs can be avoided, and vehicle drivers can stay comfortable and healthy by selecting the right position for the body and avoid stretching regularly. Through a virtual test, Xing et al. [18] quantified the stability of the driving posture and the driver's subjective evaluation of modules and seat supportive qualities, as well as the efficiency of the enhanced seat models. The findings of the study could be used to strengthen basic investigations into the stability of the driving posture and pedal controls, as well as trunk and thigh angles. Also, guidelines were established for the creation of a seat support design for truck drivers' upright seated postures.

## 2.4 *Vibration and Bad Roads*

Raffler et al. [19] used direct field assessments and self-reported data from 45 truck drivers to compare the physical burdens of whole-body vibration (WBV) and inconvenient posture. Also, manual materials handling and MSDs were examined to determine their effect on drivers' perceptions. While the measured WBV exposure levels were quite similar among the drivers, the respondents' perceptions varied significantly. With regard to posture, respondents appeared to estimate far more accurately when the variation in exposure was high. The percentages of the awkward trunk and head inclination evaluated in WBV overestimating drivers were significantly greater than in non-overestimating drivers; 77 and 80% versus 36 and 33%, respectively. Other health issues with the spine (42%), neck (67%), and the upper arm (50%) were substantially more frequently reported by WBV-overestimating drivers as opposed to non-overestimated drivers (0.25%, 13%, and 0%). The study used a comparison of



**Fig. 2** An improved model of car seat discomfort including static, dynamic, and temporal element



field and questionnaire data to identify the elements influencing drivers' perceptions of WBV exposure and found that musculoskeletal and posture issues significantly influenced the opinion of WBV-exposed drivers. Previously, a hybrid theoretical model for predicting overall discomfort was proposed [20], a schematic of which is presented in Fig. 2. Static, dynamic, and temporal elements are used in the model to provide the complete assessment of overall discomfort.

## 2.5 Driver Sleepiness

Bener et al. [21] used the multivariate logistic regression to show that driving-related fatigue, excessive speed, lapses, Epworth sleepiness score, and errors were all significantly related to the probability of a motor vehicle accident, once demographic factors were taken into consideration. The research also analysed that fatigued drivers, who have both chronic sleepiness and abnormal exhaustion, substantially increase their chances of a traffic accident which can result in severe injuries. Zhang et al. [22] conducted a naturalistic driving study (NDS), with the data collected from 34 professional drivers. After determining the level of fatigue in all drivers using the Karolinska sleepiness scale (KSS), the KSS data was transformed to successive values and modelled using curve fitting techniques. The findings indicated that fatigue prediction results are strongly related to driving performance by predicting the risk driving period and the maximum repeated driving time once the driving schedule is determined. The fatigue due to driving can be avoided or mitigated through optimization of the driving and break work schedule.

## 2.6 Age of the Driver

Depestele et al. [23] showed through statistical results that middle-aged drivers are less inclined to read an SMS/email or check online social media while driving. Heavy



vehicle drivers aged 20–25 have reported steadily increased driving distraction and fatigue rates and higher positive rates of societal and individual acceptance than drivers from 35 to 54 years of age. Elder drivers aged 65 and over reported reduced rates and acceptability of these practices. Many researchers have shown that younger drivers are more prone than non-lane-hanging drivers to be involved in accidents while changing lanes. The decrease in cognitive, sensory, and motor abilities could be the main reason that older persons are more sensitive to driver distraction.

### 3 Ergonomic Methods for Assessing Exposure to Driving Risk Factors

Numerous ergonomic assessment techniques have been created and classified into three broad groups. Selecting the most appropriate technique or combination of methods from this spectrum of existing methodologies poses a major difficulty. To provide an effective and healthy driving environment, it is important to combine these approaches with the understanding of the anatomy of the body and how it reacts to loads. The three sets of methods, as well as the names of the techniques and their features, to evaluate if drivers are at risk when engaging with the vehicle environment, are listed in Table 1.

The approaches presented in Table 1 could be found in many of the independent software applications and design packages. Design software such as Delmia, Jack, winOWAS, CATIA, HSE.Ergo.QEC, ProE, ViveLab, 3DSSPP, ErgoSoft includes OWAS, REBA, RULA, ROSA, MAPO, QEC, NIOSH lifting equation, APSA, EAWS, KIM-MHO, NPW, WERA, cognitive databases and strain index. Ergo-Plus, ViveLab, and ErgoSoft are major video-based ergonomic analysis software that is used for action detection and exploratory risk assessment of musculoskeletal disorders.

### 4 The Development of an Integrated Ergonomic Tool—Digital Human Model (DHM)

The input to the ergonomic analysis is highly reliant on the technique of observation or sensitivity measurement used. Thus, the structure of ergonomic evaluation is dependent on the available resources and the features of the driving environment. The hybrid character of ergonomic issues requires the use of various instruments for a complete ergonomic evaluation. Digital human modelling techniques incorporate a variety of strategies that integrate different ergonomic tools to evaluate driving environment design, analyse human-machine interface compatibility, and determine risks of musculoskeletal disorders. Modern technology offers analysis methods for dynamic human modelling and problem identification by combining



**Table 1** Ergonomic methods for evaluating risk factors for MSDs associated with driving [24, 25]

Types of methods	Name of techniques	Main features
1. Self-reports	1. VIDAR-Self-evaluation of the driver using videos of the driving process 2. Interview, category data, and visual analog scales 3. Evaluation of possible ergonomic risks employing a web-based tracking system	1. Driver load ratings and associated pain and discomfort estimations 2. Identification of variables that increase a driver's psychosocial risk for shoulder and neck pain 3. List of comfortable ergonomic positions that might help prevent discomfort, workplace stress, and functional restrictions
2. Observational methods	1. RULA 2. REBA 3. OWLS 4. QEC 5. LUBA 6. Checklist 7. NIOSH lifting equation	1. Concepts like body postures and force, together with action levels for evaluation 2. Elements of biomechanics include body postures and force, with activity levels for assessment 3. Force and body posture evaluation 4. Driver reactions to major body areas, as well as scores to suggest intervention 5. Angular displacement of the joint from neutral and discomfort evaluation 6. Displacement of neck, legs and trunk for repeated tasks 7. Driving posture is associated with biomechanical stress
2.a. Advanced observational methods	1. Video analysis 2. ROTA 3. TRAC 4. HARBO 5. SIMI motion	1. Hand/finger posture assessment, repetitiveness, force, velocity, and body postures are computed. Task evaluations, both static and dynamic 2. Static and dynamic task evaluation 3. Posture and activity analysis 4. Observation of different driving activities over a long period 5. Dynamic movements of the limbs and upper body are assessed

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Table 1 (continued)

Types of methods	Name of techniques	Main features
2.b. Productivity analysis	1. ErgoSoft 2. ErgoMOST 3. EMA	1. Motion analysis evaluation and early risk assessment for musculoskeletal disorders 2. The neck, upper limbs, lower limbs, and back are evaluated for risk 3. Virtual ergonomics, the collaboration between humans and robots, three-dimensional production planning, and human simulation
3. Direct methods	1. LMM 2. Body posture scanning systems 3. EMG 4. Cyberglove 5. Inclometers 6. Electronic goniometry	1. Assessment of back posture and motion 2. Measurements of displacements, velocities and accelerations of a body segment 3. Estimation of variation in muscle tension and force application 4. Measurement of the wrist, hand and finger motion with superimposed grip pressure 5. Measurement of postures and movement of the head, back and upper limbs 6. Measurement of angular displacement of upper extremity postures
3.a. Biomechanical models	1. Evaluation of Muscle effort and back stress 2. Static strength prediction programme—3D	1. Estimation of driving-related internal exposures 2. Body-integrated segmental representations
3.b. Psychophysical indices	1. Psychophysical databases; 2. Borgs scale of perceived exertion 3. Body part discomfort scale	1. Assessment of quantitative and qualitative variation in individual human reactions (heart rate variability, eye blink rate, etc.) to mental load 2. Measurement of high heart and respiration rate, profuse perspiration and muscle exertion 3. Evaluation of driver's direct experience of discomfort at different body parts

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Table 1 (continued)

Types of methods	Name of techniques	Main features
3.c. Cognitive tools	1. GSR 2. Heart rate variability (HRV) 3. EEG 4. NASA TLX 5. RSME 6. SWAT	1. Evaluating accuracy and reaction time 2. Assessment of mental demand, decision-making and skilled performance 3. Detection of abnormalities in brain waves and electrical activity of the brain 4. Assessment of time load, mental effort load and stress load 5. Assessment of reaction time, correct action and ratings 6. Assessing driving activity laps and errors

powerful CAD tools. DHM combines CAD, human factors management, and risk evaluation. Computer-generated human models, called computer manikins, are used to augment the computer software with algorithms for ergonomics assessments. RAMSIS, human builder, V5 HUMAN, Delmia, and JACK are some modern DHM software programmes that include CAD packages for simulating body positions, physiological parameters and inspecting ergonomic challenges [26].

Using DHMs, designers can render a digital representation of human beings in software that has all or part of the human qualities and abilities, hence eliminating the iterations of the design. DHMs are beneficial for design ideas in the CAD environment, as they assist designers to visualize driver-machine interaction, driver engagement, and aid in making design adjustments early on in the design process. DHMs are generally utilized in tandem with CAD systems to allow designers to conduct ergonomic analyses of driver-vehicle interactions and examine how vehicle design factors affect human occupants [27, 28].

## 5 Conclusions

Ergonomics and driving environment design issues in heavy-duty drivers play a significant impact in traffic fatalities. Several countries have not yet taken this issue as a major concern and casualties are growing. Both driver and vehicle-related ergonomic issues are prominently affected by heavy vehicle drivers. The different ways to measure the ergonomic aspects of drivers were identified, and these methods will help in finding the importance of the scenario. Choosing the most appropriate technique or combination of methods from the vast array of current approaches would help in assessing and determining the risks of musculoskeletal difficulties of drivers.



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Digital human modelling is found to be the optimum solution that integrates most of the ergonomic assessment techniques.

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# Experimental Investigation of the Hydrophobic and Modal Properties of Epoxy Nanocomposites Reinforced with Graphene Nanofillers

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**Abstract** In this paper, the hydrophobic and modal properties of the graphene nanofiller-reinforced polymer composites are investigated using an experimental approach. The graphene nanofiller-dispersed epoxy composite enhanced hydrophobic properties compared to pure epoxy, as these composites exhibited high contact angles and reduced water absorption after the experimental testing for water absorption and contact angle analysis. The enhanced performance of the graphene nanofiller composite was mainly attributed to the formation of a passive film from uniformly dispersed graphene nanofillers, which acted as a physical barrier on the composite surface. The graphene nanofillers in the epoxy composite surface during curing resulted in creating a hydrophobic surface, thereby altering the surface energy and intensifying the hydrophobicity of the epoxy surface. The work of adhesion and spreading coefficients were also determined for the composites. This study also analyses and compares the modal properties by performing an impact hammer test. The results showed that the reinforcement of graphene nanofillers in the composites significantly enhances the modal properties of the composites.

**Keywords** Nanocomposite · Graphene · Water absorption · Contact angle analysis · Modal analysis

## 1 Introduction

In recent years, polymers containing nanomaterials such as carbon nanotubes (CNT) and graphene have emerged as a significant field of research in composite hybrid materials. The need for composite hybrid materials in aeronautical, mechanical, and civil systems is steadily increasing [1]. Graphene gaining importance as filler which are held together by van der Waals force, introduction of surfactants with solvents may decrease the van der Waals interactions between the graphene layers and hence increase the interlayer spacing. Epoxy resins got superior mechanical properties and resistant to chemical degradation. The behavior of epoxy to get excellent compatibility to filler material embedded inside thereby making good covalent bonds with epoxy matrix given property enhancements. Intercalation and exfoliation of the filler materials inside epoxy follow various protocols such as use of solvent and dispersion techniques. The various dispersion techniques like ultra-sonication, ball milling, mechanical stirring and magnetic stirring are commonly adopted.

Graphene oxide (GO) is devoid of proper lattice structure, thereby lacks the chemical and physical properties due to the abundant functionalities on the structure [2] but upon reduction much of the surface functionalities get restored thereby forming pristine graphene [3]. The solvothermal reduction of graphene oxide yielding graphene-decorated graphene quantum dots (GDGQD) enhances the mechanical and thermal properties of the composite considerably which is due to the interfacial interaction and also the dielectric performance increases due to the higher charge accumulation [4]. For

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graphene oxide which has larger interlayer distance, upon reduction the interlayer distance get reduced but can be suited for attaching wide functionalities interaction on the surface thereby effectively tailoring the interlayer distance [5]. In the case of CNT, thermal decomposition influences final product characteristics like long, properly aligned CNT composites [6] with vertically aligned CNT on graphene with C–C bonding suits in 3D interconnect network for three-dimensional load withstanding applications [7]. Even though epoxy resins are superior in strength and stiffness, resistant to high temperature, lower shrinkage, low volatility and the absorption of the moisture degrades the performance of the composites [8]. The reduction of graphene enhances the various mechanical properties of the epoxy resins [9]. The study of the wetting phenomena of polymeric composites is an emerging research area [10]. The surface properties measurement of solids by contact angle technique of liquids on solid surfaces is a suitable experimental method thereby quantifying the experimental results. The extent to which a liquid spreads on a solid surface is determined by wettability of the surface. The surface energies of the medium and the contact angle subtended are crucial in determining the interfacial properties linking the surface of the polymer and liquid. The contact angle method is the basic tool and extremely valuable technique in surface science to investigate the interfacial phenomena. It is determined by the angle made by the wetted solid surface and tangent to drop surface in context of three-phase contact.

Recent research has revealed that nanoparticles may dampen vibrations in aircraft structures. The composite structure has a good damping response compared to other monotonic materials [11]. CNT reinforcement has been demonstrated to have a significant impact on the mechanical behavior of CNT-reinforced epoxy composites in the past [12]. Noor [13] developed three-dimensional elasticity solutions for the free vibration of composite-laminated plates that are isotropic, orthotropic, and anisotropic in nature. According to research done by Sobhy [14] on the vibration and buckling behavior of sandwich plates made of exponentially graded material (EGM) resting on elastic foundations under various boundary conditions, vibration frequencies and buckling loads rise as side-to-thickness ratios and aspect ratios decrease. Additionally, a plate in uniaxial compression has a higher critical buckling stress than a plate in biaxial compression. According to Natarajan [15], the deflection decreases as the volume percentage of the CNT dispersion increases. Helong Wu et al. [16] studied free vibration analysis of functionally graded graphene platelet-reinforced composite (FG-GPLRC) beams where the interaction reduces the fundamental frequency most, but it hardly affects the first-order vibration mode. GPL distribution pattern, weight fraction and dimension, fluid depth and density, beam geometry and end supports influence the free

vibration behavior. The hydrophobic and modal characteristics of graphene nanofiller-reinforced polymer composites have not been addressed in the studies mentioned above. As a result, it's crucial to know how graphene nanofillers reinforcement affects polymer composites' hydrophobic and modal characteristics. Graphene nanofillers obtained by reducing the graphene sheets by removing the oxygen-containing groups thereby recovers the conjugated structure. Residual functional groups and defects dramatically alter the structure of the carbon plane. Graphene nanofillers in comparison with graphene has two important characteristics like highly hydrophobic due to lack of polar entities and devoid of defects retaining conjugated structure.

In this paper, the hydrophobic and modal properties of the graphene nanofiller-reinforced polymer composites are investigated using the experimental approach. The graphene nanofiller-dispersed epoxy composite enhances hydrophobic properties compared to pure epoxy, as these composites exhibit high contact angle, reduced water absorption after the experimental testing for water absorption and contact angle analysis. This study also analyzes and compares the modal properties by performing experimental vibration test.

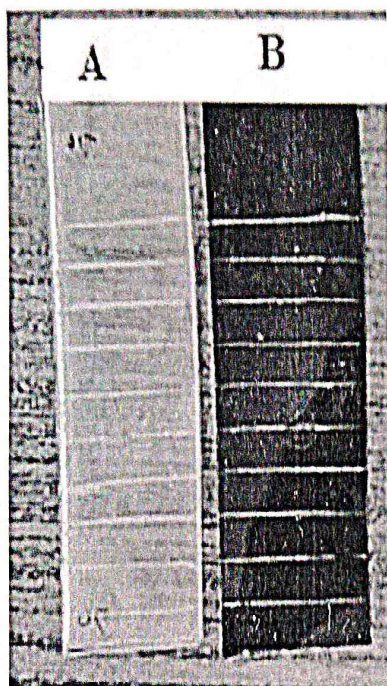
## 2 Fabrication of Epoxy/Graphene Nanofiller-Based Composites

The graphene nanofillers obtained after solvothermal reduction was mixed in ethanol and sonicated for 30 min. Then the DGEBA epoxy was added into the solution and then ultrasonicated for 1 h while maintaining in ice bath. The mix was kept on a magnetic stirrer with hot plate at 250 rpm for 1 h at 50 °C so that the ethanol got evaporated completely. Degassing was performed in vacuum oven for the mixture followed by the addition of the curing agent in the ratio 1:10. The samples were prepared by open mold casting with proper dimensions followed by post-curing for 24 h at 70 °C. The fabricated specimens are shown in Fig. 1. The graphene nanofillers are obtained by solvothermal reduction of GO where the graphene quantum dot dimensions of about ~20 nm are found out in the magnified TEM image (Fig. 2) and hence confirming the presence of graphene quantum dots (GQDs).

## 3 Experimentation of Epoxy/Graphene Nanofiller-Based Composites

ASTM D570 was adopted for the preparation of samples for water absorption test. Initially specimen was kept in hot vacuum oven at 70 °C so that a constant weight gained. Followed by samples dipped in water at room temperature. The weight gained by the samples by water absorption was taken in proper





**Fig. 1** (A) Pure epoxy (B) graphene nanofiller-reinforced epoxy composite

intervals of time for a duration of 1 month. The weighing balance got a precision of 0.1 mg. The percentage gain in water retention at a specific time  $t$  ( $M_t$ ) was evaluated by Eq. (1):

$$M_t = \frac{W_w - W_d}{W_d} 100\% \quad (1)$$

where  $W_d$  and  $W_w$  denote the weight of specimen before and after water absorption test, during a particular time period.

Contact angle measurements test was used for measuring the surface tensions of liquid on solid surfaces [17, 18]. The experiment was conducted on the instrument named KRÜSS ADVANCE with Sessile drop assumption. In order to evaluate the solid interfacial tension between liquids and solid surfaces, the contact angle method was adopted easily with different techniques [19, 20]. Thomas Young in 1805 formulated equation for contact angle using the parameters such as surface energies of the solid and liquid that is given by Eq. (2) [21]:

$$\cos \theta = \frac{\gamma_s - \gamma_{sl}}{\gamma_l} \quad (2)$$

where the contact angle is denoted by  $\theta$ , the surface energy of the solid is indicated by  $\gamma_s$ , the surface energy of the liquid



(a)



(b)

**Fig. 2** (a) TEM images of graphene nanofillers and (b) enlarged image of graphene nanofillers

is denoted by  $\gamma_l$ , which is 72.8 mJ/m<sup>2</sup> for water, and  $\gamma_{sl}$  is the interfacial free energy between the solid and the liquid.

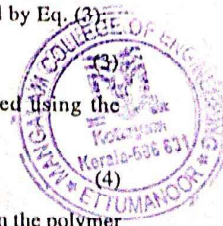
The work of adhesion ( $W_a$ ) was evaluated by Eq. (3):

$$W_a = (1 + \cos \theta) \gamma_l \quad (3)$$

The interfacial free energy was evaluated using the Dupre's equation [19] (4):

$$\gamma_{sl} = \gamma_s + \gamma_l + W_a \quad (4)$$

The spreading coefficient ( $Sc$ ) [22] between the polymer and the liquid was evaluated using Eq. (5):



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$$S_c = \gamma_s - \gamma_{sl} - \gamma_l$$

(5)

#### 4 Water Absorption Test of Epoxy/Graphene Nanofiller-Based Composites

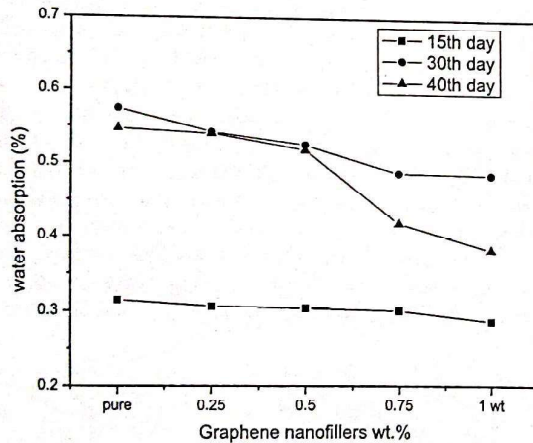
Water intake by the pure epoxy and epoxy/graphene nanofiller composites is shown in Fig. 3. Three specimens each were tested for water absorption from each category. The water intake by the composites reached a steady-state condition after 30 days that can be stated as a quasi-static state. But the intake of water recommenced after quasi-static state [23]. However, due to the polar behavior of water molecules they can just remain in micro-voids and get clustered. The oozing out of water cluster took place because of the enormous size of water cluster that the void can accommodate. The clustered water molecules got linked with oxygenated functional groups of the epoxy. The water absorption tendency is considered to rely upon free volume properties, polar group density of the epoxy [24]. The water intake by epoxy/layered

silicate nanocomposites was reported lower than pure epoxy [24]. The water molecules could infiltrate through the epoxy network and is credited by the type, nature, and behavior of the thermoset which got strong affinity toward water.

The hydrophilic functional groups of epoxy such as hydroxyl or amine groups got coupled with water molecules. The water molecules form hydrogen bonding with hydrophilic entities of epoxy resin [25]. The water retention is credited by its greater attraction toward the functional groups of the epoxies, having high polar behavior with water molecules [26]. Water infiltration to the epoxy network happens by (i) free water prickling into the composites thereby filling micro-voids, and (ii) bonding of the water molecules with the polar group of epoxy matrix [27]. From Table 1, it's clear that the resistance to water absorption of epoxy was enhanced with the embedding of graphene nanofiller, which could be attributed to the increased hydrophobicity of the composites.

#### 5 Contact Angle Test of Epoxy/Graphene Nanofiller-Based Composites

The contact angle is a measure of the ability of a liquid to wet the surface of a solid. The shape that a drop takes on a surface depends on the surface tension of the fluid and the nature of the surface. The surface tension between the droplet and atmospheric air leads to the curved shape of the droplet. Here due to the composites hydrophobic nature, contact angle increased and this increased further with concentration of graphene nanofiller. The molecular force of attraction between the liquid and the composite surface reduced as the surface energy of the composite reduced and thereby an increase in hydrophobicity of the epoxy surface [28]. The contact angle got increased from  $43.68 \pm 0.873$  for the pure epoxy to  $45.64 \pm 0.912$  for 0.25 wt.% graphene nanofiller,  $46.74 \pm 0.934$  for 0.5 wt.% graphene nanofillers, and  $55.66 \pm 1.113$  for 0.75 wt.% graphene nanofiller. However, with 1 wt.% graphene nanofiller, the contact angle decreased to  $45.99 \pm 0.919$  as there was aggregation of fillers at the epoxy surface. Here the oxygenated functionalities such as



**Fig. 3** Water absorption for various epoxy/graphene nanofiller composites

**Table 1** Water absorption for the various graphene nanofiller-epoxy samples

Samples	15th day	% Reduction in water absorption	30th day	% Reduction in water absorption	40th day	% Reduction in water absorption
Pure epoxy	0.314	0	0.574	0	0.547	0
0.25 wt.% graphene nanofiller	0.306	-2.54	0.543	-5.4	0.541	-1.09
0.5 wt.% graphene nanofiller	0.304	-3.18	0.526	-8.3	0.519	-5.11
0.75 wt.% graphene nanofiller	0.301	-4.14	0.488	-14.9	0.419	-23.4
1 wt.% graphene nanofiller	0.287	-8.59	0.486	-15.3	0.383	-29.9



hydroxyl, carboxyl, groups of graphene sheets reduced and generation of new C-N bonds, gained non-polar nature to the surface and a higher contact angle as there is a reduced surface free energy for the composite [29]. A lower contact angle was attained [30] when the cohesive interaction, which aids in a drop's formation of a sphere, gained dominance over the adhesive interaction, which causes the liquid to spread. Cohesive and adhesive molecular forces act on liquid molecules and on solid molecules, respectively. Adhesive force strongly decides the free surface energy, while it scarcely influences the high filler concentration due to the agglomeration.

The work of adhesion ( $W_a$ ), for various samples, is shown in Fig. 4. It's the work needed to set apart the solid and liquid surfaces, when the liquid droplet is tried to displace over the solid surface on account of graphene nanofiller variation in epoxy composites. It's obvious from Fig. 4, which shows the disparity of  $W_a$  regarding change in graphene nanofiller loading in epoxy. The disparity can be closely linked to the hydrophobic nature of the composites that is due to the reduced oxygenated functionalities on the graphene nanofiller surface. The solid surface free energy of the composites decreased and thereby the work of adhesion got decreased. The adhesion of dissimilar materials is determined by the molecular force of attraction. The surface energy of the substrate affects the attraction's potency. Strong molecular attraction is indicated by high surface energy, whereas lesser attractive interactions are indicated by low surface energy. The interaction between the liquid and solid surface got lower compared to the neat polymer. It's reported that the work of adhesion is directly proportional to filler loading into PVC films where it is significantly improved [31].

The spreading coefficient ( $Sc$ ) for the various samples is shown in Fig. 5. The  $Sc$  gives the extent to which the liquid

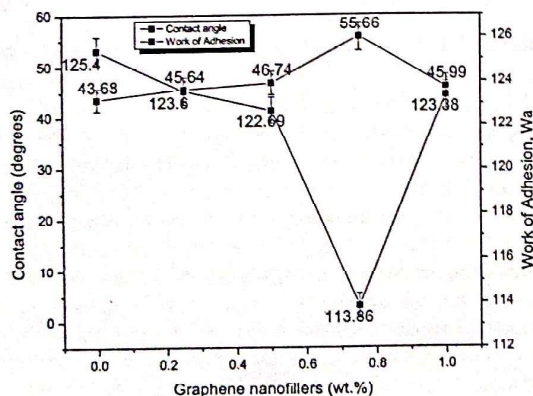


Fig. 4 Contact angle and work of adhesion for various graphene nanofiller/epoxy samples

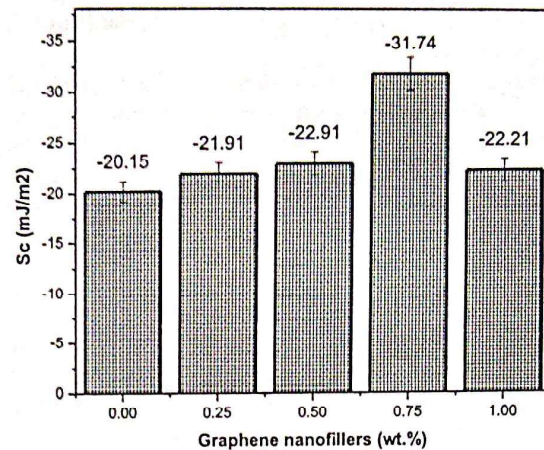


Fig. 5 Spreading coefficient ( $Sc$ ) vs various graphene nanofiller/epoxy composites

will wet and spread on the solid surface voluntarily for a positive  $Sc$  value, while a negative  $Sc$  value implies the lack of voluntary wetting and spreading thereby the existence of a finite contact angle (i.e.,  $\theta > 0$ ). Here the wetting due to water comes down with increase in the graphene nanofiller in the epoxy. The excess non-polar groups on the surface influence the hydrophobicity [32]. The enhancement in the hydrophobicity of the surface depended on the filler particle's fine dispersion within the matrix. Here the graphene nanofiller is solvothermally reduced form of GO, and hence lacks the sufficient oxygen-containing functional groups [33], thereby reducing the wetting behavior of the composites.

## 6 Modal Analysis of Epoxy/Graphene Nanofiller-Based Composites

Figure 6 shows an experiment on a small-scale model of a graphene nanofiller-reinforced polymer composite beam with dimensions of 70 mm in length, 70 mm in width, and 5 mm in thickness under a cantilever end condition to illustrate how the modal analysis of the nanocomposite is used to explain the behavior of the composite material. DGEBA epoxy resin and hardener were used to construct the polymer composite beam and conduct the experimental test. The graphene nanofiller-reinforced polymer composite beam was excited using an impact hammer, and a sensor was installed at the top layer of the composite beam to collect reaction signals from the excitation. As observed in the Dewesoft software display unit, the data acquisition system (DAQ) was employed to transform the response signal to a frequency response function [34, 35]. The modal responses of graphene nanofiller-reinforced polymer composite beam were



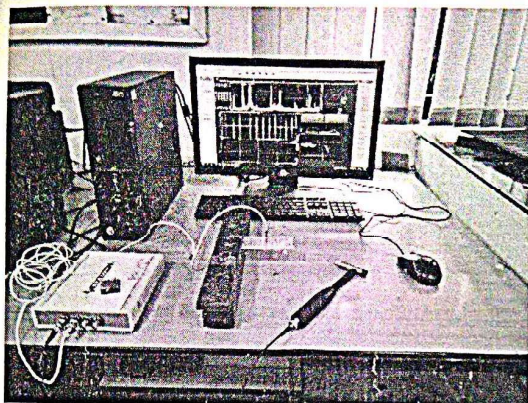


Fig. 6 Modal analysis test setup

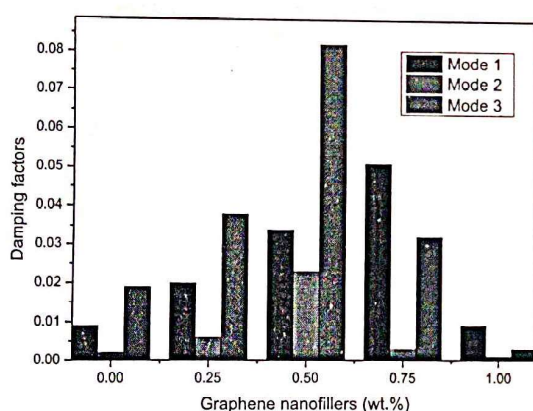


Fig. 7 Damping factors at various modes for different graphene nanofiller concentrations

measured experimentally, as shown in Fig. 6 and the results have been presented in Fig. 7.

The modal characteristics such as damping factors of the various weight percentages (0, 0.25, 0.5, 0.75, and 1) of graphene nanofiller-reinforced polymer composite beams under cantilever boundary conditions are given in Fig. 7. From the experimental results, it can be seen that the polymer composite beams with 0.75 wt.% of graphene nanofillers reinforcement has higher damping than those of the other composite beams. The first mode defines the maximum loads that the beam can withstand or how the structure will interact with the rest of the system when vibrating. As the first mode of damping is highest for the 0.75 wt.% concentration, it is expected that this is due to the higher interfacial bonding. The same concentration gains the highest hydrophobic properties. Thus, 0.75 wt.% is the optimal concentration.

## 7 Conclusions

The hydrophobic and modal characteristics of graphene nanofiller-reinforced polymer composites are examined in this work. The wetting behavior exhibits remarkable variation in the case of graphene nanofillers embedded into epoxy composites. The enhanced hydrophobicity of composites is observed with the increase in contact angle value with that of pure epoxy. The non-polar nature of graphene nanofillers is responsible for the increased hydrophobicity of the composite thereby reducing water absorption. The GO is hydrophilic in nature due to the presence of oxygenated functional groups on the surface but upon reduction of GO, the oxygenated groups are reduced thereby the hydrophobic nature persists in the epoxy with graphene nanofillers composites. This study also analyzes and compares the modal properties by performing experiments using impact hammer testing. The results show that adding graphene nanofillers reinforcement to the polymer composites improves their modal characteristics. In summary, the effect of graphene nanofillers in epoxy is that it abates the wettability as well as water absorption and enhances the modal characteristics of the polymer composites.

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## Effect of Squeeze Pressure and Strontium Addition on Tribological and Mechanical Properties of Al–Si Piston Alloy with Varying Amount of Ni

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**Abstract** Engine pistons manufactured from Al–Si are a particular set of industrial alloys which requires excellent characteristics at higher temperatures (nearly 400 °C). Concurrently, such alloys persist in retaining the properties to abrupt variation in temperature. As a result, the mechanical, tribological and thermal strains needs to be seriously examined unless ignoring the aggressive surroundings, in which they are revealed through exploitation. For performing such a group of requirements, Al alloys allocated for piston manufacturing requires an appropriate microstructure. The alloy microstructure depends on the type and percentage of composition, the casting parameters and schedule of the heat treatment cycle. Typical choices for few alloying elements are in the range 11–23Si; 0.5–3 Ni; 0.5–5.5Cu and 0.6–1.3 Mg. The author presents the benefits of squeeze casting on the microstructure and its characteristics of aluminum–silicon piston alloys. Piston alloys with variable Ni content was investigated experimentally. The role of the heat treatment on the microstructure and properties of the alloys was studied. The role of Sr on Al–Si piston alloy was also examined. The present study aims to develop a novel alloy for piston applications that operates at a higher temperature and high peak firing pressure of the engine. It can be accomplished by adding an alloying element such as Ni to Al–12Si–3Cu–1 Mg–xNi (x varies between 0.5 and 2.5Ni) alloy. Based on mechanical properties and microstructural characteristics, the ideal alloy composition is selected for further research. Later, the role squeeze pressure on the microstructural

features, tribological properties and mechanical characteristics on the piston alloys are studied and correlated.

**Keywords** Aluminum alloy · Heat treatment process · Microstructure characteristics · Mechanical characteristics · Squeeze casting

### 1 Introduction

Engine pistons manufactured from Al–Si are a particular set of industrial alloys which requires excellent characteristics at higher temperatures (nearly 400 °C) [1–3]. Concurrently, such alloys persist in retaining the properties to abrupt variation in temperature [3]. As a result, the mechanical and thermal strains needs to be seriously examined unless ignoring the aggressive surroundings, in which they are revealed through exploitation [4]. For performing such a group of requirements, Al alloys allocated for piston manufacturing requires an appropriate microstructure. The alloy microstructure depends on the type and percentage of composition, the casting parameters and schedule of the heat treatment cycle. The mechanical characteristics of cast parts significantly depend upon the alloy's microstructure [5]. Piston alloys consist of a varying number of alloying elements. Typical choices for few alloying elements are in the range 11–23Si; 0.5–3 Ni; 0.5–5.5Cu and 0.6–1.3 Mg [4].

Representative Al piston is too complicated about its chemical compositions and the attained microstructures. The author observes a minimum of five chief elements, Al, Si, Cu, Ni and Mg that have considerable effect during solidification [6, 7]. Reactions between themselves generate different phases and different intermetallic compounds. The process parameters of the casting decide the size, shape and the distribution of the intermetallic

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compounds in both as-cast and heat-treated alloys [8]. Regions exposed to larger strains requires a larger impedance to plastic distortion, and a finer microstructure is needed in these regions. Finer microstructures can accumulate larger amounts of energy [2, 9]. The piston head is exposed to higher temperatures, but minor mechanical strains, coarse grains are essential. Larger temperatures can stress out thermally triggered methods. The alloy has the potential to pay off deformations and are developed at a lower temperature. The microstructure of the alloy right away influences the mechanical characteristics of the alloy [10, 11]. At higher temperature, Al-Si piston alloys must exhibit more strength. To improve the characteristics of Al-Si alloys at higher temperatures, it is essential to bring a novel thermally steady intermetallic phases [1, 12]. At higher temperatures, thermally steady intermetallic delay the dislocation's movements and therefore improve the characteristics of the material. The strength of the same intermetallic depends on their performance at higher temperatures. Further thermally stable intermetallic attain a role of improved strength [7, 14]. Copper combines with Al  $\alpha$ -(Al<sub>2</sub>Cu) intermetallic phase through Mg combines with Si and forms an intricate intermetallic, and the Mg<sub>2</sub>Si intermetallic mostly affects the alloy properties at atmospheric temperature [7, 14]. The Mg<sub>2</sub>Si phase has been employed as strengthening phase in Al-Si piston alloys. Higher mechanical characteristics of piston alloys is again enhanced by selecting the best heat-treatment process [15]. The existence of Cu and Mg in these alloys causes the creation of Al<sub>2</sub>CuMg, the supposed S-phase, and AlxMg<sub>5</sub>Cu<sub>4</sub>Si<sub>4</sub> [7, 14].

The concluding procedure of Al-Si alloy piston manufacture is the heat treatment stage. Keeping in attention that the phase and structural deviations be subject to time and temperature, it is consequently essential to accurately describe its optimal temperature and holding time. The usual heat treatment procedure comprises solutionizing, quenching and aging. The core of solutionizing includes heating the alloy to nearby eutectic melting temperature, holding it for some time and then cooling. Concluding step of heat treatment process is aging. Furthermore, the equilibrium process is done to remove residual stresses.

The squeeze casting procedure is a unique method that correlate the rewards of traditional gravity casting and forging [16]. Here the exertion of pressure in the course of solidification results in high integrity, near-net-shape casting with a fine-scale microstructure caused by higher cooling rates which enable to achieve excellent mechanical properties [16]. The objective is to carry out research on the microstructural and mechanical behavior of Al-12Si-3Cu-1 Mg-xNi (x varies between 0.5 and 2.5Ni) in the as-cast as well as heat treatment processes. In the present

study, the above advantages of squeeze casting will be exploited for developing high strength Al-Si piston alloy.

## 2 Melting and Casting

Billets of Al-17Si have been employed to cast the required composition. Al-20 Mg, Al-30Cu and Al-75Ni have been mixed into the molten melt for attaining the demanded alloy, and Al-10Sr has been added to the melt to modify eutectic Si particles. The melting process is achieved using an 18 kW electric resistance pit furnace. Inside the furnace temperature of  $760 \pm 5$  °C has been preserved. A chromel–alumel thermocouple has been utilized for the observation of the temperature in the melt. Degassing of the molten melt has been done by sparkle pure, dry N<sub>2</sub> gas into the molten metal through a graphite shaft. Finally, the molten metal has been transferred into the warm-up molds (Fig. 1). For squeeze casting, liquefied metal has been shifted to a die. When the liquefied metal is shifted to die cavity, pressure of 100 MPa is employed on it for about 2 min.

## 3 Characterization of Alloys

Optical metallography and Scanning Electron Microscopy evaluated the structural features of the castings. Chemical analysis was performed using SPECTROMAXx Optical Emission Spectrometer. The mechanical characteristics (tensile strength and hardness) were assessed using an Instron Universal Testing Machine (1195/8801) and Brinell Hardness Machine (Indentec). Rotating beam bending fatigue test was done on a Carl Schenck fatigue testing machine. For conducting a wear test on the optimum chemical composition, a reciprocating wear testing machine was used. Reciprocating wear testing machine is used to model tribological

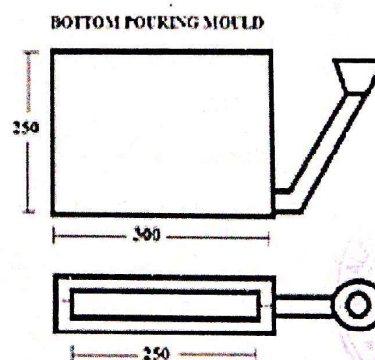


Fig. 1 Sizes of molds used for molding. (Units are in mm)



behavior of the components which are having a reciprocating motion like a piston in the cylinder.

## 4 Results and Discussions

### 4.1 Chemical Examination of Different Alloys

Experimental alloys compositions, which was investigated by a spectrometer, is specified in Table 1.

### 4.2 Hardness values and microstructural characteristics of Al-12Si-3Cu-1 Mg alloys by means of variable Ni

#### 4.2.1 Alloys in the as-Cast Condition

Addition of Ni to Al-Si-Cu-Mg, further increases in hardness values upon heat treatment. Amount of Ni content and the insertion of Ni creates  $\text{Al}_3\text{Ni}$ , which improves the hardness of the alloy. This improvement in hardness is owing to the existence of Ni carriage intermetallics that is caused because of the high motive power for compound creation among Al and Ni (size factor, electronegativity) and little solubility of Ni in Al (max approximately 0.05% at the eutectic temperature) [17]. Ni combines with other elements forming  $\text{Al}_3\text{Ni}$ ,  $\text{Al}_7\text{Cu}_4\text{Ni}$ ,  $\text{Al}_3\text{CuNi}$ ,  $\text{Al}_7\text{Cu}_4\text{Ni}$  and  $\text{Al}_8\text{FeMg}_3\text{Si}_6$  phases [17].

#### 4.2.2 Alloys Behavior During Heat Treatment

The strength of said materials will depend on the amount of interconnectivity and areas of the hard phases surrounded by the Al matrix. The eutectic phase consists of nearly soft eutectic Al, rigid eutectic Si and  $\text{Al}_3\text{Ni}$ . To initiate a hard-eutectic region, the rigid eutectic Si and  $\text{Al}_3\text{Ni}$  are three-dimensionally connected. Ni phase arrangement with eutectic Si appear an intensely interconnected three-dimensional arrangement, those area is powerfully conserved during solution treatment. In the presence of  $\text{Al}_3\text{Ni}$ , the volume content of the hard region increases. Therefore, the system is considered to have achieved higher contiguity (interconnectivity of the eutectic network). Subjecting on the quantity of eutectic phase, Ni would be essential to maintain the linkage of the eutectic Si network. The amount

of  $\text{Al}_3\text{Ni}$  in the eutectic proportionally increases as the Ni content increases. Adding Ni to the alloy increases the hardness, which reaches maximum values when the amount is increased up to 1.78Ni. However, further increasing the Ni content decreases the values of hardness. It appears that contingent on the quantity of the eutectic phase, comparatively Ni would be essential to maintain the linkage of the eutectic Si and  $\text{Al}_3\text{Ni}$  network. Increasing the quantity of  $\text{Al}_3\text{Ni}$  does not further develop the contiguity, and the hardness of the alloy decreases. It assumes that this is due to the connection between the  $\text{Mg}_2\text{Si}$  phase and  $\text{Al}_3\text{Ni}$  skeleton in Mg-containing alloys, which could also contribute to the contiguity, and as a consequence, a smaller amount of Ni would be required. Figure 2 illustrates the variation of hardness for different alloys with varying Ni content.

### 4.3 Role of Sr and Squeeze Casting on the Characteristic of Al-12Si-3Cu-1 Mg-1.78Ni Alloys

#### 4.3.1 Microstructural Analysis

The microstructure comprises of primary Si and a combination of  $\alpha$ -Al plus eutectic silicon. Primary Si is of polyhedral shape. The shape of eutectic Si particles is of needle-like shape. Due to the presence of alloying

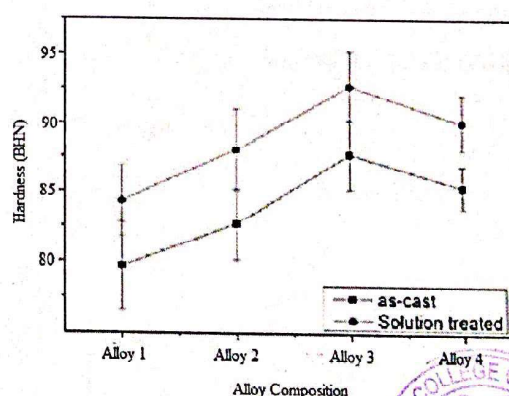


Fig. 2 Plots showing the variation of hardness for different specimens

Table 1 Alloy composition with varying Ni

	Si	Cu	Mg	Ni	Fe	Mn	Ti	
Alloy 1	12	3	1	0.3	0.17	0.04	0.01	Bal
Alloy 2	12	3	1	0.8	0.17	0.04	0.01	Bal
Alloy 3	12	3	1	1.8	0.19	0.04	0.01	Bal
Alloy 4	12	3	1	2.28	0.18	0.04	0.01	Bal



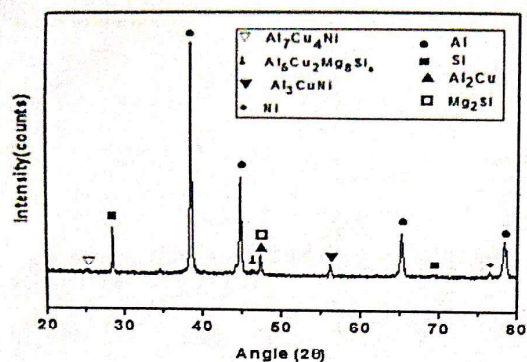


Fig. 3 X-ray diffraction model of Alloy 3

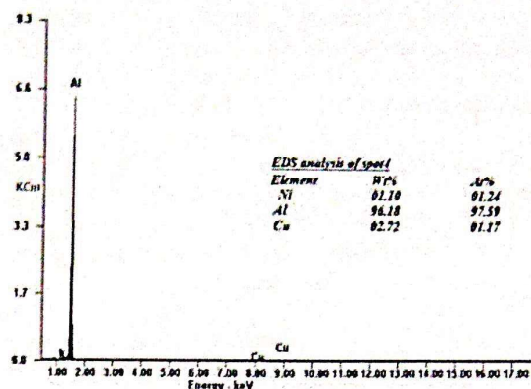


Fig. 6 EDS spectra of spot 2

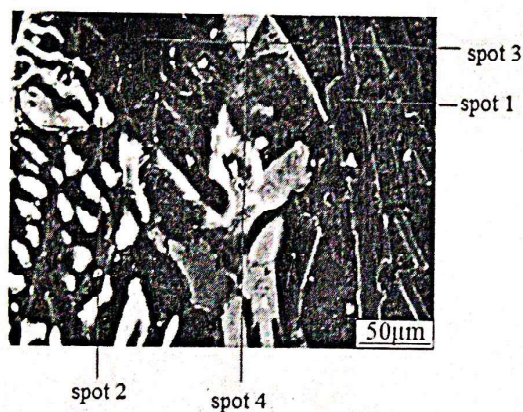


Fig. 4 SEM micrograph of Alloy 3

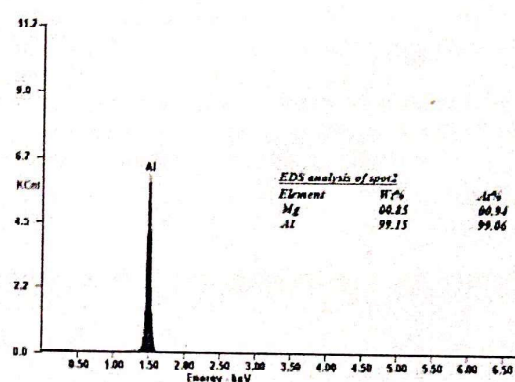


Fig. 7 EDS spectra of spot 3

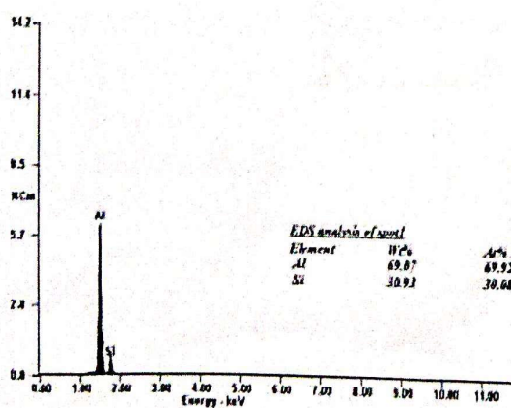


Fig. 5 EDS spectra of spot 1

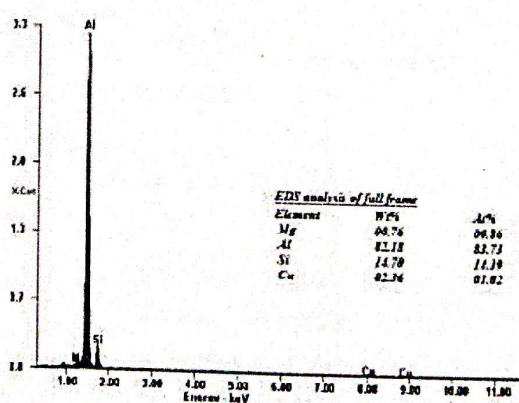
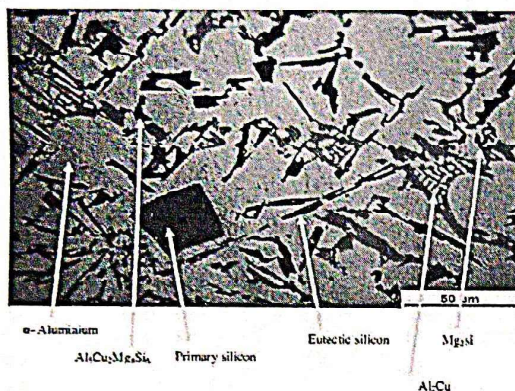


Fig. 8 EDS spectra of spot 4

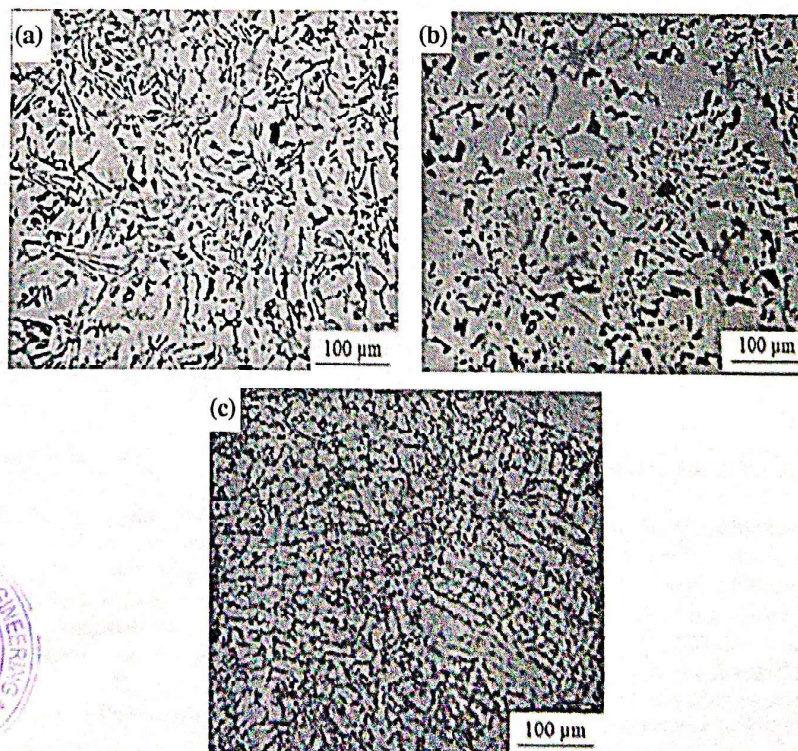


**Table 2** Phases by EDS

Spot No	Phases
Spot 1	Eutectic Si
Spot 2	$\text{Al}_7\text{Cu}_4\text{Ni}$
Spot 3	$\alpha\text{-Al}$
Spot 4	$\text{Al}_3\text{Cu}_2\text{Mg}_8\text{Si}$

**Fig. 9** Identification of phases for Alloy 3

**Fig. 10** Microstructure of the heat-treated alloys. a Al-12Si-3Cu-1 Mg-1.7Ni (gravity). b Al-12Si-3Cu-1Mg1.7Ni-0.04Sr (gravity). c Al-12Si-3Cu-1 Mg-1.78Ni-0.04Sr (squeeze)



elements, various intermetallics are developed. Figure 3 illustrates the XRD pattern and Fig. 4 illustrates the image obtained from SEM and the corresponding EDS spectra of different spots are shown in Figs. 5, 6, 7, 8. Composition of the different phases by EDS are shown in Table 2. All the phases are identified and marked in the microstructure. Figures 9 and 10 show the microstructure at diverse conditions. Degree of modification also computes by computing the aspect ratio of the eutectic Si particles (Table 3).

#### 4.3.2 Mechanical Properties

The shape of eutectic Si particles determines its mechanical characteristics of Al-Si piston alloy. Application of pressure raises the freezing point, which increases the degree of undercooling of the primarily superheated alloy. The rate of nucleation rises that develops a finer microstructure. By the blending of Sr modifier, the eutectic Si particles alter their shape into almost spherical ones. For Sr-modified alloy the heat treatment takes a more influence regarding the spheroidization of Si-eutectic and is the reason for the betterment of properties (Table 4).





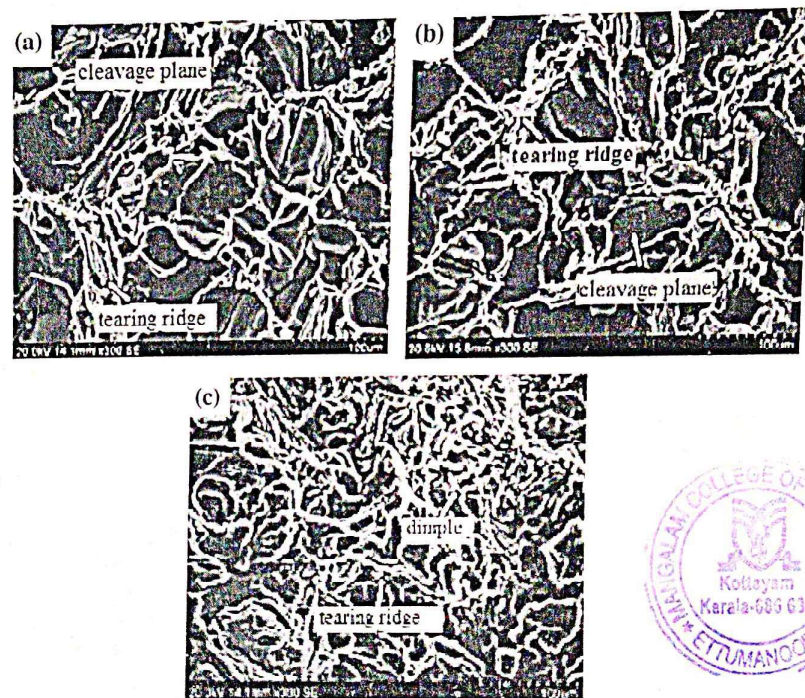
Table 3 Eutectic Si particle parameters at heat-treated state

Alloys	Cast process	Length, $\mu\text{m}$	Breadth, $\mu\text{m}$	Aspect ratio
Al-12Si-3Cu-1 Mg-1.7Ni	Gravity	26.4	1.47	18.7
Al-12Si-3Cu-1 Mg-1.7Ni-0.04Sr	Gravity	19	3.8	5.2
Al-12Si-3Cu-1 Mg-1.7Ni-0.04Sr	Squeeze	9	4.6	1.8

Table 4 Mechanical characteristics of piston alloys

Alloys	Process	Tensile properties				Hardness (BHN)	
		UTS (MPa)		Elongation (%)		As-cast	T6 condition
Al-12Si-3Cu-1 Mg-1.7Ni	Gravity die cast	155	275	2.5	1.6	88	100
Al-12Si-3Cu-1 Mg-1.7Ni-0.04Sr	Gravity die cast	180	285	2.2	1.2	100	115
Al-12Si-3Cu-1 Mg-1.7Ni-0.04Sr	Squeeze die cast	325	380	2	1.0	120	135

Fig. 11 SEM images of the fractured surface subjected to the tensile test a Al-12Si-3Cu-1 Mg-1.7Ni (gravity). b Al-12Si-3Cu-1 Mg-1.78Ni-0.04Sr (gravity) c Al-12Si-3Cu-1 Mg-1.78Ni-0.04Sr (squeeze)



#### 4.3.3 SEM Analysis of Tensile Fracture Surfaces

The scanning electron microscope (SEM) images of alloys undergoing heat treatment are shown in Fig. 11. The unmodified alloy illustrates a fracture which is in nature of brittle type. The form of eutectic Si particles and primary Si particles mainly controls the mechanism of fracture. Coarse Si particles control the beginning and dissemination sites of the initial cracks. For Sr-modified, squeeze-cast alloy the tensile fractured surfaces are smooth. That is why the ductility of

the squeeze casted modified is better than that of die-cast alloy.

Regular pits by excellent cleavage surfaces have been created (shown in Fig. 10). Due to this the sample experiences substantial plastic distortion prior to the overload-triggered crack. Sr modification decreases the area of the cleavage surfaces meaningfully, thereby the quantity of dimples intensifies significantly due to greater ductility. The pockets left by the small grains that are pulled out can also be seen. These changes resulting from grain refinement could be the



reason for the higher UTS and hardness exhibited by the Sr-modified, squeeze-cast specimen.

#### 4.4 Fatigue Test

The microstructural characteristics comprise primary Si, eutectic Si, intermetallic, slip bands and grain size. Defects in the casting such as pores and oxides affect the fatigue characteristics of Al-Si alloy. The outcome illustrates that by the decrease in stress amplitude, the fatigue strength of piston alloy rises considerably. The cause for greater strength of the piston alloy is that, the precipitates are sufficient enough to disperse in the Al matrix which fixes the dislocation and reinforces the matrix. The structure of the dislocation is rich in slip dislocation dipoles, and the dislocations are gathered in the slip band structure because of the interaction and pileup of dislocations. This shows that in the early cycles, the plastic strain concentrates in the slip band. The dislocation bands are mostly set up by dislocation lines through clear direction. When the amplitude of stress rises, which causes the decrease in the distance between the slip bands and the slip bands becomes heavier and thicker and also more and more slip system begins, and the density of dislocation within the slip system increases thereby increasing the interaction between the dislocations. By increasing the density of dislocation, moving spaces of dislocations become reduced, and the interaction among dislocations quickly rises, thus resistance to deformation rises. Fatigue test results are shown in Table 5, where the bending stress value is varied from 300 to 90 MPa. Figure 12 shows the stress amplitude versus the number of cycles.

#### 4.5 Reciprocating Wear Analysis

The sliding rate was kept constant at 0.6 m/s, and the sliding distance was 500 m. The modified squeeze-cast sample exhibits a lesser wear rate to the die-cast sample (Fig. 13). The needle-shaped eutectic Si act as stress raisers, that's why the unmodified specimen shows a greater rate of wear and

Table 5 Fatigue test outcomes

Stress MPa (S)	No. of cycles (N)
300	7500
270	14,000
235	31,000
200	50,000
150	343,000
115	902,000
107	(Continued) 10,000,000
90	(Continues) 13,000,000

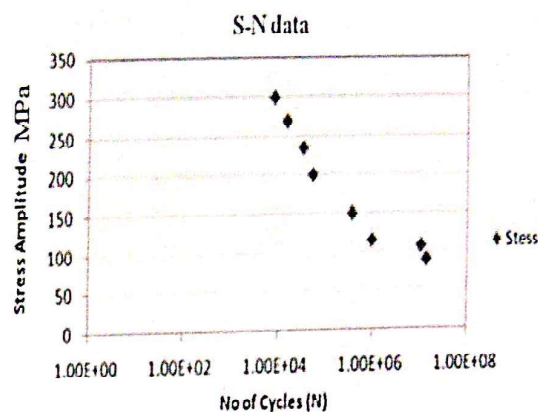


Fig. 12 Stress amplitude versus number of cycles

leads to the presence of cracked eutectic Si phase in addition to the primary Si phase.

#### 4.6 SEM Analysis of Wear Surfaces

SEM micrographs of the wear surface of heat-treated die-cast and heat-treated, squeeze-cast alloys are shown in Fig. 14. The squeeze-cast alloys being in a decent situation so that they have better wear resistance and mechanical characteristics. The better quality of the surface seen in the squeeze-cast alloys takes a reduction in the friction coefficient. Figure 10 illustrates the alloy surfaces, squeeze- and gravity-cast samples possess paths corresponding to the wear line and is due to abrasive wear mechanism. During sliding, the applied stress is rigorously high; due to this, plastic deformation of the fracture takes place. The wear is metallic in nature because it shows smooth strips, and it exhibits smaller grooves through plastic deformation.

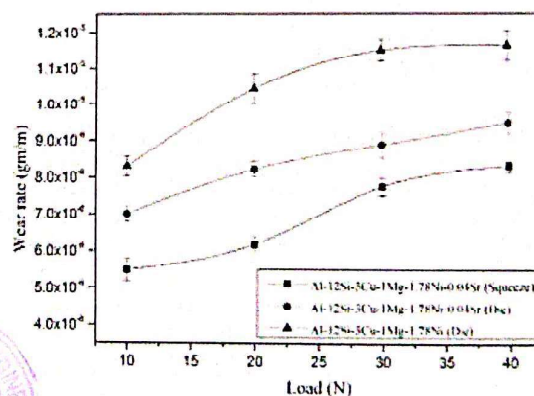
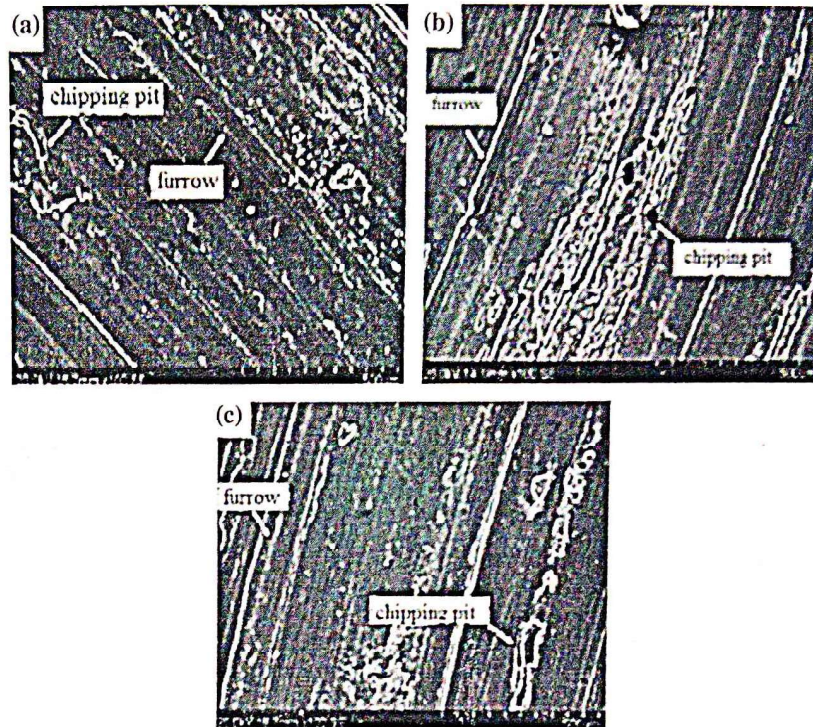


Fig. 13 Plots showing the deviation of wear rate versus load



**Fig. 14** SEM images of worn surface of alloys, subjected to reciprocating wear test  
**a** Al-12Si-3Cu-1Mg-1.7Ni (gravity) **b** Al-12Si-3Cu-1 Mg-1.78Ni-0.04Sr (gravity) **c** Al-12Si-3Cu-1 Mg-1.78Ni-0.04Sr (squeeze)



During the unmodified condition, the worn-out peripheral reveals a type of wear called adhesive-type and is because of the occurrence and violation of micro welds during sliding. For Sr-modified, squeeze-cast specimen, the worn-out surface does not show abrasion-linked furrows and strips. It is concluded that the Sr-modified, squeeze-cast piston specimen shows a lesser rate of wear. The heat-treated alloys are exposed to depthless and thin micro furrows than cast alloys.

## 5 Conclusions

From the experimental studies conducted on Al-Si piston alloys, the following conclusions are derived.

1. Alloying Ni to Al-12Si-3Cu-1 Mg, the hardness values begin to rise with rise in Ni amount and reaches a maximum of 1.78Ni and is due to the formation of  $Al_3Ni$  phase. Al-12Si-3Cu-1 Mg alloys that contain 1.78Ni has the optimal hardness values compared to alloys having a lower or higher content of Ni.
2. The mechanical properties of the as-cast Sr-modified Al-12Si-3Cu-1 Mg-1.78Ni specimens have been found to be more than that of the unmodified specimen. The presence of 0.04Sr alters the plate-like eutectic Si to finer and is the reason for improving the properties.

3. The Sr-modified squeeze-cast specimen shows better properties and somewhat lesser elongation. The squeeze-cast alloy shows higher properties related to the die-cast one due to the occurrence of fine eutectic Si and a more homogeneous microstructure.
4. Fatigue properties of squeeze-cast piston alloy is studied by rotating-beam bending fatigue test resulting in the fatigue limit of the alloy 107 MPa and 115 MPa at 107 number of cycles.

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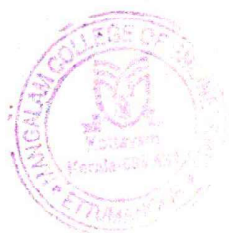




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# Cenosphere filled epoxy composites: structural, mechanical, and dynamic mechanical studies

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## Abstract

The present study referred to the lightweight cenosphere filled, and epoxy composites (0, 7.5, 15, and 22.5 vol.%) developed with the help of the hot compression moulding process. To ensure the strength of composites, the prepared system was analyzed with tensile, flexural, impact properties, and dynamic mechanical characteristics discussed. Cenosphere-filled composites attained the maximum tensile strength of 19.5 MPa, which is 60% better than the neat epoxy. Adding cenosphere particles increases the tensile, flexural, and impact strength at a superior level. Dynamic mechanical analysis revealed that in 22.5 vol.% of cenosphere reinforced composites, energy dissipation and maximum storage modulus of 6 MPa was enhanced. The surface morphologies of the fractured specimens were characterized using scanning electron microscope (SEM). The morphological investigations indicate a good state of particle distribution in the epoxy matrix.

**Keywords** Epoxy composites · Cenosphere particle · FT-IR · Tensile · Flexural · DMA properties

## 1 Introduction

Power plants in India produce about 600,000 tonnes of fly ash per day or 219 million metric tonnes of fly ash per year. In India, the majority of power plants (70%), as of now, have over 197 coal/lignite-based thermal power plants that run with a coal base. The burning of coal in the thermal power plant results in fly ash that generates 133 MTs of CFA (half yearly) (2021–2022), which is expected to exceed more than 1000 MT in 2031–32 [1, 2].

The majority of the fly ash that these thermal power plants produce is considered to be industrial waste. Many different research organizations' primary focus is recycling and discovering alternative applications for these types of industrial waste. In India, 56% of all fly ash was used in various engineering applications, the majority of which were associated with the cement industry. The application of fly ash covered in various sectors such as building and construction accounts for 50%, low-lying area fills for 17% of roads and pavement for 15%, dyke raising for 4%, and brick industries for 10% [3]. They are also frequently used in pressure vessels, ship hulls, and automobile industries, owing to their specific strength, stiffness, shrinkage, warpage reduction, and high-temperature resistance [4]. The remaining 44% of fly ash is a source of concern because of

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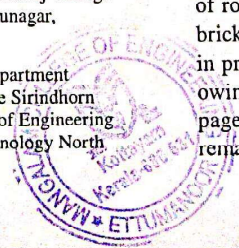
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its negative environmental impact. Therefore, it is essential to investigate the possibility of using fly ash in various other industrial contexts [5, 6].

Even though the proper exploitation of fly ash, the remaining amount of fly ash requires plenty of sq. m of land or ash ponds, water, and energy to dispose of the fly ash. It is not managed properly due to its very low density and can become floating [3]. Sim et al. studied the effect of fly ash on epoxy-based composites. Higher volume fractions (30%) showed weak matrix/filler bonding. Large (90 nm) fly ash particles reduced tensile strength [7]. High-temperature and-pressure fabrication of fly ash/polystyrene composites improved filler-matrix bonding and mechanical properties [8].

Cenosphere is an inert small hollow silicate sphere obtained from a naturally occurring by-product of the burning process at coal-fired thermal power plants [7]. Fly ash cenosphere contains silica, alumina, and iron oxides with carbon, calcium, magnesium, and sulphur. Fly ash's lightweight, thermal resistance, and acoustic properties make it a good low-cost composite filler [9–11]. Cenosphere is widely used in a variety of products, including cement, tiles, pavement blocks and bricks, polymer doors and panels, geopolymers, sports equipment, paints and enamels, insulation, automobile bodies, marine craft bodies, agriculture, herbicide, fertilizer and fire, and heat protection devices [5, 12]. It is a lightweight, inert, hollow sphere with a large amount of silica and alumina filled with air and gases. It has a composition similar to fly ash particles which constitute predominately metal oxides [7]. The natural properties of the cenosphere make it possible to use them either in dry or wet slurry form. Cenosphere is easy to handle and provides a low surface area-to-volume ratio. Due to their inert properties, they are not affected by solvents, water, acids, or alkalis [13]. The compatibility of cenosphere with special cement and adhesives coating and composites has been well identified. They are used extensively as filler material to reduce the weight of cement and polymers such as plastics, rubbers, and resins. Hence, they could be used as lightweight fillers in polymers and are also better alternatives to metallic and costlier fillers [12].

The cenosphere includes a hollow microsphere containing silica and alumina [13]. They have employed fly ash to make flame retardant panels, which were projected to use for fire prevention in house doors and firewalls of structures in buildings. Though, the maximum concentration of fly ash in polycarbonate leads to a reduction in mechanical properties [13]. Furthermore, one possible way to properly utilize the cenosphere is to disperse easily in various commercial polymers like polyethylene, epoxy, and polypropylene to produce particulate-filled polymer composites for lightweight applications. Numerous investigators used cenosphere as reinforcing fillers in polyester [14], epoxy [15], and polyvinyl ester [6]. Willis and Masters [16] studied the outcome of filler concentration on the mechanical properties of cenosphere/polyester composites and exposed

the hike in the flexural modulus with flexural strength reduction. Arijit Das [17] studied cenosphere filled polypropylene's structural, thermal, mechanical, and dynamic mechanical properties. Deepthi et al. investigated the mechanical and thermal properties of composites made of high-density polyethylene and cenosphere [18]. Due to the rigidity of cenosphere particles, the tensile strength of composites increased. The mechanical properties of jute epoxy composites with cenosphere filler were investigated. The 5 vol.% cenosphere particles and 35 vol.% jute fiber show better mechanical properties. But, increasing the concentration of jute decreases thermal conductivity [19]. Chauhan and Sunil Thakur reported the wear and friction properties of Cenosphere particulate-filled vinyl ester composites [20]. In this connection, structural, mechanical, and dynamic mechanical and tribological studies have been conducted in an epoxy filled with Cenosphere as the inorganic filler for lightweight structural applications.

## 2 Materials and testing

### 2.1 Materials

Epoxy (HY 551) resin, polyamine hardener comprehending a tetra-amine functional group used in this work, and other solvents were purchased from Giba Energy Ltd, Tamilnadu, India. The density of the epoxy resin was around  $1.36 \text{ g/cm}^3$ , and the melt flow index was  $1.8 \text{ g/min}$ . The filler used in this investigation, a cenosphere less than the particle size of  $60 \mu\text{m}$  and a bulk density of  $0.4\text{--}0.5 \text{ g/cm}^3$ , was bought from Cenosphere India Pvt., Ltd., Kolkata, India. The fabrication procedure of epoxy is depicted in Fig. 1. An epoxy resin with a hardener 10:1 ratio was prepared with the cenosphere as a filler (Table 1).

#### 2.1.1 Compression molding of epoxy/cenosphere polymer composites

The cenosphere-reinforced polymer (CRP) sheets have been produced using a hot compression molding technique for varying particle percentages of 0, 7.5, 15 and 22.5 vol.%. The epoxy-cenosphere mixture was prepared by mixing a definite proportion of the cenosphere with epoxy resin by hand stirring until all the cenosphere was evenly dispersed [21]. The prepared mixture is then poured into a mold having a dimension of  $300 \times 300 \times 3 \text{ mm}$  of steel die with an applied pressure of 15 MPa and a temperature of  $140^\circ\text{C}$  for a curing time of 24 h. After the curing process, test samples were cut to the required sizes prescribed in the ASTM standards [22]. The composite designation and composition of CRP composites are detailed in Table 1.



Fig. 1 Development of epoxy-cenosphere composites

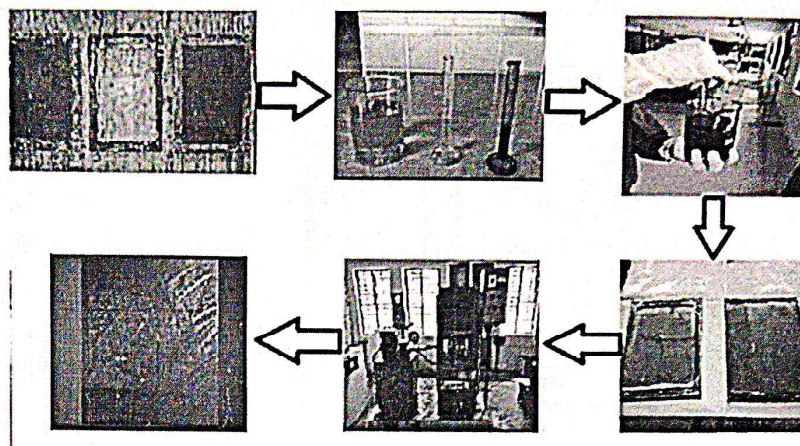


Table 1 Composite designation and composition of CRP composites

Composite designation	Epoxy (vol.%)	Cenosphere (vol.%)
EP	100	0
CRP-7.5	92.5	7.5
CRP-15	85	15
CRP-22.5	77.5	22.5

## 2.2 X-ray fluorescence spectroscopy (X-RF)

The elemental composition (vol.%) and the peak of cenosphere particles were analyzed with X-ray fluorescence spectroscopy with an XGT diameter of 100 and a current of 1 mA.

### 2.2.1 Fourier transform infrared spectroscopy (FTIR) analysis

FT-IR spectra of cenosphere-reinforced epoxy composites were recorded by an FTIR (Perkin Elmer Spectrum) to determine the chemical structure. CRP composite samples were combined in KBr with a 1:10 ratio, and the mixed samples were dried at 60 °C. Each FT-IR spectrum was captured with a resolution of 2 cm<sup>-1</sup> and a dynamic range that extended from 4500 to 500 cm<sup>-1</sup>.

### 2.2.2 Microstructure and fracture analysis (SEM)

Analyses of cenosphere microstructure and fractured surfaces of composites were executed using scanning electron

microscopy (SEM). Each sample was given a thin layer of gold coating to make the conductive sample using a Quick Coater Metalizer Sanyu Electron SC-701.

## 2.3 Mechanical testing

Tensile and flexural measurements of the CRP composites were determined using Tinius Olsen (Model H 10, Capacity 10 KN) Universal tensile testing machine at a constant crosshead speed of 5 mm/min. The tensile and flexural test was conducted per the standard procedures of ASTM: D638 and ASTM: D790, respectively. The CRP composite samples were subjected to the Izod impact test, which was carried out using a Tinius Olsen impact tester following the standards of ASTM D256. Five specimens were evaluated in each set of composites, and the average data were reported.

### 2.3.1 Dynamic mechanical analysis (DMA)

Dynamic mechanical analysis (DMA) was incorporated to characterize the dependency of elastic modulus ( $E'$ ) and loss modulus ( $E''$ ), and tan delta of the CRP composite specimen based on the temperature and frequency of the testing environment. The temperature dependence of the tan  $\delta$  was measured in the temperature range from -40 to 150 °C with a heating rate of 3 °C/min at a frequency of 30 Hz. The frequency dependence of the tan  $\delta$  was measured in the frequency range from 10 to 800 Hz at  $T_g$  in an argon atmosphere. Dynamic mechanical analysis of compression moulded specimens was measured using DMA Q800 (TA Instruments, USA) in tensile mode.



### 3 Results and discussion

#### 3.1 X-ray fluorescence spectroscopy (X-RF) of cenosphere particles

Figure 2 shows the various particles in the cenosphere and the number of elements detailed in Table 2. Silica and aluminium are the major peaks and max vol.% in the cenosphere particle.

#### 3.2 FTIR spectroscopy

Figure 3 shows the FTIR spectra of cenosphere-filled epoxy composites. The broad, strong peak lying in  $3490\text{ cm}^{-1}$  is related to the flexible vibration of the hydroxyl group ( $-\text{OH}$ ), which specifies that the quantity of hydroxyl group ( $-\text{OH}$ ) reduces, with similar results observed in fly ash-filled epoxy composites [15]. The three characteristics' peak around  $2950\text{ cm}^{-1}$  is related to the  $-\text{C}-\text{H}-$  stretching vibration of the propyl group, a similar peak observed in high-density polyethylene-fly ash cenosphere composites [14].  $-\text{NH}_2$  deformation mode is witnessed at  $1550\text{ cm}^{-1}$ . The  $\text{CH}_2$  deformation modes of propyl amine is observed at  $1300\text{ cm}^{-1}$ . CRP composites having a peak of  $1030$  and  $1085\text{ cm}^{-1}$  are caused by the  $-\text{OH}$  hydroxyl group and are associated with the  $\text{Si}-\text{O}$  bond asymmetric stretching vibrations. In addition, the bands at around  $441.6\text{ cm}^{-1}$  show the presence of  $\text{Fe}-\text{O}$  stretching vibrations in cenosphere composites [15].

#### 3.3 Mechanical properties

The tensile strength of cenosphere-reinforced epoxy composites is shown in Fig. 4. It is noticed that the tensile strength of

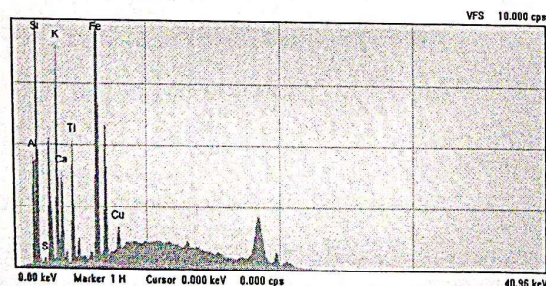


Fig. 2 X-RF image of cenosphere particles

Table 2 Composition of cenosphere powder obtained by X-ray fluorescence spectroscopy (XRF)

Elements	Al	Si	S	K	Ca	Ti	Fe	Cu
Composition	22.7	49.16	0.37	11.03	3.55	3.14	9.54	9.24

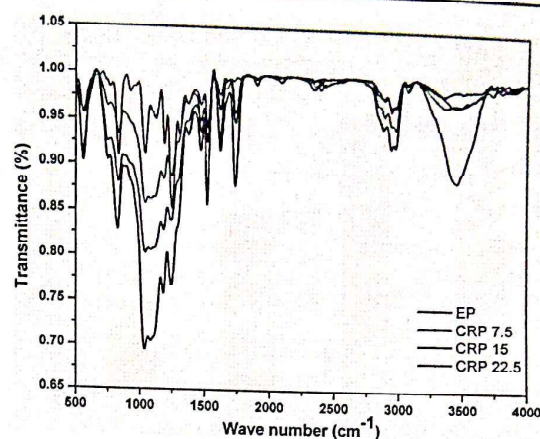


Fig. 3 FTIR spectra of cenosphere-epoxy composites

neat epoxy is 12 MPa; with the addition of cenosphere content (7.5 vol. %), the tensile strength increased marginally, and the maximum of CRP composites was attained at 19.5 MPa of 22.5 vol.%, when compared to pure epoxy it is ~ 60% higher than it. Incorporating cenosphere into the epoxy matrix modifies its nature from brittle to tough, which is the affidavit for the hike in tensile strength [19].

The flexural strength of cenosphere-reinforced epoxy composites is exposed in Fig. 5. The values of CRP composite flexural strength are increased with the addition of particle content 7.5 vol.%. Further loading of filler content to 15 vol.%, the flexural strength increases to 54.5 MPa, which is ~ 91.2 times higher than the neat epoxy. Still, adding cenosphere particles into the epoxy matrix reduces the flexural strength due to the agglomeration of cenosphere particles into the matrix, which leads to cluster formation and restricts the melt flow and more slippage of layers took place while the bending test [16].

The impact strength of cenosphere-reinforced epoxy composites is exposed in Fig. 6. From impact test results, the energy observed by epoxy is much less than the other CRP composites. The trend indicates an increase in impact strength with increasing cenosphere content. Including cenosphere particles (7.5 vol.%) in epoxy resin increases the impact strength. It increased particle content from 7.5 to 22.5 vol.%, and the impact strength reached the maximum level of  $19.68\text{ kJ/m}^2$  because epoxy's brittle nature transformed into a tough state.



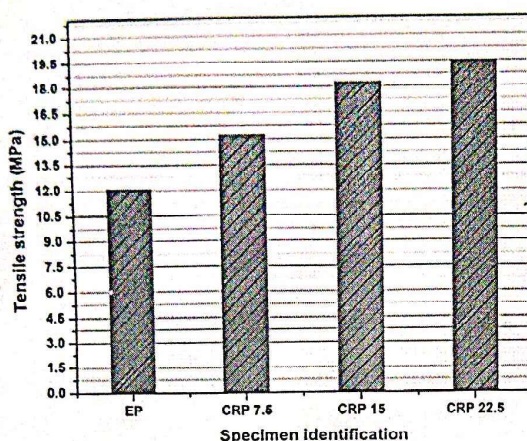


Fig. 4 Variations of tensile strength with volume fractions of cenosphere particle

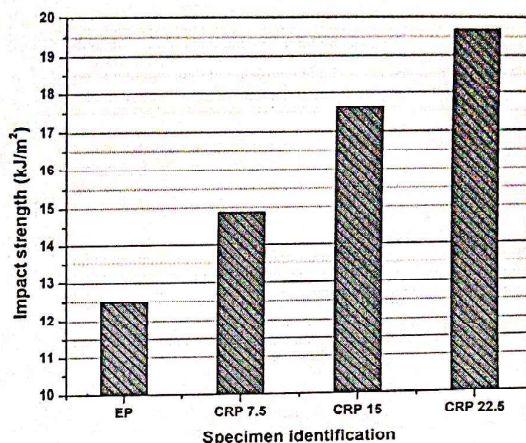


Fig. 6 Variations of impact strength with volume fractions of cenosphere particle

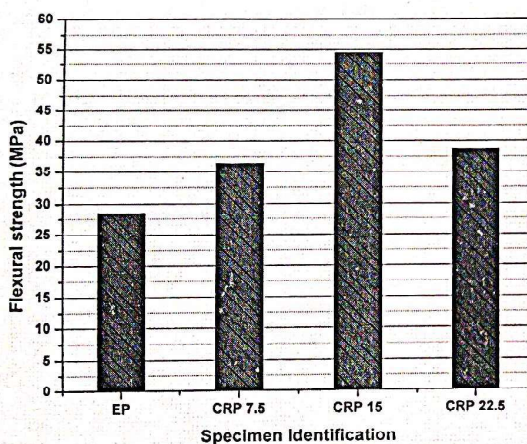


Fig. 5 Variations of flexural strength with volume fractions of cenosphere particle

### 3.4 Fractured surface morphology

The SEM micrograph investigations have demonstrated the state of cenosphere particle dispersion and distribution at the micro-structural level (Fig. 7). The surface morphology showed that the cenosphere content increases, and the number of visible cenosphere particles on the scanned surface increases, indicating good distribution (Fig. 7b–d). The presence of the cenosphere tightly embedded and mechanically interlocked by the resin indicates good dispersion of the particles in the bulk of the matrix at higher loadings of cenosphere content.

Figure 7b and c corresponds to CRP 7.5 and CRP 15; more cenosphere is distributed across the fractured surface. The surface characteristics also indicate that shear deformation has been substantially stopped, possibly due to increased mechanical constraints imposed by cenosphere particles. More intense filler dislodging was observed on increasing the cenosphere loading to 22.5 vol.% (PPC-20) (Fig. 7d). Dislodging of cenosphere particles is also discernible on the surface, indicating a poor state of polymer–filler adhesion. Additionally, a broken cenosphere indicates a shift from ductile plastic deformation to brittle failure in moderately filled composites. Increasing cenosphere content decreases inter-particle distances, limiting the polymer phase's contribution to fracture mode via homogeneous deformation [23, 24].

A higher amount of cenosphere particles reduces the inter-particle distance and incompatibility of filler/matrix, restricting the epoxy matrix to contribute to fracture mode (homogeneous deformation), as shown in Fig. 6b and c. The bulk morphological feature shows up to 15 vol.% of loading (CRP 15 vol.%), matrix-controlled deformation, whereas beyond that, basically on cenosphere controlled as clearly shown in the micrograph, massive debonding of particle into matrix Fig. 7d.

### 3.5 Dynamic mechanical analysis

#### 3.5.1 Storage modulus

The solid-state dynamic mechanical results with the variation of storage modulus are shown in Fig. 8 at a frequency of 1 Hz. The storage modulus increases dramatically by implying cenosphere into the epoxy matrix over the complete temperature. The  $E'$  increased from 3.8 GPa to 6 GPa



Fig. 7 SEM micrograph of fractured surfaces. a Tensile fractured specimen of EP. b CRP 7.5 vol.%. c CRP 15 vol.%. d Tensile specimen of CRP 22.5 vol.%

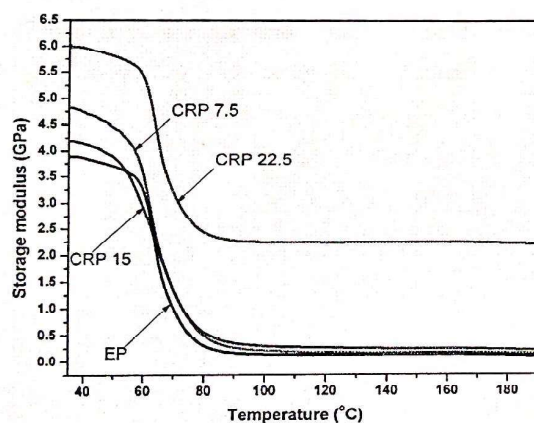
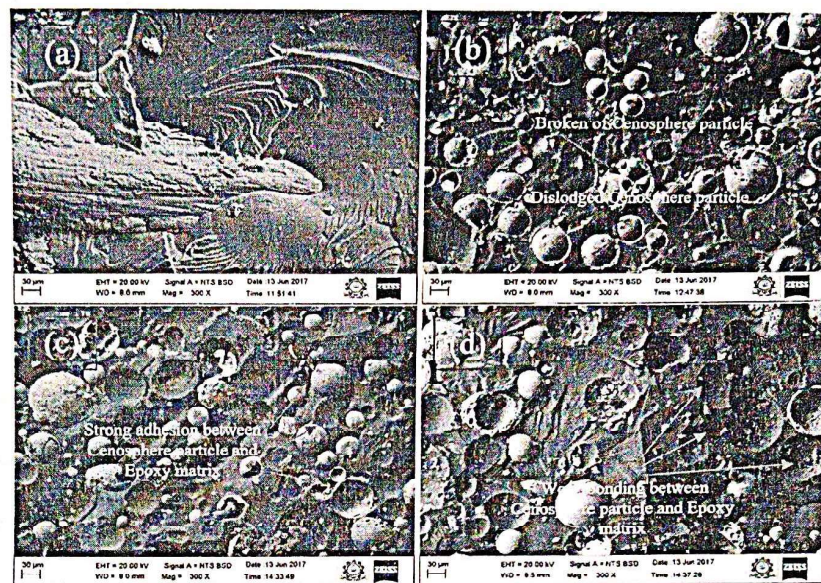


Fig. 8 Storage modulus vs. temperature

with 22.5% cenosphere concentration, followed by other compositions. This effect can be ascribed to the high intrinsic stiffness of cenosphere particles. This reflection agrees with the theoretical expectation that is characteristic of rigid spherical particle-filled composites. A similar trend was noticed with the addition of cenosphere in epoxy foams [19]. Further increment of temperature  $E'$  decreased gradually due to softening of the composites, and a sharp, deep fall occurred between 50–85 °C, corresponding to glass

transition temperature ( $T_g$ ).  $E'$  can be preserved above an increased temperature range at a higher moderate level.

### 3.5.2 Loss modulus

The dependence of cenosphere content on the loss modulus of CRP composites at a frequency of 1 Hz is shown in Fig. 9. The magnitude of  $E'$  increased substantially with incorporating of cenosphere particles on the epoxy matrix, reaching the peak value of 0.45 GPa. Further loading of the cenosphere reduced the loss modulus slightly. Still, all reinforcement had close loss modulus values. The loss modulus increased over the entire temperature and attained a maximum value; the further increase in temperature reduces the loss modulus due to the free movement of polymer chains [25, 26]. The loss modulus also increased around 60–70 °C in the glass transition region; this is in agreement with the storage modulus.

### 3.5.3 Complex modulus

The effect of the tan delta on CRP composites is shown in Fig. 10. The tan delta, which displays variations in the viscoelastic behavior of the materials, seems to be a ratio of a loss modulus to a storage modulus. Cenosphere incorporation reduces the tan delta due to greater restriction in the appropriate movement of the molecules in the CRP composites. The interfacial bonding will be accelerated, and slippage will occur when the composites undergo high temperatures, which may indicate energy loss between the two phases. The tan delta



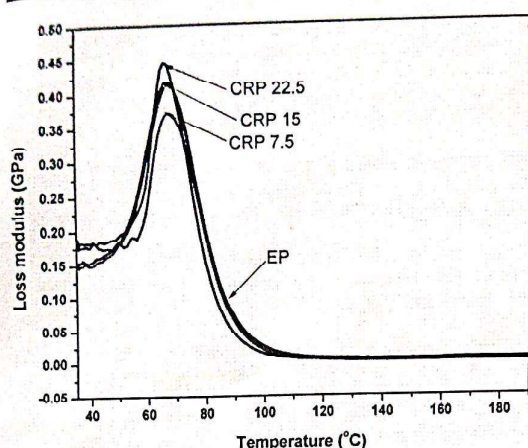


Fig. 9 The temperature dependence of loss modulus

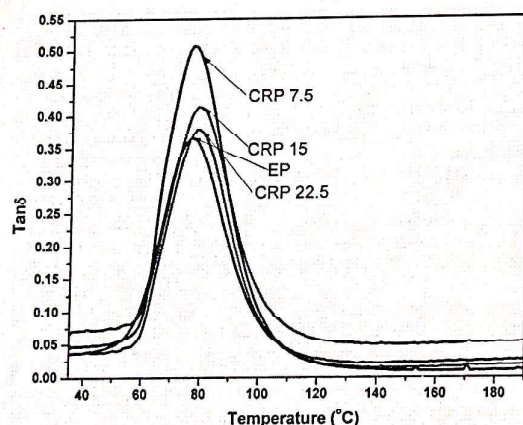


Fig. 10 Tan delta curves for CRP composites

peaks for epoxy (EP) are around 78 °C and are not significantly shifted to all other reinforcements, that confirm the addition of cenosphere will not affect the  $T_g$ . The growing trend of  $E'$  and decreasing the tan delta at elevated temperatures ensures the solid interface between the cenosphere and epoxy matrix and interaction among cenosphere.

#### 4 Conclusion

Using cenosphere as the filler material, the present research aimed to develop a sustainable, new epoxy-based polymer material for lightweight applications. On specimens fabricated from an epoxy matrix material reinforced with 7.5, 15, and 22.5% cenosphere by volume, tensile, flexural, impact,

and dynamic mechanical tests were conducted, and the following conclusions were drawn.

The better interfacial adhesion between cenosphere and epoxy and this result enhanced the mechanical properties. An increase in the volume percentage of the cenosphere in the specimens increased the tensile strength. As a result of the incorporation of a spherical cenosphere into the matrix material, crack growth along the matrix material was slowed during tensile loading. During tensile loading, the interaction of crack fronts with the cenosphere, as opposed to the matrix material, improved the tensile properties of epoxy specimens relative to those of unmodified epoxy specimens.

The flexural strength of the epoxy matrix increased with the volume percentage of the cenosphere because cenosphere fillers can absorb compressive loads during point loading. The impact properties of the epoxy matrix are dramatically increased by adding a higher percentage of cenosphere.

DMA investigations showed that the damping properties of cenosphere-filled composite is enhanced. The  $\tan \delta$  value of the composite filled with 7.5 and 15 vol.% cenosphere decreases slightly higher than the matrix. But the  $\tan \delta$  value of the composite filled with 22.5 vol.% Cenosphere decreases slightly lower than the matrix. Thus, adding a cenosphere certainly enhances the damping capacity of epoxy resin. As a concluding remark, cenosphere-filled epoxy composites are preferred for lightweight applications and various applications.

**Author contributions** K. Pratheesh, T. Ramkumar, and P. Narayanasamy conceived the research idea. R. Prithivirajan developed the composite of materials. P. Balasundar and S. Indran verified the analytical methods and test results. M.R. Sanjay and Suchart Siengchin investigated and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

**Data availability** Data sharing does not apply to this article as no datasets were generated or analyzed during the current study.

#### Declarations

**Ethics approval** Not applicable

**Competing interests** The authors declare no competing interests.

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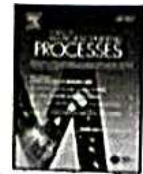
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# Characterization of material, mechanical, static bending and vibration properties of glass fiber composite panels reinforced with graphene nanofillers

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## ABSTRACT

The present study investigates the material, mechanical, static bending and vibration characteristics of glass fiber reinforced polymer (GFRP) composites reinforced with graphene nanofillers. The crystallinity, functional groups, morphology, and tensile and flexural strengths of GFRP and graphene reinforced GFRP composites were examined using a variety of material and mechanical characterization techniques, including X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), scanning electron microscope (SEM), and tensile and flexural tests. The first-order shear deformation theory (FSDT) based finite element (FE) model was developed to obtain the static bending and vibration characteristics of the graphene reinforced GFRP composite panels. The validity of the FE model is matched with numerical data published in the literature. Further research is conducted into the effects of the wt% of graphene, end conditions, curvature ratio, and aspect ratio on the static bending and vibration characteristics of graphene reinforced GFRP panels. The findings of this study indicate that graphene reinforced GFRP panels could be utilized in a variety of applications, particularly for parts used in the aerospace and automotive industries.

## 1. Introduction

Composite structures are frequently used in the military, marine, and aviation industries because of their exceptional stiffness-to-weight ratio, high shear strength, and lower density [1,2]. The fiber-matrix interfacial adhesion of composites with fiber reinforcement greatly enhances their mechanical performance. These composite structures' stiffness is frequently decreased by dynamic loads in various environments. To enhance the mechanical characteristics of such structures, nano particles such as carbon nanotubes (CNT) [3] and graphene [4] have been incorporated into laminated composites. Compared to CNTs, graphene has a greater surface area, which makes it less expensive to synthesize [5]. Graphene is renowned for its higher strength and stiffness, and as a result, it acts as a matrix filler, increasing the interfacial surface area for matrix bonding and thereby increasing the matrix's strength and modulus [6–8]. The flexural and tensile strength of the composites were improved by an effective load transfer achieved with graphene in epoxy due to the wrinkled structure and increased interfacial bonding [9]. Ac-

cording to Netkueakul et al. [10], increasing graphene in epoxy reduced particle aberration, which was further reduced as the filler particle surface area was reduced. Han et al. [11] showed higher mechanical and thermal performance employing graphene in epoxy over CNT-epoxy due to the high specific surface area offered by the graphene for adhesion and interlocking process between wrinkled graphene and epoxy.

Surface roughness is created by functionalizing graphene, which allows graphene to interlock with epoxy, improving mechanical characteristics and allowing for effective stress transfer [12]. Sharma et al. [13] found that the polar functionalities at the margins of graphene oxide (GO) and epoxy chains interact to cause interfacial adhesion between carbon fiber reinforced polymer (CFRP) and graphene. At the fiber matrix interface, there is an inherent weak zone that can be improved by boosting reaction sites or triggering surface energies with chemicals. As a result, graphene functionalization enhances interfacial adhesion. The mechanical characteristics of epoxy composites were significantly improved by using fillers like graphene nanoplatelets (GNP)

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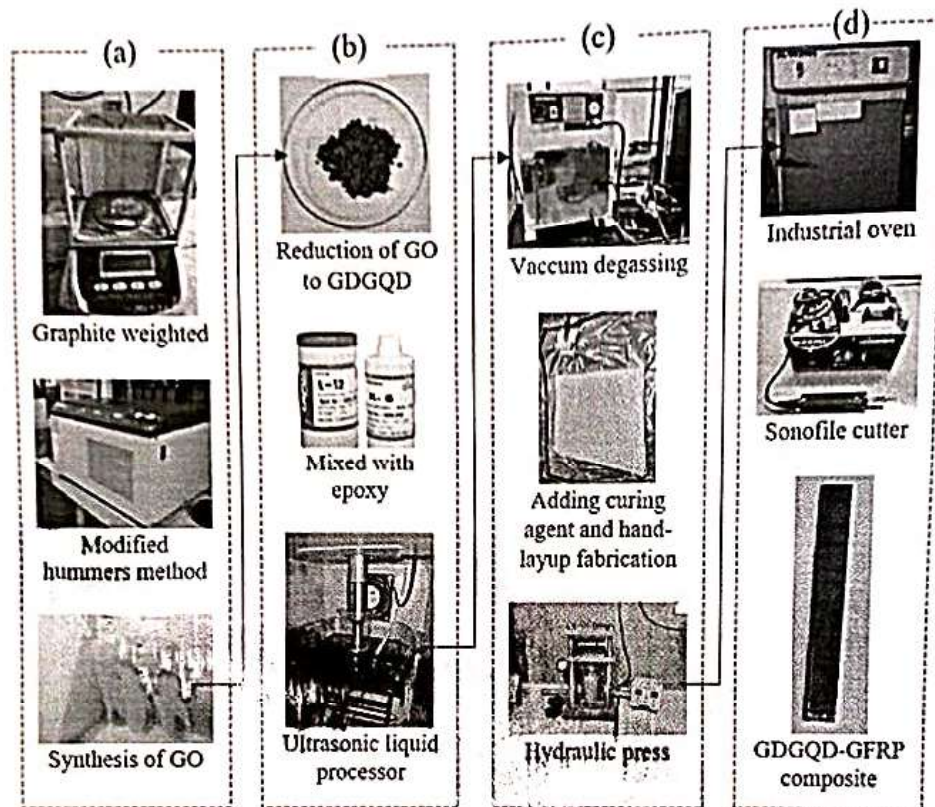


Fig. 1. Preparation of graphene reinforced GFRP composites (a) raw materials (b) dispersion (c) fabrication (d) specimen.

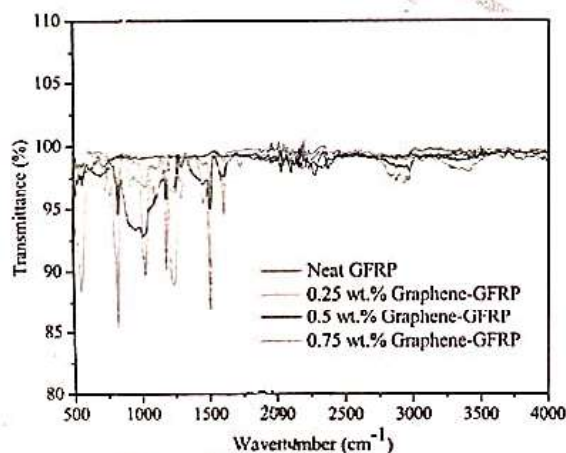


Fig. 2. FTIR spectra for GFRP composites with various wt% of graphene.

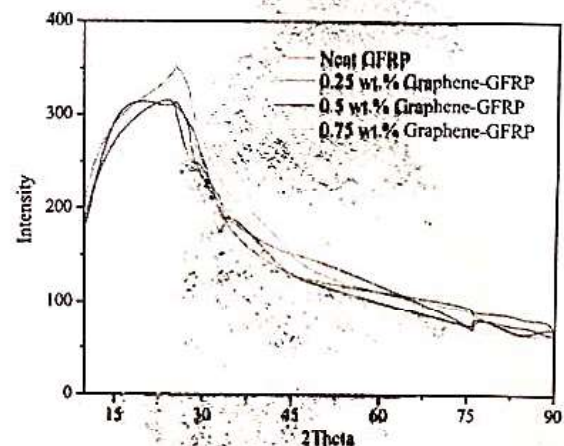


Fig. 3. XRD spectra for GFRP composites with various wt% of graphene.

or GO [14–16]. Wu et al. [17] looked into the interaction of GO's oxygen functions with epoxy and discovered that a wrinkled shape improved the interfacial strength of Aramid fibers. According to Qin et al. [18], GNP coated CFRP/epoxy composites had 52 % higher flexural strength and 19 % higher interlaminar shear strength than uncoated CFRP/epoxy composites. The compressive and flexural properties of composites were reported to be improved by the impregnation of carbon nanofiber with CNT-epoxy by Iwahori et al. [19]. Kim et al. [20]

found that 0.3 wt% CNT loading in epoxy considerably increased flexural modulus, strength, and fracture strain when compared to unfilled CFRP composites. Experimental research was used by Shankar et al. [21] to examine the hydrophobic and modal characteristics of the graphene reinforced epoxy composites. Kereti et al. [22] proposed that sonication time for the composite mixture preparation has a direct relation to the increase in mechanical properties of GFRP. This was performed by obtaining higher ultimate tensile strength and flexural strength values with an increased sonication time for a duration of



Table 1  
d-spacing of GFRP composites with various wt% of graphene.

XRD parameter	0.25 wt%	0.5 wt%	0.75 wt%
2 $\theta$ hkl(°) GFRP	25.91	26.01	25.66
$d_{hkl}$ (nm) GFRP	0.343	0.342	0.349

60 min sonication, but after 4 wt% of GNP, it considerably decreased due to the particle agglomeration. Wang et al. [23] found that the 3 wt% GNP/GFRP improved flexural strength by 16.20 %. Also, the flexural modulus of the GNP/GFRP was 26.3 % increased with 5 wt% GNP reinforcement.

The vibration and buckling analysis of functionally graded graphene platelets (FG-GPL) reinforced beam using Timoshenko beam theory was carried out by Kitipornchai et al. [24]. They suggest that using graphene platelets (GPL) with larger surface areas but fewer single graphene layers to achieve higher fundamental frequencies and critical buckling stresses. The non-linear vibrational properties of FG-GPL plates with a piezoelectric layer were examined by Thanh et al. [25] using classical plate theory. Ghasemi et al. [26] obtained a higher frequency for symmetrically reinforced CNTs/fiber/polymer/metal hybrid cylindrical shells than asymmetrically reinforced shells. Qin et al. [27] investigated the vibration characteristics of functionally graded (FG)

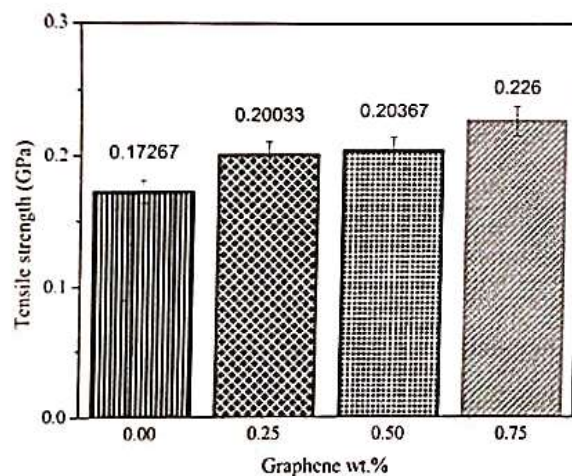


Fig. 4. Tensile strength for GFRP composites with various wt% of graphene.

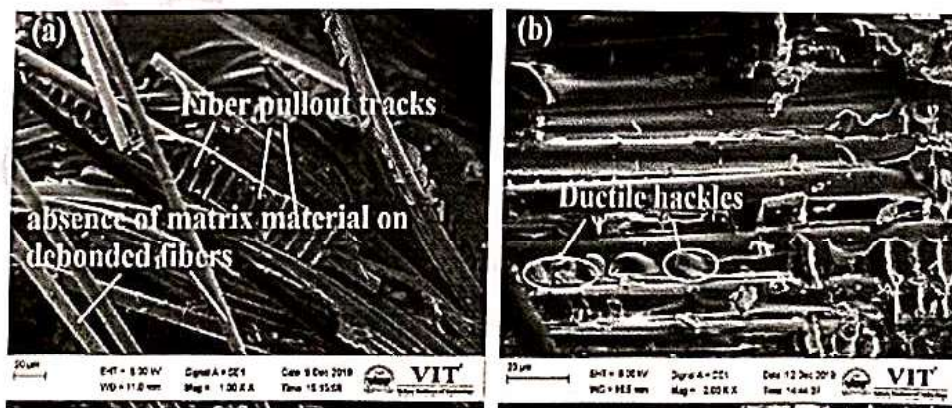


Fig. 5. SEM images of GFRP composites (a) Neat GFRP (b) Graphene reinforced GFRP composites.

nanocomposite shells reinforced with GPL based on first-order shear deformation theory (FSDT). They reported that various parameters such as filler layers, weight fraction, and aspect ratio influence the frequency response of FG graphene shallow shells. Bidgoli et al. [28] investigated the vibration characteristics of sandwich shells with CNT-reinforced piezoelectric face-sheets using the inverse hyperbolic shear deformation theory (IHSDT). Rahimi et al. [29] reported higher natural frequencies for simply supported conditions than the cantilever boundary conditions of FG-GPL reinforced shells. While increased GPLs and decreased porosity increased the natural frequencies. Mellouli et al. [30] used modified FSDT to analyze the free vibration of a FG-CNT nanocomposite shells. Zhang et al. [31] used FSDT to analyze the bending, buckling, and vibration of graphene oxide powder (GOP)-reinforced nanocomposite beams. They found that the GOP performed better than CNTs at enhancing the mechanical behaviours of nanocomposites.

The bending and dynamics of a nanocomposite shell panel reinforced with FG-CNT were examined by Zhang et al. [32] using FSDT. They discovered that the non-dimensional deflections reduced as the CNT concentration increased. The bending properties of composite plates reinforced with FG-CNT were examined by Soni et al. [33] using the IHSDT. Arefi [34] observed a decrease in in-plane and transverse displacement components for a doubly curved piezoelectric shell with an increase in small-scale parameters. The bending and vibration analysis of FG-GPL shell using isogeometric analysis (IGA) combined with higher order shear deformation theory (HSDT) was carried out by Van Do et al. [35] and they found that the GPL reinforcement pattern, and weight fraction improved dynamic behavior of graphene embedded cylindrical and spherical panels. Wuite and Adali [36] characterized the impacts of CNT volume percentage and diameter on deflection and made comparisons with CFRP composites, finding that CNTs had a stiffening impact when employed in structural applications like beams. Tornabene et al. [37] examined the effect of agglomeration by altering particle concentrations and using a variety of functions to reflect the volume fraction distribution across the shell thickness. Numerous parametric investigations have demonstrated that the aggregation of CNTs significantly affects the static response of composite structures. The bending analysis of laminated composite shells carried out by Sharma et al. [38] using IHSDT.

Although most of the research on the vibration and bending behavior of CNT and graphene reinforced nanocomposite structures without fiber reinforcement has been published in the literature review, the dynamic and bending characteristics of graphene reinforced GFRP composite panels has not been investigated. Initially, the flexural and tensile properties of GFRP laminates containing 0–0.75 wt% graphene were assessed using ASTM standard tests. A FE model based on FSDT



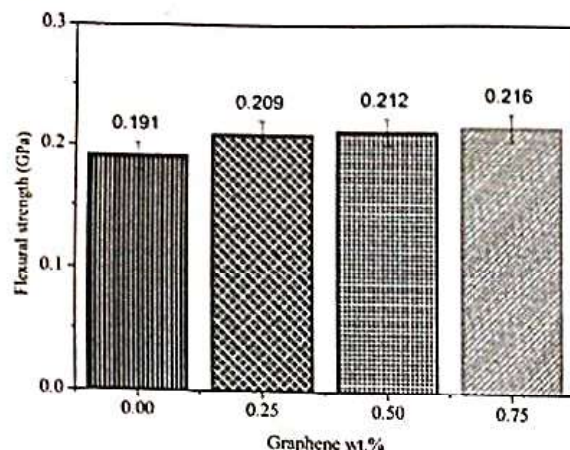


Fig. 6. Flexural strength for GFRP composites with various wt% of graphene.

has been formulated to evaluate the vibration and bending responses of graphene reinforced GFRP composite panels. In terms of natural frequencies and deflection, the validity of the FE data is compared to numerical studies in the literature, and it demonstrates an incredibly high level of agreement for composite panels. A parametric study of the influence of graphene weight percent, end conditions, and aspect ratios on the vibration and bending responses of graphene reinforced GFRP composite panels was also performed.

## 2. Material and mechanical characterization of graphene reinforced GFRP composites

Fig. 1 depicts a flow chart of the manufacturing process. The graphene nanofiller was mixed in ethanol and sonicated for 30 min. After that, the DGEBA epoxy was added to the solution and sonicated for 1 h in a cold bath. The mixture was stirred at 250 rpm for 1 h at 50 °C on a magnetic stirrer with a heated plate until the ethanol had fully evaporated. The mixture was degassed in a vacuum oven, then the curing agent was added in a 1:10 ratio. Furthermore, a hand layup approach was used to thoroughly fill twelve-layer glass fiber with the epoxy-graphene matrix, and the manufactured composites were cured in a vacuum oven at 70 °C for 12 h.

### 2.1. FTIR analysis

A Fourier transform infrared (FTIR) spectrum was used to track the interaction of a functional group of graphene reinforced with GFRP composite. Fig. 2 shows the graphene reinforced GFRP composite's FTIR spectrum. The peaks at 1072  $\text{cm}^{-1}$ , 1236  $\text{cm}^{-1}$ , 1506  $\text{cm}^{-1}$ , 1606  $\text{cm}^{-1}$ , and 2924  $\text{cm}^{-1}$  are due to the C—N, C—O, N—O, C=C, and C—H stretching respectively. The stretching vibration of the N—H group, which is missing in the neat GFRP composite, is attributed to the peak at 3369  $\text{cm}^{-1}$ . The peaks at 3381  $\text{cm}^{-1}$ , 2926  $\text{cm}^{-1}$ , and 1606  $\text{cm}^{-1}$  show N—H stretching when the graphene interacts with the GFRP. The nitro group's C—N stretching is represented by the new peaks at 1230  $\text{cm}^{-1}$  and 1031  $\text{cm}^{-1}$ , and the N—O stretching is represented by the peak at 1506  $\text{cm}^{-1}$ . The interaction of the filler and the epoxy is indicated by the peak shift from 711  $\text{cm}^{-1}$  for GFRP to 825  $\text{cm}^{-1}$  for C=C stretching. The N—H and C—N stretching peaks are missing in GFRP, but their existence in the graphene reinforced GFRP demonstrates graphene-epoxy interaction with GFRP. The functional group interaction may be seen in the peak changes for the methyl and nitrile groups when filler/epoxy is added to the fiber.

### 2.2. XRD analysis

A Bruker D8 advanced diffractometer was used for the X-Ray Diffraction experiment, which was adjusted at 40 kV and 30 mA. The XRD diffractograms of the GFRP composites are shown in Fig. 3. The diffraction spectra from 0° to 60° were displayed at a scan rate of 0.1 per minute, and the d spacing was calculated using Bragg's law:  $\lambda n = 2d \sin \theta$ , where  $\lambda$  is the incident ray wave-length,  $\theta$  is the incident angle, and 'n' is an Integer denoting the order of reflection from the solids. Table 1 shows the d-spacing data of graphene reinforced GFRP composites. The hexagonal primitive structure was represented by the diffraction crystal planes (002) and (100). For GFRP with 0.75 wt% graphene,  $2\theta = 25.66^\circ$  was achieved. The composites had a maximum interlayer spacing of 0.34 Å for specimens with 0.5 wt% and 0.75 wt% graphene and a tiny diffraction peak at  $2\theta = 26.01^\circ$  and  $25.66^\circ$ , respectively. This suggested that the GFRP composites had either an intercalated or an exfoliated structure.

### 2.3. Tensile characteristics

The tensile characteristics of the graphene reinforced GFRP composites were tested (Instron machine, Model 8801) according to ASTM D3039 with a sample dimension of 130 mm  $\times$  13 mm  $\times$  2.5 mm. The average strength values are shown in Fig. 4. The GFRP reinforced with filler obtained a maximum increase in ultimate tensile strength (UTS) of 31.39 % compared to neat material. The tensile strength enhancement was due to the well dispersed and non-agglomerated nanoparticles that led to better interfacial bonding with the composite surfaces. The superior strength of composites is due to this interfacial interaction with the stretching of surface functionalities of graphene/epoxy and GFRP.

The fractographic analysis of the graphene reinforced GFRP composites was performed with SEM (ZEISS-EVO18). Fig. 5 (a) shows neat epoxy with more debonded fibers. The fiber pullout is visible in Fig. 5 (b) and shows the interfacial interaction between ductile hackles and the matrix material on the fiber surface, indicating a superior interaction due to the fine dispersion of filler. These observations depict matrix toughening and a strengthened fiber-matrix interface with graphene reinforcement, where the functional group interactions (methyl and nitrile) at the nanoscale led to the improved composite stiffness.

### 2.4. Flexural characteristics

The flexural characteristics of the graphene reinforced GFRP composites were tested according to ASTM D-790 with a sample dimension of 128 mm  $\times$  13 mm  $\times$  4 mm. Fig. 6 depicts the GFRP composites' flexural strength values. The GFRP reinforced with filler obtained a maximum increase in flexural strength of 13.08 % compared to neat material. The flexural strength enhancement was due to the incredible rigidity offered by the filler that enhanced the load bearing ability. Fig. 7 (a) shows pristine epoxy-fibers on the surface, as well as longer length projecting fibers free of matrix, which are evident due to poor interfacial adhesion. The matrix impregnated GFRP, which was filled with filler, was hardly projected out. Fragmented fiber surfaces, on the other hand, developed matrix traces on the surface without disrupting the interfacial layer (Fig. 7 (b)). The superior flexural strength of composites is due to this interfacial interaction of graphene/epoxy and GFRP.

## 3. Mathematical formulations

A laminated panel made of graphene reinforced GFRP composite was featured in this work for the development of the FE model. Fig. 8 shows a schematic illustration of a composite panel. The mechanical loading details are shown in Fig. 8 (b) and (c). The composite panel's length is  $L$ , thickness is  $H$ , while the radius of curvature and subtended



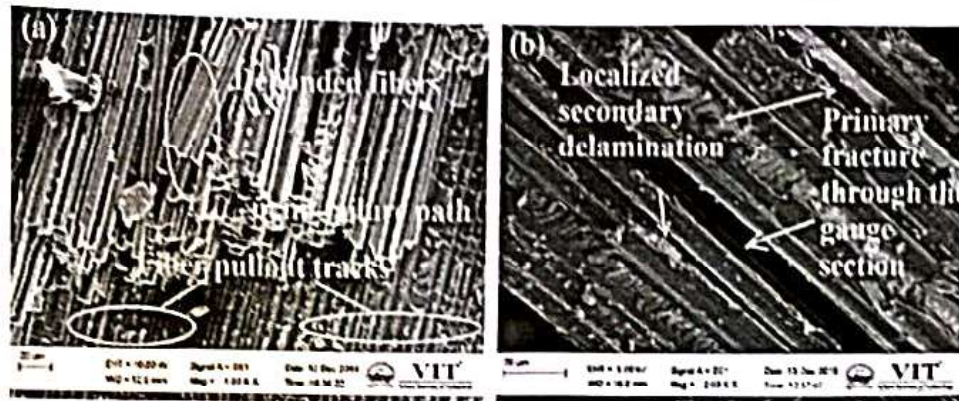


Fig. 7. SEM images of flexural tested GFRP composites (a) neat epoxy GFRP (b) graphene reinforced GFRP composites.

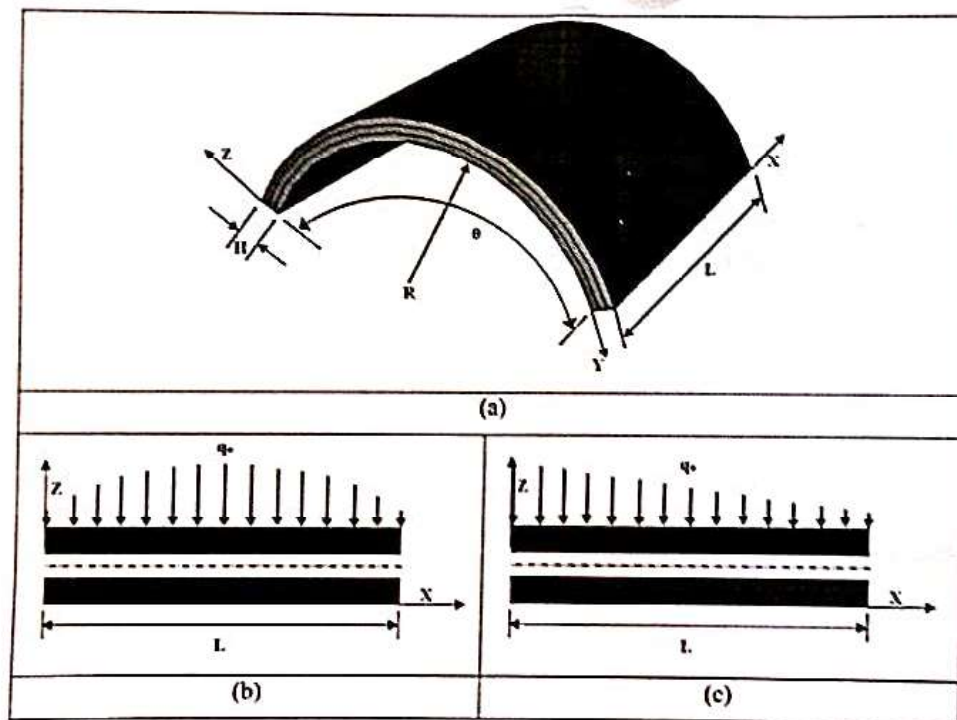


Fig. 8. (a) GFRP panel (b) Sinusoidal distributed load (SSL) (c) Uniformly varying load (UVL).

Table 2  
Vertical deflection of clamped cylindrical panel subjected to UDL 275.8 Pa.

Mesh size	Vertical deflection (mm)			
	Present FSDT	Van Do et al. [35]	Aghdam et al. [41]	Reddy [42]
2 × 2	0.2914	0.2885	0.281	0.288
4 × 4	0.2896			
6 × 6	0.2891			
8 × 8	0.2887			
10 × 10	0.2886			
12 × 12	0.2886			

Table 3  
The non-dimensional deflection of the CNT reinforced composite structures under UDL.

Volume fraction of CNT	Non-dimensional deflection		% error
	Soni et al. [33]	Present FSDT	
0.11	0.03608	0.0363	0.72
0.14	0.02971	0.030	0.97
0.16	0.02336	0.0236	0.93

angle are  $R$  and  $\theta$ , respectively. The FSDT displacement field components are shown in [32].

$$w(x, y, z) = u_\theta(xy) + z\lambda_x(xy) \quad (1)$$



**Table 4**  
Stresses and non-dimensional deflection of laminated composite structure under SSL.

References	$\bar{u}$	% error	$\bar{v}_x$	% error	$\bar{v}_y$	% error
Pagano [43]	0.4385	1.25	0.539	0.46	0.0216	2.31
Sahoo and Singh [44]	0.4341	0.25	0.5462	1.78	0.0216	2.31
Present FSDT	0.4330	–	0.5365	–	0.0211	–

**Table 5**  
The non-dimensional frequencies of the cylindrical panels.

End conditions	R/L	Non-dimensional natural frequencies		% error
		Van Do et al. [35]	Present FSDT	
CCCC	5	14.1421	14.179	–0.26
	10	11.8649	11.893	–0.24
	20	11.2179	11.245	–0.24
	50	11.0295	11.056	–0.24
	100	11.0023	11.028	–0.23
SSSS	5	7.8361	7.798	0.48
	10	6.5434	6.529	0.22
	20	6.1771	6.170	0.11
	50	6.0705	6.065	0.09
	100	6.0551	6.051	0.07

$$v(x, y, z) = v_0(x, y) + z \lambda_z(x, y) \quad (2)$$

$$w(x, y, z) = w_0(x, y) \quad (3)$$

where  $u$  and  $v$  denote the displacement field elements of the GFRP panel with respect to the  $x$  and  $y$  axes. The mid-plane displacements of the GFRP layers along the  $x$  and  $y$  axes are  $u_0$  and  $v_0$ . The rotational displacements are denoted by  $\lambda_x$  and  $\lambda_y$ . The transverse displacement on the  $z$  axis is denoted by  $w$ .

The strain energy equation is as follows:

$$U = \frac{1}{2} \int_V (\epsilon)^T (\epsilon) dv \quad (4)$$

The kinetic energy equation is stated as

$$T = \frac{1}{2} \{d\}^T [J] \{d\} \quad (5)$$

Nine-noded isoparametric elements with 5 degrees of freedom ( $u_0, v_0, w, \lambda_x, \lambda_y, \phi_z$ ) at each node were evolved to develop the equations of motion. The deformation field vector ( $d$ ) and shape functions ( $N_i$ ) are used to describe deformations of the GFRP panel at any point.

$$\{d\} = \sum_{i=1}^9 [N_i] \{d_i\} \quad (6)$$

The Lagrange's equation is used to obtain the governing equation for dynamic analysis of the GFRP panel, which is written as [39]

$$[m_T] \{\ddot{d}\} + [k_T] \{d\} = \{f\} \quad (7)$$

where  $k$  and  $m$  are the element structural stiffness and mass matrices, respectively. The displacement field vector is  $d$ , and the force vector is  $f$ . The system governing equation is written as

$$\delta(U - W) = 0 \quad (9)$$

where  $U$  is the total strain energy;  $W$  is the work done;  $\delta$  is the variation symbol; and  $\Pi = U - W$  is the total potential energy.

The governing equations for static bending analysis of the GFRP panel in the FE form are represented as

$$[K] \{q\} = \{F\} \quad (10)$$

#### 4. Validation

This section compares the outcomes of the current FSDT formulation with those mentioned in the literature by taking into account a range of numerical instances. A convergence study was first performed to determine the ideal mesh size for fine-tuning solutions. The results of composite panels in this numerical analysis have converged with a mesh size of  $12 \times 12$ . Due to the faster processing time, the entire numerical research was carried out with the same mesh size for all the parametric conditions. The numerical solutions given in Van Do et al. [35] for a composite panel are used as a comparison in this validation study. For the simulation, the following properties are taken into account:  $L/R = 0.2$ ,  $R = 2.54$  m,  $\theta = 11.46^\circ$ ,  $h/R = 0.00125$ ,  $E = 3.1$  GPa, and  $\nu = 0.3$ . Table 2 shows the vertical deflection of the panel. A significant level of consistency can be seen between the Van Do et al. [35] results and those obtained using the present FSDT.

The developed FSDT model is further validated for CNT reinforced nanocomposite plates under SSSS conditions. The geometrical and material details of the structure are taken from Soni et al. [33]. Table 3 contrasts the non-dimensional deflections calculated for the composite plate using the current FSDT with those documented in the literature. They are confirmed to be in good agreement.

The correctness of the FSDT formulation is further confirmed by matching the non-dimensional stresses and deflections of the composite structure derived with the current FSDT to those found in the literature with the various properties considered as:  $E_1/E_2 = 25$ ,  $G_{12} = G_{13} = 0.5E_2$ ,  $G_{23} = 0.2E_2$ ,  $\nu_{12} = 0.25$ ,  $L/h = 100$  and ply orientation =  $\{0^\circ/90^\circ/90^\circ/0^\circ\}$ . The findings are shown in Table 4. The findings of the current FSDT formulation and those of Pagano [43], and Sahoo and Singh [44] are in good agreement.

The current FSDT's validity is further confirmed by contrasting the frequencies attained using it with those documented in the literature. The geometrical and material details of the cylindrical panels are:  $a/b = 1$ ,  $R = 10$  m,  $E = 3$  GPa,  $\nu = 0.34$  and  $\rho = 1200$  kg/m<sup>3</sup>. Table 5 shows the results of the panel. A significant level of consistency can be seen between the Van Do et al. [35] results and those obtained using the present FSDT.

The reliability of the FSDT is further confirmed by matching the outcomes produced with the current FEM to those found in the literature. Subramani and Ramamoorthy [39] provided the material and geometrical details for the CNT reinforced GFRP cylindrical panel, such as:  $E_1 = 30.24$  GPa,  $E_2 = 6.93$  GPa,  $\nu_{12} = 0.2813$ ,  $G_{12} = 2.79$  GPa,  $G_{23} = 2.52$  GPa,  $\rho = 1691$  kg/m<sup>3</sup>,  $L = 0.3$  m,  $B = 0.3$  m,  $H = 0.0013$  m and, ply orientation =  $\{90^\circ/0^\circ/90^\circ/0^\circ/90^\circ\}$ . Table 6 contrasts the natural frequencies calculated for the CNT reinforced GFRP panel using the current FSDT with those documented in the literature [39]. They are confirmed to be in excellent agreement.

#### 5. Structural characterization



Table 6

Natural frequencies of the CNT reinforced GFRP composite cylindrical panel under CFFF end condition.

Mode (m, n)	Natural frequencies (Hz)									
	Subramani and Ramamouthy [39]					Present FEM				
	Exp results	Curvature ratio (R/L)				FSDT results	Curvature ratio (R/L)			
		5	10	20	Plate		5	10	20	Plate
1, 1	6.3	6.38	6.36	6.35	6.34	6.28	6.33	6.23	6.21	6.20
1, 2	13.27	13.36	13.37	13.37	13.38	13.01	13.15	13.09	13.08	13.07
2, 1	35.21	39.70	39.74	39.71	39.67	38.48	39.42	39.03	38.88	38.79
2, 2	47.60	51.37	51.66	51.73	51.75	49.13	50.75	50.66	50.63	50.62

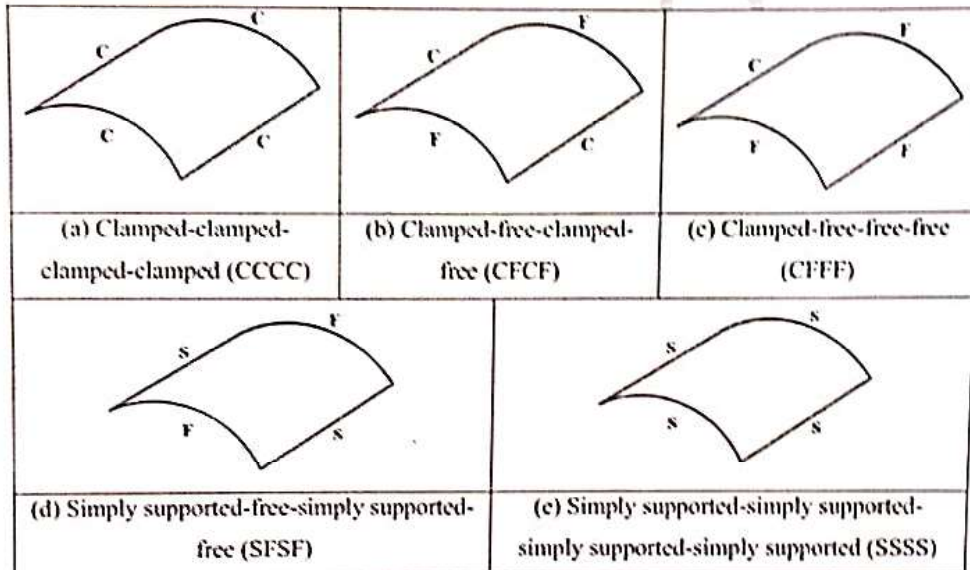


Fig. 9. Various end conditions considered for the analysis.

taken into consideration in this investigation. The considered panel has the following geometrical properties: length ( $L$ ) = 600 mm,  $\theta = 28.66^\circ$ , radius of curvature ( $R$ ) = 1200 mm, ply thickness ( $h$ ) = 0.2083 mm and thickness ( $H$ ) = 5 mm. The material details for the graphene reinforced GFRP composite are taken from Section 2 such as:  $E_1 = E_2 = -1.12Gr^2 + 3.624Gr + 6.861$  GPa,  $\nu_{12} = -0.008Gr^2 - 0.068Gr + 0.2998$ ,  $G_{12} = -0.4001Gr^2 + 1.4052Gr + 2.6394$  GPa, and  $\rho = 24.8Gr^2 + 13.4Gr + 1718.1$  kg/m<sup>3</sup>, where  $Gr$  is the wt% of graphene.

### 5.1. Static bending behavior of GFRP composite panels

The effect of weight percent of graphene (0, 0.25, 0.5, and 0.75) on the static behavior of the graphene reinforced GFRP composite panel under different end conditions is analyzed, including two types of mechanical loading conditions (UVL and SSL) and shown in Figs. 10 and 11. For comparison, the deflections for the neat GFRP composite panel, which has no bearing on the graphene addition, are also shown. As expected, the deflection significantly decreases after the graphene is incorporated into the composite panels, and steady deflection reduction is observed as the graphene weight percentage increases, which is due to the resulting increased stiffness of the composite panel. The deflection of the graphene reinforced GFRP composite panel is 24.42 % less than that of the neat GFRP panel under CCCC conditions. This is caused by the greater stiffness of GFRP panels with graphene reinforcement. A

similar pattern of behavior was reported by Van Do et al. [35] for FG-GPL reinforced nanocomposite panels. It can also be seen that as the curvature ratio increases, the non-dimensional deflections increase. From the results, it is observed that the static bending of GFRP composite panels appears to be reduced more effectively by the graphene reinforcement.

The influence of the aspect ratio on graphene reinforced GFRP composite panels under CFCF end conditions has been studied and the results are presented in Fig. 12. The deflections increase with the influence of the aspect ratio. As a result, it can be inferred that the deflections are less for thick GFRP panels as compared to thin GFRP panels. Fig. 13 demonstrate the analysis of the effects of curvature ratio on the stresses of the graphene reinforced GFRP composite panel under CFCF end conditions. The in-plane and transverse stresses of the graphene reinforced GFRP composite panel are significantly influenced by the curvature ratio. It appears as an increase in in-plane and transverse stresses as the curvature ratio rises. This may be because flat structures are less stiff than panels with the least amount of curvature since they supply less bending and stretching energy.

### 5.2. Vibration behavior of the GFRP composite panels

The effects of increasing the weight percentage of graphene on the dynamic behavior of the GFRP composite panel under various end conditions are examined. Fig. 14 shows that the natural frequencies were higher in GFRP composite panels with graphene reinforcement than in



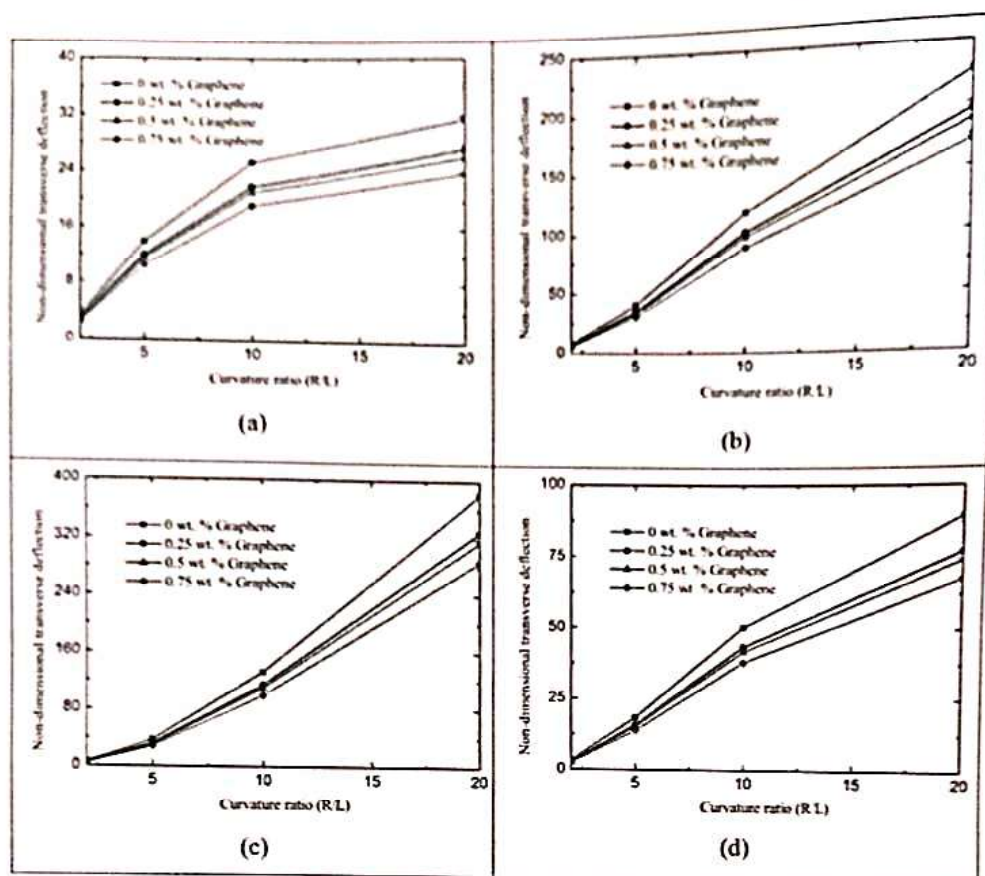


Fig. 10. The non-dimensional deflection of the GFRP panels with various wt% of graphene reinforcement under UVL. (a) CCCC (b) CFCF (c) SFSF (d) SSSS.

neat GFRP panels. The fundamental frequency of the graphene reinforced GFRP composite panel is 14.13 % superior to those of the GFRP panels without graphene reinforcement under CCCC conditions. This is because graphene and glass fiber have a high interfacial interaction, which helps to enhance the stiffness of the GFRP composite panels reinforced with graphene.

The findings of an investigation into the impact of altering the aspect ratios on the vibration behavior of the GFRP panel under CFCF end conditions are shown in Fig. 15. It has been discovered that the natural frequency of the GFRP composite panel decreases as the aspect ratio rises. This might be because the rigidity of the panel is decreased when the aspect ratio rises. The impacts of increasing curvature ratios under CCCC end conditions are explored on the vibration characteristics of the GFRP composite panel, and the outcomes are shown in Fig. 16. The findings demonstrate that increasing curvature ratio decreases the natural frequency in all the modes investigated. This may be due to the fact that the composite panel with the least amount of curvature produces greater natural frequencies since it offers more bending and stretching energy than flat structures.

## 6. Conclusions

In this study, the material, mechanical, static bending and vibration properties of graphene reinforced GFRP composites were investigated. XRD, FT-IR, and SEM were used to analyze the material characteristics of GFRP composites reinforced with graphene. According to the XRD analysis of graphene reinforced GFRP composite, the increased d-spacing of graphene facilitates the dispersion of particles in the matrix.

Peak shifts for the methyl ( $-\text{CH}_2$ ) and nitrile ( $-\text{C}-\text{N}$ ) groups of the graphene filler with fiber are shown in the FTIR spectra, demonstrating a functional group interaction. For graphene reinforced GFRP composites compared to pristine GFRP composites, the tensile strength and flexural strength increased by 31.39 % and 13.08 % respectively. According to the numerical findings, GFRP panels with graphene reinforcement have lower non-dimensional deflections than GFRP panels without graphene reinforcement. The deflection of the graphene reinforced GFRP panel is 24.42 % less than that of the neat GFRP panels under CCCC end conditions. It was found that the deflections decreased along with the weight percentage of graphene. The fundamental natural frequency of the graphene reinforced GFRP panel is 14.13 % higher than that of the GFRP panel under CCCC end conditions. Further findings from the parametric investigations have shown that the wt% of graphene, curvature ratio, aspect ratio and end condition have notable effects on the static bending and vibration behavior of the GFRP composite panels. Consequently, the current study may serve as a guide for the efficient design and development of GFRP panels reinforced with graphene for aerospace applications.

## Declaration of competing interest

The authors affirm that they have no known financial or interpersonal conflicts that would have appeared to have an impact on the research presented in this study.



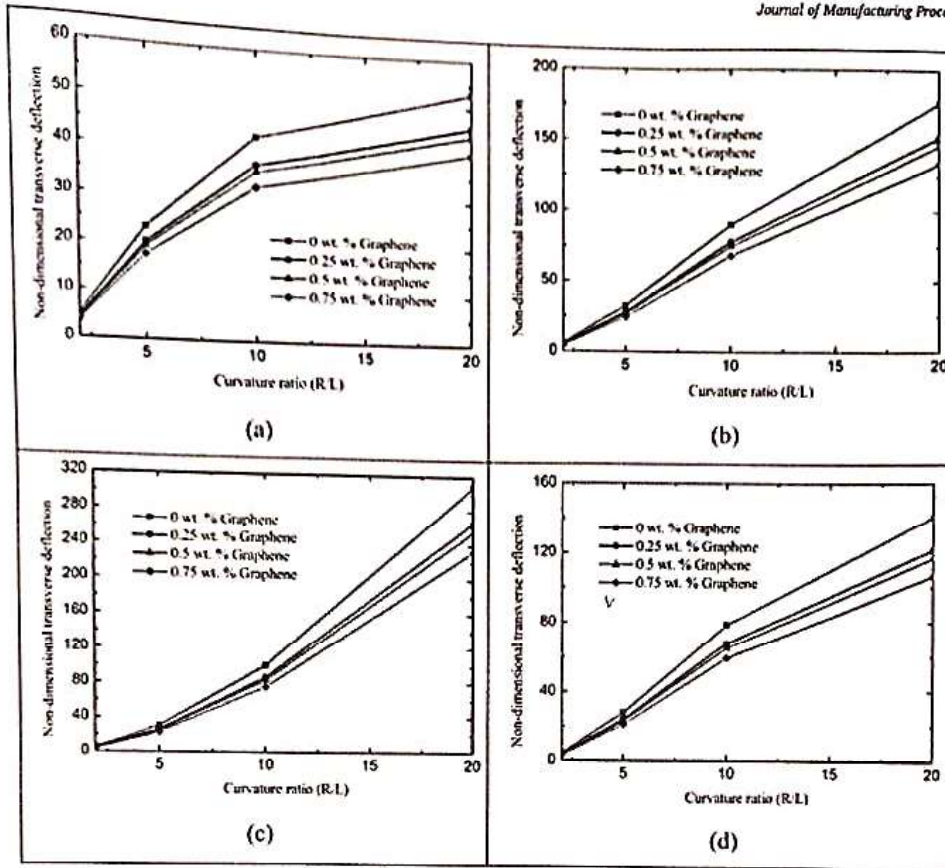


Fig. 11. The non-dimensional deflection of the GFRP panels with various wt% of graphene reinforcement under SSL. (a) CCCC (b) CFCF (c) SFSP (d) SSSS.

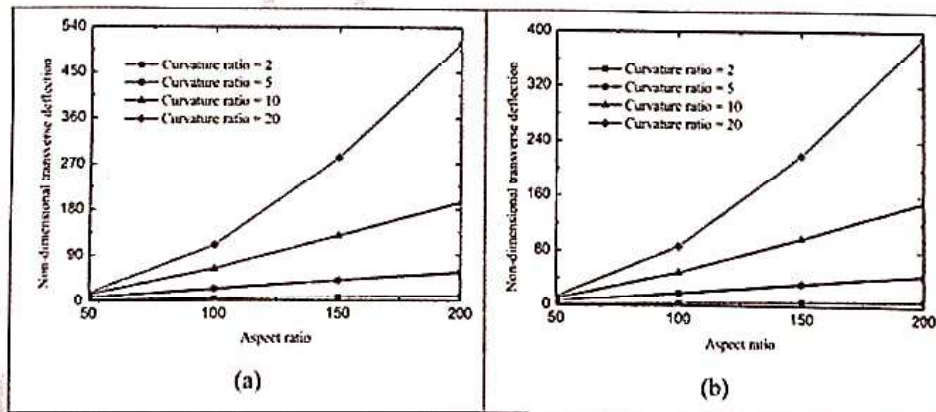


Fig. 12. Non-dimensional deflection of a graphene reinforced GFRP panel under CFCF end conditions. (a) UVL (b) SSL.

#### Data availability statement

The raw/processed data required to reproduce these findings cannot be shared at this time as the data also forms part of an on-going study.



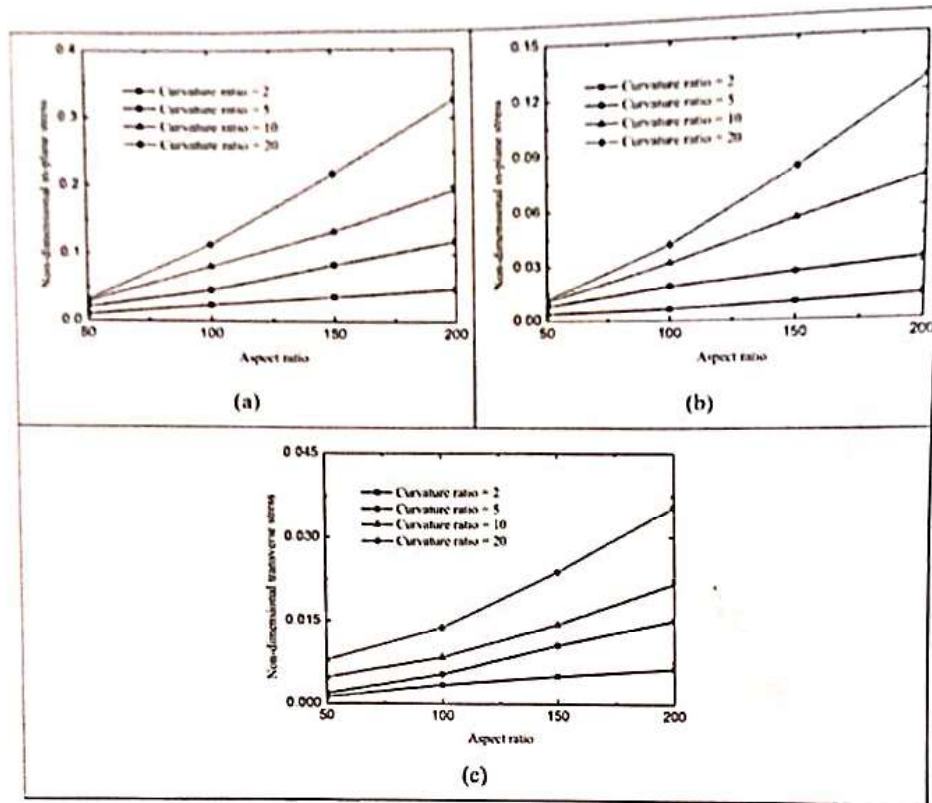


Fig. 13. Non-dimensional in-plane and shear stresses of a graphene reinforced GFRP panel with SSL under CFCF end conditions. (a)  $\bar{\sigma}_{xx}$  (b)  $\bar{\sigma}_{yy}$  (c)  $\bar{\tau}_{xy}$ .



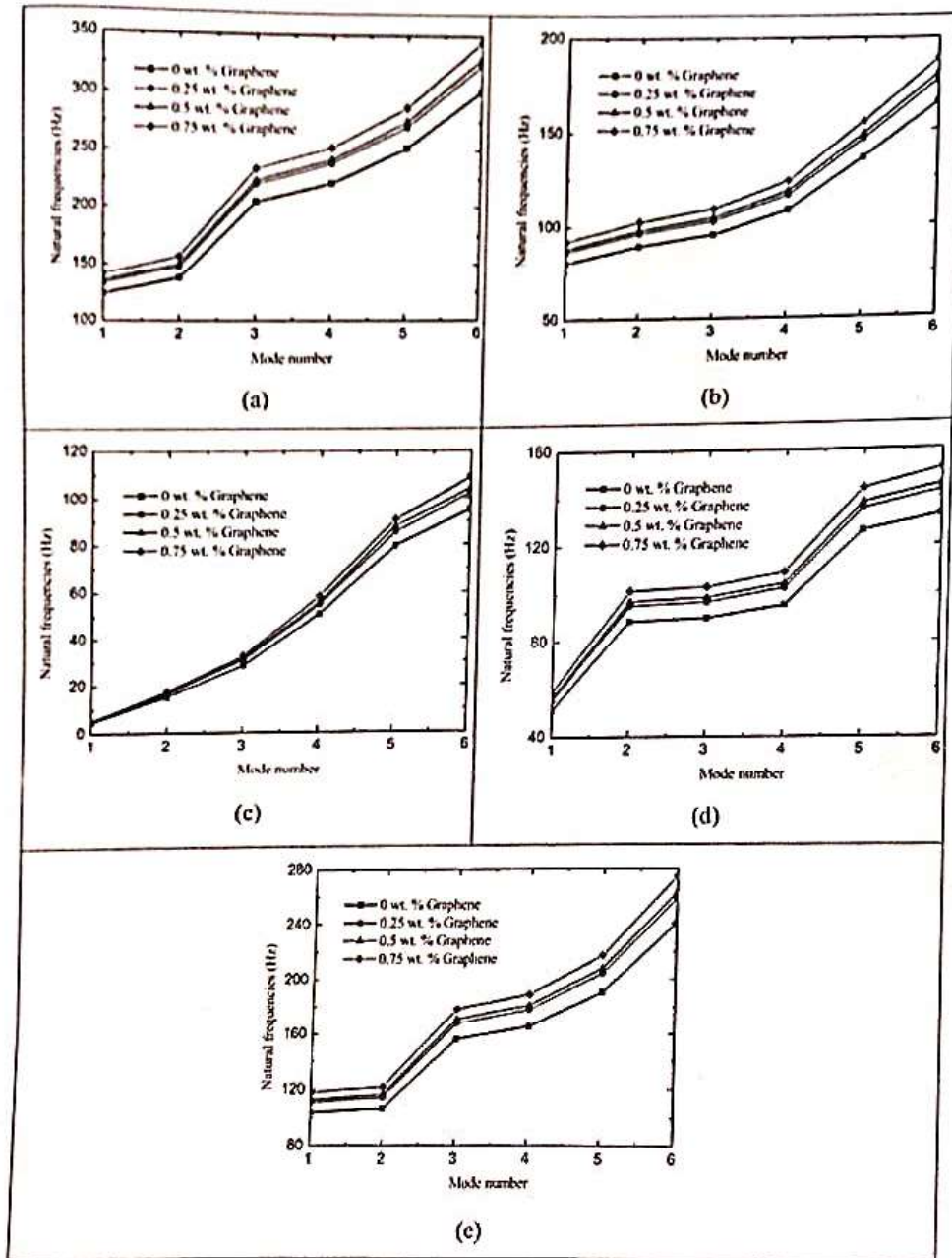


Fig. 14. The effect of graphene wt% on the natural frequencies of GFRP composite panel under different end conditions (a) CCCC (b) CFCF (c) CFFF (d) SFSF (e) SSSS.



X. Liao et al.

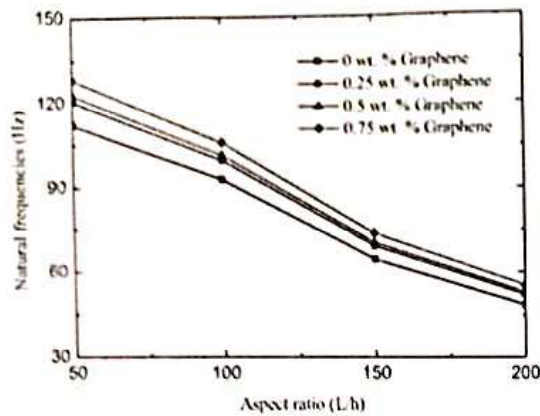


Fig. 15. The effect of aspect ratios on the natural frequencies of GFRP composite panels with various wt% of graphene reinforcement under CFCF end conditions.

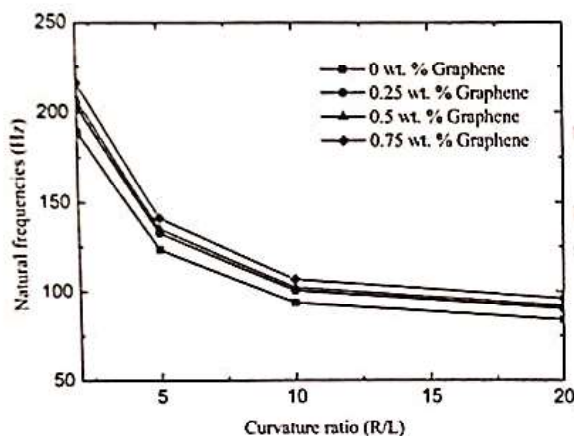


Fig. 16. The effect of curvature ratios on the natural frequencies of GFRP panels with various wt% of graphene reinforcement under CCCC end conditions.

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CORRECTED PROOF



# Effect of corn husk fiber length and diameter on load bearing, fatigue, and DMA properties of biosilica toughened epoxy composite

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## Abstract

This study examined how the diameter and length of corn husk fiber affects the mechanical, fatigue, and DMA properties of epoxy-based composite material. As filler, biosilica, which is made from wheat husks, was used to make composites. By hand layup process, the composites were created and then characterized as per the ASTM standards. Results revealed that the N21 composite designation offered improved tensile and flexural strength, Izod impact and hardness up to 94 MPa, 137 MPa, 3.62 J, and 86 shore-D. But compared to all composite designations, the composite designation N23 has the highest tensile and flexural strength, Izod impact, and hardness values, which are 134 MPa, 182 MPa, 4.84 J, and 88 Shore-D, respectively. Similarly, the composite designation N21 gives improved fatigue life counts of 21,629 by adding 1 vol. % of biosilica and fiber length of 70 mm and diameter of 200  $\mu\text{m}$ . In the same way, the highest storage modulus and loss factor of 5.5 GPa and 0.3 were noted for composite N23. The fiber diameter of 200  $\mu\text{m}$  and a length of 70 mm demonstrate effective load shearing phenomenon and bonding between the fiber and matrix. Overall, the lesser diameter fiber with a higher length outperformed and it is recommended for high-performance composite making.

## KEYWORDS

dynamic mechanical properties, fatigue, natural fiber, SEM, WHA biosilica

## 1 | INTRODUCTION

Natural, renewable, and biodegradable products have been developed as a result of growing public awareness of environmental issues worldwide since they do not release any harmful pollutants during production, use, and disposal.<sup>[1]</sup> Businesses in the textile and other fiber-using industries have been searching for new natural fiber sources that might be compared to the performance characteristics of important natural fibers like cotton and linen for years. This could reduce the dependency on land and other resources needed to produce fiber at a profit.<sup>[2]</sup> It may be

possible to conduct research on corn husk, a cellulose rich fiber that is generally discarded as garbage, as a textile fiber. The second-most significant crop in the world is corn, also referred to as maize. Stover (stalk, leaves, and husks), which is produced during corn farming, has been studied for a variety of reasons by researchers.<sup>[3]</sup> A more environmentally friendly material for cleaner production, Hassan et al.<sup>[4]</sup> studied the mechanical, fatigue, and DMA behavior of corn husk fiber and orange peel biochar epoxy composite. Developing a high-toughness bio composite cleaner manufacturing material for cutting-edge engineering applications was the aim of this study. According to



the study, a significant toughening was produced by the cellulosic fiber, which also reduced the epoxy's excessive brittleness. The composite also has outstanding mechanical properties, such as tensile and flexural strengths of 166, 191 MPa, impact toughness of 6.64 J, hardness of 91 shore-D, and fatigue life counts of 28,554. Similarly, Madueke et al.<sup>[5]</sup> investigated the limitations of natural fibers and composites, concentrating on tensile strength using coir as a comparison. The author discovered that these fibers, although exhibiting beneficial properties such as low density and environmental compatibility, have the common property of non-uniformity along their length, resulting in variable diameter and cross-sectional area. Thus according to the results the composites made using the coir have inferior properties. Similarly, Alsaadi et al.<sup>[6]</sup> investigated the influence of pistachio shell particle concentration on the mechanical characteristics of polymer composite. The maximum tensile strength, flexural strength, and impact strength were recorded at 10, 5, and 5 wt% pistachio shell particle concentration, respectively.

However, due to its size-to-strength ratio, versatility, and low cost, fiber-reinforced epoxy composites with high toughness and strength are much sought for engineering applications.<sup>[7]</sup> High-toughness composites are crucial in a wide range of technological applications, such as the automotive, aerospace, and structural industries. Fiber-reinforced epoxy composites have strong tensile, flexural, and impact characteristics in general because of their fiber-matrix interface adhesion.<sup>[8]</sup> Composites with extraordinarily high fiber-matrix interfaces have better mechanical properties. Chemical surface treatment of fiber improves adhesion by changing the fiber's surface, because they have better specific mechanical properties than metallic alloys.<sup>[9]</sup> It is noted that high performance areca-reinforced polyester composite were prepared by Thilagham et al.<sup>[10]</sup> using wheat husk bio silica. This study aims to investigate the effects of varied wheat husk ash (WHA) bio silica particle concentrations on the mechanical and wear properties, fatigue, and hydrophobic behavior of polyester composites made from areca fiber. Results revealed that the addition of areca fiber and biosilica improved the load bearing properties of composite.

So based on the previous literatures there was no similar combinations of reinforcements were researched by researchers. But the need of this research is much essential in the process of making waste turned to wealth and its composite application. Thus in this study the combined effect of the corn husk fiber infused into the bio-silica toughened epoxy resin composite could investigate to fill the research gap. The study aims to investigate the mechanical, fatigue, and DMA properties of the aforementioned hand layup composite. Prior to the development composite, the fiber could treat with silane to improve the

bonding with resin. Wide range of applications, including structural, automotive, electrical and home infrastructure products may benefit from these properties improved composites with higher cost concern factor.

## 2 | EXPERIMENTAL PROCEDURE

### 2.1 | Materials

To develop composites, a density of up to 1.2 g/cm<sup>3</sup>, LY556<sup>TM</sup>, HUNTSMAN India Pvt. Ltd. liquid diglycidyl ether of Bisphenol A resin was used as matrix. This resin can be cured using the curing catalyst triethylenetetramine (HY 951). Maize husk short fiber of length 50 and 70 mm as well as diameters 300 and 200  $\mu$ m were procured from Metro Composites, Chennai, India in raw condition. The fiber density was about 1.48 g/cm<sup>3</sup>. Figure 1A,B shows the photographic and optical macroscopic view of corn husk fiber, similarly, Figure 1C,D shows the Scanning Electron microscope (SEM) images of 200 and 300  $\mu$ m fiber.

### 2.2 | Biosilica preparation

The extraction of biosilica from wheat husk has steps followed in Figure 2. Using thermochemical process the wheat husks were converted as biosilica. During the combustion process, WHA is prepared and purified. The created WHA was again mixed with NaOH and stirred at 80°C for 1 h to obtain silicate solution. Using Whatman grade-41 filter paper, the generated sodium silicates were filtered and separated. The resulted precipitations were further treated with 1 N HCl having pH of 7 at ambient temperature. The silica gels were aged for 24 h after stirring to generate xerogel silica. Further, the slurry was heated in an oven for 20 h at 70°C to achieve a fine wheat husk biosilica particles of size 60–80 nm.<sup>[11]</sup>

### 2.3 | Surface modification of fiber and biosilica

Separate silane treatments are used to improve the surfaces of corn husk fiber and bio silica. In a glass beaker, carefully blended 95% of ethanol and 5% of distilled water has taken to produce the silane solution. Second, acetic acid is added to the resulting solution, which has a pH range of 4.5–5.5, to adjust the pH. The ethanol-water solution must be gradually filled with silane drops until the necessary saturation level is obtained. The methoxy group from the silane

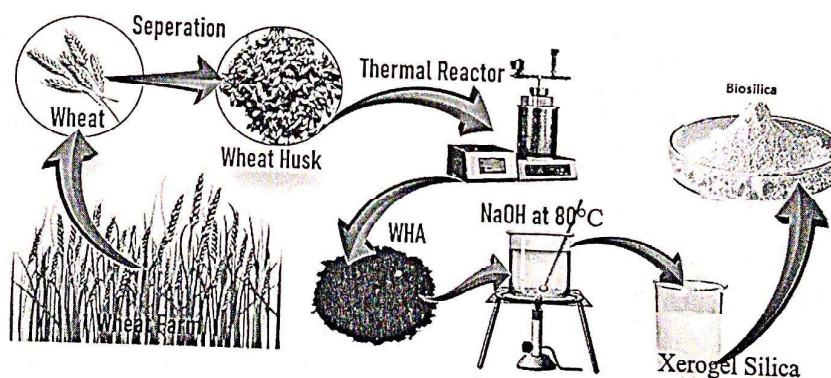




**FIGURE 1** Cross section images of corn husk fiber (A) photographic, (B) optical microscopic, (C, D) SEM micrographic views.



**FIGURE 2** Biosilica preparation route from wheat husk.



component was then removed and the solution was gently agitated until all silanol groups had been dissolved. To create a Si—O—Si structure, the fiber and cellulose are removed from the silane solution after soaking for 10 min and then oven-dried for 20 min at 110°C.<sup>[12]</sup>

## 2.4 | Composite laminate preparation

Before creating a composite, the lay-up surface is cleaned as part of the mold preparation process. Wax is then used after washing to make it easier to remove the laminate. If any edge gaps are discovered, silicon-rubber is applied to the laminate's perimeter to mark the lamination region.

The epoxy resin, bisphenol A (LY556), is collected in a cleaned glass beaker that has been supplemented with biosilica after the preparation of the mold is complete. Stirring was continued until the mixture was well-blended and free of lumps.<sup>[13]</sup> The catalysts are added up to 10% of weight after that the biosilica made from wheat husk and epoxy has been completely mixed. After placing the chopped corn husk fiber on the mold, the resin mixture is slowly poured and the mixture was left to cure. Due to the slow polymerization generated by the 10:1 resin-hardener mixture ratio, the cure time at room temperature is about 24 h. After that, the composite is post-cured by being heated for 4 h in a hot air oven at 120°C (Table 1).<sup>[14]</sup>



TABLE 1 Composite designation with different combinations.

Composite designations	Epoxy (vol%)	Corn husk fiber (vol%)	Biosilica (vol%)	Fiber length (mm)/ fiber diameter ( $\mu$ m)
N0	100	—	—	—
N11	70	30	—	50/300
N12	69	30	1	50/300
N13	67	30	3	50/300
N21	70	30	—	70/200
N22	69	30	1	70/200
N23	67	30	3	70/200

TABLE 2 Characterization details with machine specifications.

Tests performed	ASTM standards	Machines used
Tensile	D-3039	INSTRON 4855, UK
Flexural	D-790-17	Traverse speed of 1.12 mm/min
Izod impact	D256-10	Ms. Rathnakar machine tools Pvt. Ltd., 25 J
Shore-D Hardness	D 2240	Blue steel Durometer
Fatigue behavior	D 3479	MTS Landmark, USA, 370 load frame series
DMA	D 4065	Dual cantilever mounted DMA analyzer with sweep mode
SEM	—	HITACHI, S-1500, JAPAN

### 3 | CHARACTERIZATION OF COMPOSITE

To find any noticeable surface faults, the epoxy-based wheat husk biosilica dispersed with corn husk fiber composite is visually inspected. According to the ASTM specifications three test specimens are cut out of the laminate using abrasive water jet machine (Maxiem Water Jets, 1515 KENT). The machine runs with a maximum 220 psi jet pressure, 0.3 g/s abrasive flow rate, 1.1 mm nozzle diameter, and 3 mm SOD throughout the processes.<sup>[15]</sup> Table 2 presented the load bearing, mechanical, fatigue, and DMA process parameters and its testing machinery details.

### 4 | RESULTS AND DISCUSSION

#### 4.1 | Mechanical properties

The mechanical characteristics of a biosilica toughened epoxy composite with corn husk fiber reinforcement are shown in Figure 3. Due to the lack of reinforcing elements, the composite designation N0 exhibits the lowest

mechanical parameters, measuring 62 MPa, 98 MPa, 0.33 J, and 86 Shore-D for tensile and flexural strength, Izod impact, and hardness, respectively.<sup>[16]</sup> This composite designation exhibits brittle fracture with shear cups and river markings on its fractured surface, as seen in Figure 4A, because it is made of pure matrix. However, adding an additional 30% of maize husk fiber to the composite material results in improved mechanical qualities for designations N11 and N21. In comparison with N21, the composite designation N11 exhibits higher values of 94 MPa, 137 MPa, 3.62 J, and 86 Shore-D for the properties such as tensile, flexural, Izod impact, and hardness, respectively. This is because of highly fibrillated maize husk fiber, which distributes the applied load uniformly throughout the composite.<sup>[17,18]</sup> As shown in Figures 4B,D,E, the presence of  $\text{NH}_2$  functional group chemically reacts with the free OH group of the epoxy resin to generate a strong reaction and improved the toughness. Moreover different fiber length and diameter are the cause of the small variations in values because a matrix with a shorter length and a bigger diameter can debone more readily with fiber,<sup>[19]</sup> as seen in Figure 4C. Figure 4D illustrates the relationship between the improvement in mechanical properties and the decrease in fiber diameter as a result of the loss of hemicellulose in the fibers caused by the silane treatment.<sup>[20]</sup> The reason behind is as the diameter of fiber increases, the possibility of the presence of defects increases. Additionally, adding biosilica in amounts of 1 and 3 vol% improves the mechanical properties of composites with the designations N12, N13, N22, and N23. However, when compared to all composite designations, composite designation N23 exhibits greatest tensile and flexural strength, Izod impact, and hardness values of 134 MPa, 182 MPa, 4.84 J, and 88 Shore-D. As compared to pure the composite designation N23 shows the decrement in tensile and flexural strength, Izod impact, and hardness by 53%, 49%, 93%, and 2%. This improvement is due to the inclusion of biosilica. The micro load sharing mechanisms inside the matrix were made better by



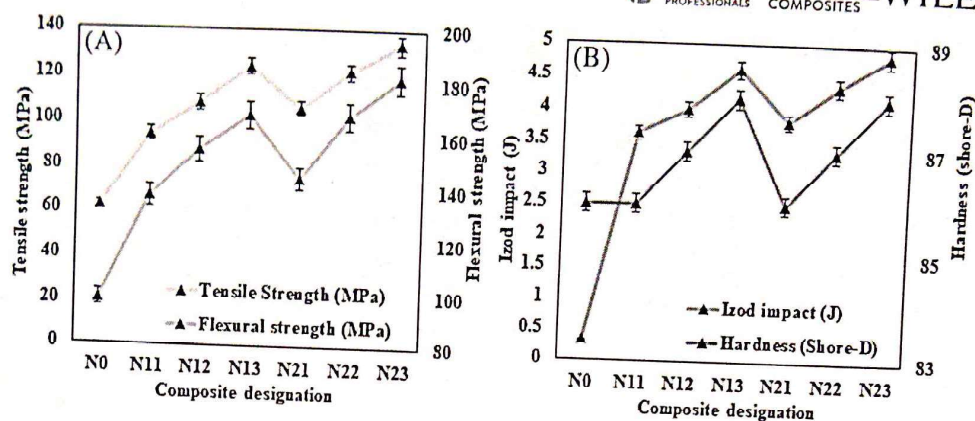


FIGURE 3 Mechanical properties of various composite designations.

FIGURE 4 SEM fractured portions of tensile tested samples.



the addition of biosilica, which also increased the epoxy composite's resistance to rapid impacts.<sup>[21]</sup> However, the thicker the fiber, the more the flaws and irregularities it

contains and the thinner the fiber, the fewer flaws and irregularities or defects present.<sup>[22]</sup> For variable length and diameter reinforcements, the hardness values of



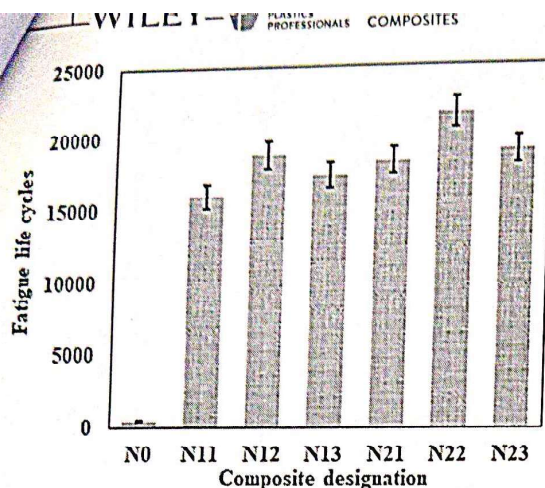


FIGURE 5 Fatigue life counts for various composite designations.

both composite designations in all categories show the same value.

#### 4.2 | Fatigue behavior

Figure 5 shows the fatigue life counts of various composites tested. It is noted that the composite designation N0 has the lowest measured cycle of 176. This lesser fatigue life is the result of its extreme brittleness and absence of reinforcements. The life of the composite decreases as the applied load is repeated and the stress intensity reaches higher level.<sup>[23]</sup> This is due to the fact that the rate of microcracks creation and transmission accelerates with increasing stress applied, causing the composites to deform plastically.<sup>[24]</sup> For composite designations N11 and N21, additional inclusions of maize husk fiber amounting to 30 vol% enhanced the fatigue life cycles by 97.01% and 97.39%, respectively. The dispersed reinforcements are distributed uniformly throughout the composite as a result of this increase in values caused by the matrix.<sup>[25]</sup> Due to the variation in fiber length and diameter, the composite material with the designation N21 exhibits significantly longer fatigue life cycles than N11. This is because, compared to 5 cm corn husk fibers, the 7 cm corn husk fibers in the epoxy matrix showed a higher efficiency of load transfer from matrix to fiber.<sup>[26]</sup> However, the fatigue life cycles for the composites with designations N12, N13, N22, and N23 increased when biosilica is further incorporated into this corn husk reinforced epoxy composite, which has various fiber length and fiber diameter. This is in comparison to pure epoxy. However, the composite designator N22, which contains 1 vol% biosilica and fiber that are 200  $\mu\text{m}$  in diameter,

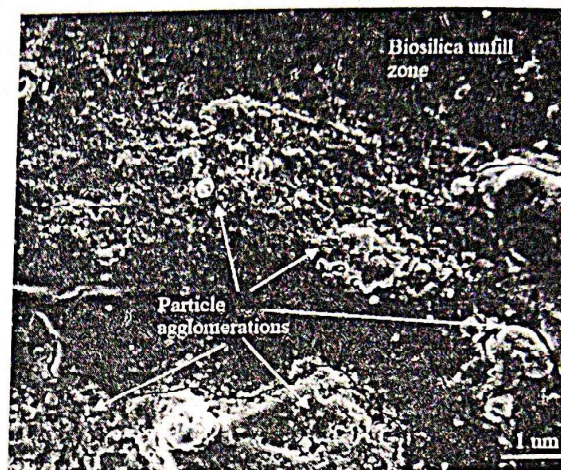


FIGURE 6 SEM micrograph of particle agglomerations in the composite.

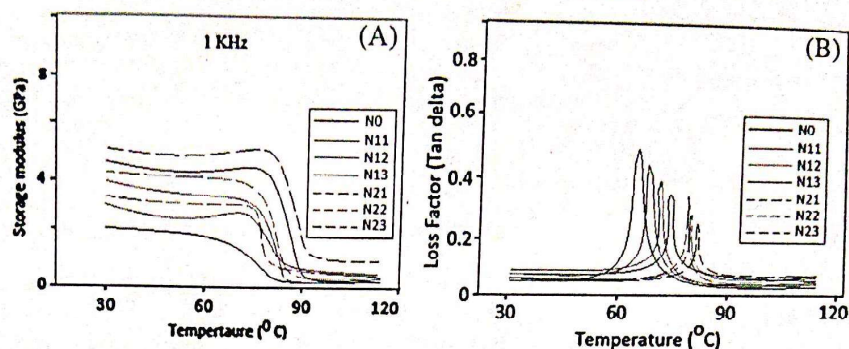
has a higher fatigue life cycle of 21,629. The equal dispersion of biosilica particle throughout the matrix and improved load absorption behavior of the composite with proper length and diameter of the fiber are the causes of this increase.<sup>[27]</sup> However, a further increase in biosilica shortens the fatigue life cycles for composites with the designations N13 and N23, because the aggregation of particle at one location makes the composite brittle by nature<sup>[28]</sup> as shown in Figure 6. From this, high intensity microcracks are developed and led the composite failure early.

#### 4.3 | Dynamic mechanical analysis

Figure 7 shows the DMA values for various composite designations. It has been noted that the plain epoxy resin has a storage modulus of 2.3 GPa and a loss tangent of 0.5. This decreased storage modulus is a result of the secondary molecules' fast mobility and high stretch ability in the primary C—C linkages of epoxy resin.<sup>[29]</sup> Because the epoxy molecules cannot store the energy delivered as stress and are rotating at high temperatures and frequencies, the loss tangent is similarly significant for simple epoxy matrix.<sup>[30]</sup> Furthermore, the DMA values for composite designations N11 and N21 are improved by the addition of reinforcement by 30 vol%. The higher values for DMA with longer lengths and smaller diameters of fibers significantly improved the load bearing effect. The improved storage modulus and loss factor, which are around 4.1 GPa and 0.4, respectively, are indicated by the composite designation N21. The damping  $\tan \delta$ , which depends on the interface and adhesion between the fibers



FIGURE 7 DMA graphs for various composite designations.



and the matrix, is used to express the energy loss of a material under cyclic stress.<sup>[31]</sup> However, due to the presence of too much hemicellulose on the fiber, the 70 mm long and 200  $\mu$ m wide fiber has a stronger bonding with the matrix than the 50 mm long and 300  $\mu$ m wide fiber. This improved storage modulus is the cause of presence of surface modified corn husk fiber, which holds many of the epoxy molecules as reacted form and hinders the rotation of epoxy molecules. Thus large temperature input and vibration is needed to activate the secondary molecules of epoxy primary C—C chain.<sup>[32]</sup> Any material that is ductile exhibits a low damping value, whereas any material that is rigid exhibits a high damping value. Additionally, adding 1 and 3 vol% of biosilica enhances the DMA values for the composite designations N12, N13, N22, and N23. The composite designation N23 exhibits the highest storage modulus and the lowest loss factor compared to other composite designations since it has fibers that are 70 mm long and 200  $\mu$ m long combined with 3 vol% of biosilica.<sup>[33]</sup> Biosilica has been added, and as a result, the voids have been filled and the secondary epoxy molecules are being adhered strongly. In the presence of biosilica, the inertia of the C—C main chains spins more slowly, which requires greater heat energy to activate them.<sup>[34]</sup> The inclusion of biosilica improves the storage modulus because it reduces the degree of rotation of epoxy molecules.<sup>[35]</sup> Thus improved storage modulus is observed.

## 5 | CONCLUSIONS

In this study, the mechanical, fatigue, and DMA characteristics of an epoxy composite reinforced with corn husk fiber and wheat husk biosilica were investigated. Following is a summary of the study's findings: In terms of tensile, flexural, Izod impact, and hardness, the fiber and biosilica reinforced composites show improved results. The composite designation N23 exhibits improved tensile

and flexural strength, Izod impact, and hardness of about 134 MPa, 182 MPa, 4.8 J, and 88 Shore-D. For the composite designations N11 and N21, the addition of maize husk fiber by 30 vol% extended the fatigue life cycles by 97.01% and 97.39%. Higher fatigue life cycles were seen up to 21,629 by adding 1 vol% biosilica and using fiber that was 70 mm long and 200  $\mu$ m in diameter. The improved storage modulus and loss factor, which are about 4.1 GPa and 0.4, respectively, are indicated by the composite N21. The deboned fiber from the matrix surface is visible in the SEM fractography of mechanically tested samples reveals that the diameter of 200  $\mu$ m and a length of 70 mm fiber in the matrix produced high toughness. Overall the lesser diameter of fiber with higher length produced better results in all properties investigated. Thus it is recommended to use lesser diameter fiber with high length for making high toughness composite.

## DATA AVAILABILITY STATEMENT

All data are within manuscript.

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Surface Review and Letters Online Ready No Access

# INVESTIGATION AND OPTIMIZATION OF TRIBO-MECHANICAL BEHAVIOR OF SQUEEZE CASTED AL-SI PISTON ALLOY-BASED METAL MATRIX COMPOSITE USING RESPONSE SURFACE METHODOLOGY AND NEURAL NETWORK

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and

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## Abstract

The piston in the automobile engine must withstand high stress and temperatures and also have low weight. The alloy of Al-Si is the most commonly used in the piston. The reinforcement using ceramics, fibres or nanoparticles will increase the properties of the piston alloy. In this work, the piston alloy is fabricated as a metal matrix composite of Al-Si reinforced by TiC-MoS<sub>2</sub> using the squeeze casting method. The squeeze casting effect on the matrix and the reinforcement is studied using tensile testing and microstructure analysis. The strength hardness obtained from the experimentation gives the highest tensile strength of 330 MPa and the hardness of 110HBN. The fractography and morphology are investigated using SEM (scanning electron microscope), resulting in the lowest porosity of 3.21% obtained in the composite material. The tribological behavior was also investigated at the condition of dry Sliding using pin on disc tribometer gives the lowest coefficient friction of 0.31 and the wear rate of 0.0051 mm<sup>3</sup>/m. The experiment is numerically designed and optimized using the response surface methodology (RSM). The obtained value is predicted and validated using a hybrid approach of deep belief network-reptile swarm algorithm (DBN-RSA). The regression of the parameters is about 99.97% showing that the model is very accurate to the experimental results. The RMSE of the proposed method implies less error and shows the accuracy level of the parameters. The result shows that the



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designed model is best fitted for the tribological and mechanical properties investigation of metal matrix composite.

**Keywords:**

- Squeeze casting
- metal matrix composite
- tensile testing
- microstructure
- tribological behavior

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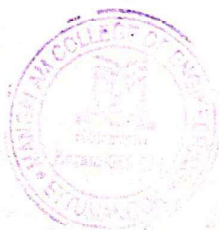
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- **Squeeze casting**
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- **tensile testing**
- **microstructure**
- **tribological behavior**



  
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## **Modelling the drivers and barriers of the dry fish supply chain traceability for micro and small enterprises in India: an ISM and MICMAC approach**

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**Abstract:** The adoption food traceability system in dry fish supply chain deserves attention. For implementing a food traceability system, it is essential to identify the variables and analyse their inter-relationships that impact its adoption. This research aims to model the major drivers and barriers and their interrelationships in the dry fish supply chain in India's micro and small enterprises (MSEs) using interpretive structural modelling (ISM) and Matrices d'Impacts Croisés Multiplication Appliqué a un Classement (MICMAC) analysis. Data were collected from 226 stakeholders of dry fish supply chain through a cross-sectional survey (both online and offline) located in Kerala and Tamil Nadu, two major maritime states of India. The finding shows that quality and safety concerns are the most critical drivers in implementing the traceability system. The government's lack of support, high cost of traceability system, absence of unified standards, limited awareness and lack of a coordinator are identified as significant barriers.

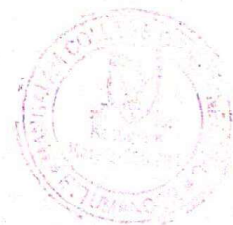
**Keywords:** supply chain traceability; dry fish; micro and small enterprises; MSEs; interpretive structural modelling; ISM; MICMAC; India.

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## 1 Introduction

The Indian fisheries industry is now a substantial business sector, shifting from its traditional function to subsistence and supplementary activity. More than 16 million primary fishermen depend on the seafood industry for their living, and the number is double that throughout the entire supply chain (Rajeev and Bhandarkar, 2022). Fisheries products should be processed as quickly as possible after being caught since the preservation or processing methods determine the shelf life and quality of the final product. Drying is thought to be the most cost-effective method for fish preservation, reducing actual post-harvest by catch loss and increasing value addition in India, where the consumption of dried fish accounts for roughly 32% of all marine landings and about 17% of all fish used to produce dry fish (Bharda et al., 2017). Micro and small enterprises (MSEs) are the main stakeholders of the dry fish supply chain in India. Also, these MSEs depend mainly on a paper documentation system for traceability where the information sharing is limited to tier one up-stream and downstream partners (Marchante et al., 2014). Identifying the first actor in the seafood products supply chain is one of the major issues because of the lack of records for all fishing vessels which further leads to a lack of transparency in the seafood supply chain. Consumer confidence in the seafood industry has been harmed by several outbreaks of food-borne diseases and incidences of food fraud. Customer concerns regarding the origin of food products, production processes, raw materials, and environmental impact have increased in recent years etc. (Kamble et al., 2020; Moovendhan et al., 2019). The increasing awareness is helping the dry fish supply chain to establish a traceability system positively. Since it decreases the likelihood of a recall, traceability is acknowledged as a tool for safety and quality, enhancing sustainability and lowering the overall cost of the food product (Jose and Shanmugam, 2020). Fishery enterprises must use traceability systems in order to guarantee the supply chain's quality and safety for dry fish (Wang et al., 2009).

Identifying the factors and analysing their interactions are crucial for implementing a traceability system in a food supply chain. In order to develop a traceability framework in the dry fish food production network, it is necessary to look into the drivers and barriers. Recent studies tend to identify and summarise the drivers and barriers to implementing the food traceability system of agri-food, meat, fish, drinks and cheese products (Jose et al., 2022; Jose and Prasannavenkatesan, 2023). However, there is still no evidence in the literature that a scientific article has examined and determined the interdependency of the factors that promote and inhibit the adoption of traceability in India's dry fish supply chain networks. The research questions of the present study are:

- 1 What are the significant drivers and barriers that affect traceability adoption in the dry fish supply chain?
- 2 What are the contextual relationships among these variables?
- 3 How to establish a multilevel hierarchy structural model of the drivers/barriers?

Interpretive structural modelling (ISM) and Matrices d'Impacts Croises Multiplication Appliqué a un Classement (MICMAC) analysis are used to model these variables and their contextual relationships. The ISM technique is used since it is a precise and helpful model for several purposes based on the contextual relationships among the factors of the systems (Khaba and Bhar, 2018). The remaining sections of this paper are organised as follows: Section 2 presents the literature review. The various steps associated with the



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ISM are highlighted in Section 3. The result and discussion are reported in Section 4. Finally, in Section 5, conclusions and areas of further research are discussed.

## **2 Literature review**

### **2.1 Dry fish supply chain**

The leading players in the supply chain for the dry fish sector are fishers, processors, and traders. Fishermen, commission agents, processors, traders, wholesalers, and retailers are the dominant players in the north-east region of India's dry fish supply chain (Upadhyay et al., 2017). Kaminski et al. (2020) proposed a mixed-methods study to determine the fish losses encountered by male and female value chain actors in a fishery in western Zambia. Ncranjala et al. (2022) identified that the Sri Lankan dry fish supply chain comprises the producers, wholesalers, retailers, and consumers as the key stakeholders. Dry fish supply chain typically includes the activities such as collecting raw fish, washing, salting, dressing and splitting raw fish, solar drying/open drying, sorting, packaging, storage, transportation and marketing, and each link includes much information (Donnelly and Karlsen, 2010).

### **2.2 Traceability of food products**

Food traceability connects with where and how food products are produced, processed and distributed (Dediu et al., 2016). The Codex Alimentarius Commission (CAC) defines food traceability as the ability to follow the movement of food through certain stages of production, processing, and distribution. Traceability is the capability to access information related to things to be considered throughout their whole life cycle using recorded identification (Jose and Prasannavenkatesan, 2023). RFID, internet of things (IoT), blockchain and quick response (QR) code-based traceability systems have been proposed to track food products and provide information to customers, which might diminish unhealthy practices and the hazard of food extortion and upgrade the level of food quality and safety (Jose et al., 2022). The term 'traceability' includes both 'tracking' and 'tracing' (Dandage et al., 2017). Tracking is a forward process where the location in the supply chain network recognises the end clients, and tracing is an opposite process wherein the origin is distinguished. Traceability gives continuous information about the raw material sources, the process involved, logistics and the location of products along the supply chain. The more precise the tracing system, the faster a producer can identify and undertake food safety and quality problems.

### **2.3 Drivers of traceability system**

To implement the food traceability system, it is necessary to identify the drivers and their inter-relationships that impact traceability in the value chain (Faisal and Talib, 2016). Drivers are factors that cause a system to be the way it or guide decisions around a framework (Mattevi and Jones, 2016). The perceived drivers can emphatically impact a firm's capacity to execute a new practice and promote another drive (Ali and Aboelmaged, 2022). Besides, identifying the drivers helps food enterprises assess their initiatives to execute a traceability framework (Haleem et al., 2019). The main drivers for



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implementing the traceability system identified from the literature are shown in Table 1. Quality (Aung and Chang, 2014; Pant et al., 2015; Mai et al., 2010) and safety (Aung and Chang, 2014; Pant et al., 2015) concern, food safety regulation (Dandage et al., 2017; Lewis and Boyle, 2017; Pant et al., 2015), and to obtain competitive advantage (Bosona and Gebresenbet, 2013; Canavari et al., 2010) received much attention in the previous literature.

**Table 1** Drivers of food traceability identified from the literature

<i>Drivers</i>	<i>References</i>
Quality concern[A1]	Aung and Chang (2014), Pant et al. (2015) and Mai et al. (2010)
Safety concern[A2]	Aung and Chang (2014) and Pant et al. (2015)
Food safety regulation[A3]	Dandage et al. (2017), Lewis and Boyle (2017) and Pant et al. (2015)
Technological advancements[A4]	Pant et al. (2015)
Reduced recall expenses [A5]	Aung and Chang (2014)
To obtain competitive advantage [A6]	Bosona and Gebresenbet (2013) and Canavari et al. (2010)
Suppliers/consumers request[A7]	Mai et al. (2010)
Product information [A8]	Pant et al. (2015)

#### 2.4 Barriers of traceability system

The execution of traceability in the food supply chain is challenging because of numerous barriers. Alserhan et al. (2022) conducted a study to identify different barriers in the Halal industry. Sandhu et al. (2011) distinguished that apparent obstruction adversely affects entrepreneurial inclination. High costs of application of the traceability system (Dediu et al., 2016; Aung and Chang, 2014), lack of unified standards (Bosona and Gebresenbet, 2013; Storoy et al., 2013; Zhang et al., 2011), privacy and security concerns (Zhang and Zou, 2017; Hardt et al., 2017), lack of infrastructure (Dediu et al., 2016; Zhang et al., 2011), uncertainty about the future benefits (Dediu et al., 2016; Zhang et al., 2011), limited awareness of traceability and its benefits (Mattevi and Jones, 2016; Pant et al., 2015), lack of support from the government (Dandage et al., 2017; Mai et al., 2010; Dana, 2000) and lack of a traceability coordinator (Canavari et al., 2010; Rombe et al., 2018) are the commonly listed barriers of traceability.

#### 2.5 ISM approach

ISM is an interpretive learning process that provides a fundamental understanding of complex situations and suggests a strategy for dealing with a problem in network or graph theory representation of intricate patterns of contextual relationships among distinct components (Faisal and Talib, 2016). The ISM approach transforms uncertain and poorly articulated mental models of frames into explicit, well-defined models. Additionally, it enables researchers to build a matrix of the intricate connections between various factors directly or indirectly related to a challenging choice while minimising the number of queries represented by a digraph. ISM is the best method for identifying the



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structure within the framework (Khaba and Bhar, 2018). Researchers have used ISM for vendor selection (Sharma, 2022), identifying sustainability enablers (Raut et al., 2017), green maintainability (Mathiyazhagan et al., 2013), prioritising supply chain complexity drivers (Kavilal et al., 2018), analysing the various factors of financial sectors (Kaur et al., 2022) and so on.

**Table 2** Barriers of food traceability identified from the literature

Barriers	References
High costs of the traceability system [B1]	Dediu et al. (2016) and Aung and Chang (2014)
No unified standards in the markets [B2]	Bosona and Gebresenbet (2013), Storoy et al. (2013) and Zhang et al. (2011)
Privacy and security concerns [B3]	Zhang and Zou (2017) and Hardt et al. (2017)
Information limitation [B4]	Mattevi and Jones (2016)
Capacity[infrastructure] limitation [B5]	Dediu et al. (2016) and Zhang et al. (2011)
Uncertainty about the future benefits [B6]	Dediu et al. (2016) and Zhang et al. (2011)
Reluctance to change [B7]	Dediu et al. (2016)
Limited awareness of traceability and its benefits [B8]	Mattevi and Jones (2016) and Pant et al. (2015)
Inadequate Practices [B9]	Dandage et al. (2017)
Lack of support from government [B10]	Dandage et al. (2017) and Mai et al. (2010)
Lack of a coordinator for traceability practices [B11]	Canavari et al. (2010) and Rombe et al. (2018)

### 3 Dry fish supply chain in two major Indian states

In order to get information along the value chain and recall it in the instance of public health hazards, food products must be traceable (Oliveira et al., 2021; Thota et al., 2020). To identify the dry fish supply chain shown in Figure 1, two questions are included for each stakeholder: 'who are your direct/ immediate customers?' and 'who are your direct/tier1 suppliers?' Data were gathered from 226 stakeholders in Kerala and Tamil Nadu, two central maritime states of India, through a cross-sectional survey to understand the dried fish supply chain (Kumarran, 2012). Fishermen, brokers/first receivers, distributors, wholesale/retail stores, consumers, and government authorities are among the stakeholders. Figure 1 depicts a typical dry fish supply chain. Fishermen first deliver their catch to the first receiver, who serves as a delivery intermediary between the fisherman and the processor. The processor is responsible for storing, processing, preserving, and subjecting them to steps that deem the dry fish healthy and fit for consumption. Additionally, the processor ensures that the dried fish are packaged into different boxes according to characteristics, including variety, size, shelf life, and processing processes. After purchasing the dried fish from the processor, the wholesaler or retailer distributes the products to customers. Furthermore, the traders also collect the

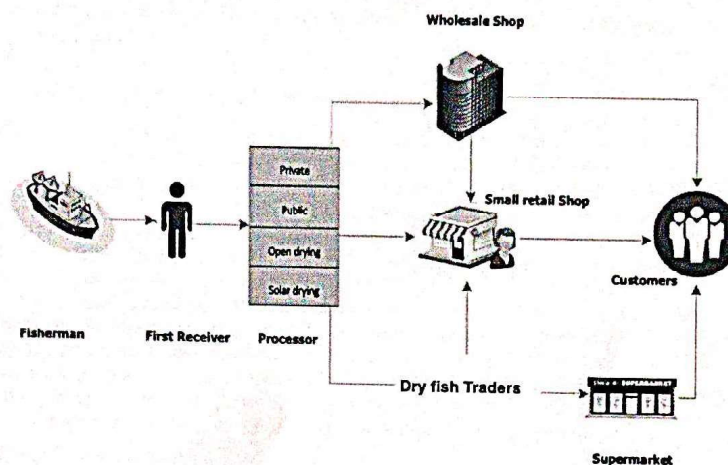


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processed dry fish products from processors and transport them to their establishments located nearby the processing centre (Upadhyay et al., 2017; Haque et al., 2015).

**Figure 1** Illustration of dry fish supply chain in two major Indian states (see online version for colours)



#### 4 Methodology

This research proposes the ISM-based approach to visualise the interrelationships among dry fish supply chain traceability drivers and barriers. The steps associated with the ISM are explained below.

- Identification of variables: drivers and barriers are identified through an extensive literature review. A cross-sectional survey was conducted among 226 dry fish supply chain stakeholders in Kerala and Tamil Nadu, two central maritime states of India. Four specialists from the fisheries department (Central Institute of Fisheries Technology) and three from the academic sector were consulted to validate these drivers and barriers.
- Contextual relationship: a logical relationship is made among the factors regarding which pairs of variables would be investigated from the factors indicated in step 1. For each factor, a structural self-interaction matrix (SSIM) is created, displaying pair-wise relationships among the system's variables.
- The self-interaction matrix for the drivers and barriers is structured and pair-wise relationships between the systems are developed.
- The SSIM is used to construct the reachability matrix, which is then checked for transitivity. A crucial assumption in ISM is that the contextual relation is transitive.



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If a variable A is connected to B and B is connected to C, then A is essentially tied to C, which is what it expresses.

- e A directed graph is drawn using vertices and lines of the edges from the canonical matrix form of the reachability matrix, and the transitive links are removed. The resulting digraph is converted into an ISM model by replacing variable nodes with statements.

#### 4.1 Structural self-interaction matrix

An extensive literature review identified eight food traceability drivers and eleven barriers. Four specialists from the fisheries department and three from the academic sector were consulted to validate these drivers and barriers. These industry and academia experts are very familiar with issues with implementing a traceability system. They were requested to remark on the sufficiency of drivers and barriers and to add or delete any other variables. Based on personal conversations, the selected drivers and barriers from the literature were finalised for analysis. The same specialists' perspectives were considered when establishing contextual links between the identified drivers and barriers. Each expert received an SSIM sheet to help them determine the contextual relationships between various drivers and barriers. The experts examined the outcome, and a final matrix was created that reflected their consensus on the findings. The symbols used for constructing SSIM and resultant SSIM (Kavilal et al., 2017) are given in Table 3, and the SSIM for the drivers and barriers are shown in Tables 4 and 5, respectively.

**Table 3** Symbols used to build the SSIM

Symbols	Rules for constructing SSIM
V	If driver <i>i</i> leads to driver <i>j</i> , and driver <i>j</i> and driver <i>i</i> are not related.
A	If driver <i>j</i> connects to driver <i>i</i> but is unrelated to driver <i>i</i> .
X	If driver <i>i</i> and driver <i>j</i> share a relationship.
O	If there is no relationship between driver <i>i</i> and driver <i>j</i> .

**Table 4** SSIM [for drivers]

Variables	A8	A7	A6	A5	A4	A3	A2	A1
Quality concern [A1]	V	V	V	O	V	V	X	
Safety concern [A2]	V	V	V	O	V	V		
Food safety regulation [A3]		V	V	O	V	V		
Technological advancements [A4]	V	O	V	V				
Reduced recall expenses [A5]			O	V	V			
Gaining competitive advantage [A6]		A	V					
Suppliers/consumers request [A7]	V							
Product information [A8]								



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#### 4.2 Development of initial reachability matrix (K)

The initial reachability matrix is derived from SSIM matrix by substituting V, A, X and O by the digits 1 and 0. The rules for replacement are given below.

- If the  $(i, j)$  entry in the SSIM is V, then the  $(i, j)$  entry in the reachability matrix becomes 1, and the  $(j, i)$  entry becomes 0.
- If the  $(i, j)$  entry in the SSIM is A, then the  $(i, j)$  entry becomes 0 and the  $(j, i)$  entries becomes 1.
- If the entry in the SSIM is X, then both  $(i, j)$  and  $(j, i)$  entry become 1.
- If the entry in the SSIM is O, then the  $(i, j)$  entry in the reachability matrix becomes 0 and the  $(j, i)$  entry also becomes 0.

Following these rules, the initial reachability matrix for the drivers and barriers is formed, as shown in Tables 6 and 7.

**Table 5** SSIM [for barriers]

Variables	B11	B10	B9	B8	B7	B6	B5	B4	B3	B2	B1
High costs of the traceability system [B1]	V	A	O	O	V	V	V	V	O	X	
No unified standards in the markets [B2]	A	A	V	X	V	V	O	V	V		
Privacy and security concerns [B3]	A	A	A	A	O	A	O	V			
Information limitation [B4]	A	A	A	A	O	A	A				
Capacity (infrastructure) limitation [B5]	A	A	A	A	A	A					
Uncertainty about the future benefits [B6]	A	O	X	A	X						
Reluctance to change [B7]	A	A	X	A							
Limited awareness of traceability and its benefits [B8]	A	A	V								
Inadequate practices [B9]	A	A									
Lack of support from government [B10]	O										
Lack of a coordinator for traceability practices [B11]											

#### 4.3 Development of final reachability matrix (H)

The transitivity rule is incorporated into the formation of the final reachability matrix, as discussed in step no. 4. The final reachability matrix (H) is obtained by adding the initial reachability matrix (K) with the unit matrix I and raising it to its power until the condition in the equation  $H = ((K + I)^x) = ((K + I)^{x+1}) = \dots x > 1$  is satisfied. The final reachability matrix, along with dependence and driving power, is shown in Tables 8 and 9, respectively.



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**Table 6** Initial reachability matrix for the drivers

Variables	A1	A2	A3	A4	A5	A6	A7	A8
A1	1	1	1	1	0	1	1	1
A2	1	1	1	1	0	1	1	1
A3	0	0	1	1	1	0	1	1
A4	0	0	0	1	1	1	0	1
A5	0	0	0	0	1	1	1	0
A6	0	0	0	0	0	1	1	0
A7	0	0	0	0	0	0	1	1
A8	0	0	0	0	0	1	0	1

**Table 7** Initial reachability matrix for the barriers

Variables	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11
B1	1	1	0	1	1	1	1	0	0	0	1
B2	1	1	1	1	0	1	1	0	1	0	0
B3	0	0	1	1	0	0	0	0	0	0	0
B4	0	0	0	1	0	0	0	0	0	0	0
B5	0	0	0	1	1	0	0	0	0	0	0
B6	0	0	1	1	1	1	1	0	1	0	0
B7	0	0	0	0	1	1	1	0	1	0	0
B8	0	1	1	1	1	1	1	1	1	0	0
B9	0	0	1	1	1	1	1	0	1	0	0
B10	1	1	1	1	1	0	1	1	1	1	0
B11	0	1	1	1	1	1	1	1	1	0	1

**Table 8** Final reachability matrix of drivers

Variables	A1	A2	A3	A4	A5	A6	A7	A8	Driving power
A1	1	1	1	1	1*	1	1	1	8
A2	1	1	1	1	1*	1	1	1	8
A3	0	0	1	1	1	1*	1	1	6
A4	0	0	0	1	1	1	1*	1	5
A5	0	0	0	0	1	1	1	1*	4
A6	0	0	0	0	0	1	1	1*	3
A7	0	0	0	0	0	1*	1	1	3
A8	0	0	0	0	0	1	1*	1	3
Dependence power	2	2	3	4	5	8	8	8	40/40

Note: 1\* entries are comprised to incorporate transitivity.



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**Table 9** Final reachability matrix of barriers

Variables	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	Driving power
B1	1	1	1*	1	1	1	1	1*	1*	0	1	10
B2	1	1	1	1	1*	1	1	1*	1	0	1*	10
B3	0	0	1	1	0	0	0	0	0	0	0	2
B4	0	0	0	1	0	0	0	0	0	0	0	1
B5	0	0	0	1	1	0	0	0	0	0	0	2
B6	0	0	1	1	1	1	1	0	1	0	0	6
B7	0	0	1*	1*	1	1	1	0	1	0	0	6
B8	1*	1	1	1	1	1	1	1	1	0	1*	10
B9	0	0	1	1	1	1	1	0	1	0	0	6
B10	1	1	1	1	1	1*	1	1	1	1	1*	11
B11	1*	1	1	1	1	1	1	1	1	0	1	10
Dependence power	5	5	9	11	9	8	8	5	8	1	5	74/74

Note: 1\* entries are comprised to incorporate transitivity.

**Table 10** ISM analysis (iteration method) for drivers

Level	Elements	Reachability set	Antecedent	Intersection set
1	1	1, 2, 3, 4, 5, 6, 7, 8	1, 2	1, 2
	2	1, 2, 3, 4, 5, 6, 7, 8	1, 2	1, 2
	3	3, 4, 5, 6, 7, 8	1, 2, 3	3
	4	4, 5, 6, 7, 8	1, 2, 3, 4	4
	5	5, 6, 7, 8	1, 2, 3, 4, 5	5
	6	6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	6, 7, 8
	7	6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	6, 7, 8
	8	6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	6, 7, 8
2	1	1, 2, 3, 4, 5	1, 2	1, 2
	2	1, 2, 3, 4, 5	1, 2	1, 2
	3	3, 4, 5	1, 2, 3	3
	4	4, 5	1, 2, 3, 4	4
	5	5	1, 2, 3, 4, 5	5
3	1	1, 2, 3, 4	1, 2	1, 2
	2	1, 2, 3, 4	1, 2	1, 2
	3	3, 4	1, 2, 3	3
	3	4	1, 2, 3, 4	4
4	1	1, 2, 3	1, 2	1, 2
	2	1, 2, 3	1, 2	1, 2
	3	3	1, 2, 3	3
5	1	1, 2	1, 2	1, 2
	2	1, 2	1, 2	1, 2

Note: Italic denotes similar values (level partitions).



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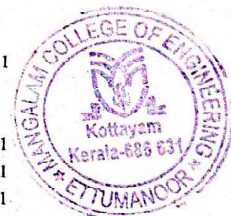


## 4.4 Carrying out level partitions

The final reachability matrix is used to construct the reachability set (R) and antecedent set (C) for each identified driver and barrier. The element itself, plus the other components it might assist in achieving, make up the reachability set R. On the other hand, the drivers, barriers, and other components that could aid their removal are included in the antecedent set (R). All drivers and barriers are considered while calculating the intersection of these elements (RC). The top level items in the ISM hierarchy were those for which the reachability and intersection sets were equal. The top-level element is recognised, and then it is eliminated from the remaining elements. Each driver and barrier level is located, and then they are highlighted once more. These iteration procedures are continued until all the layers are achieved, as shown in Tables 10 and 11 for the drivers and barriers.

Table 11 ISM analysis (iteration method) for barriers

Level	Elements	Reachability set	Antecedent	Intersection set
1	1	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	2	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	3	3, 4	1, 2, 3, 6, 7, 8, 9, 10, 11	3
	4	4	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	4
	5	4, 5	1, 2, 5, 6, 7, 8, 9, 10, 11	5
	6	3, 4, 5, 6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	7	3, 4, 5, 6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	8	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	9	3, 4, 5, 6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	10	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	10	10
	11	1, 2, 3, 4, 5, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
2	1	1, 2, 3, 5, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	2	1, 2, 3, 5, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	3	3	1, 2, 3, 6, 7, 8, 9, 10, 11	3
	5	5	1, 2, 5, 6, 7, 8, 9, 10, 11	5
	6	3, 5, 6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	7	3, 5, 6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	8	1, 2, 3, 5, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	9	3, 5, 6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	10	1, 2, 3, 5, 6, 7, 8, 9, 10, 11	10	10
	11	1, 2, 3, 5, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	1	1, 2, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
3	2	1, 2, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	6	6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	7	6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	8	1, 2, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	11	1, 2, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11



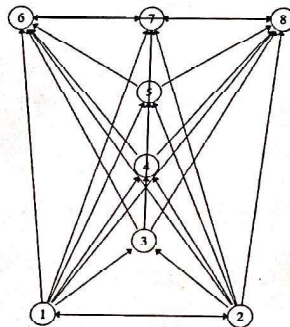
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**Table 11** ISM analysis (iteration method) for barriers (continued)

Level	Elements	Reachability set	Antecedent	Intersection set
3	9	6, 7, 9	1, 2, 6, 7, 8, 9, 10, 11	6, 7, 9
	10	1, 2, 6, 7, 8, 9, 10, 11	10	10
	11	1, 2, 6, 7, 8, 9, 11	1, 2, 8, 10, 11	1, 2, 8, 11
4	1	1, 2, 8, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	2	1, 2, 8, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	8	1, 2, 8, 11	1, 2, 8, 10, 11	1, 2, 8, 11
	10	1, 2, 8, 10, 11	10	10
	11	1, 2, 8, 11	1, 2, 8, 10, 11	1, 2, 8, 11
5	10	10	10	10

Note: Italic denotes similar values (level partitions).

**Figure 2** Diagram of drivers

#### 4.5 Development of digraph

The name 'digraph' comes from the directed graph and refers to the graphical depiction of the elements, contextual links, and hierarchical levels. The final reachability matrix, combined with the levels of the drivers and barriers of food traceability mentioned in the previous section, is used to draw down the digraph. Here, the first level is used to set the top-level drivers and barriers, followed by the second-level drivers and barriers. Similar to this, further drivers and barriers are added to the hierarchical structure until the bottom-level drivers and barriers are shifted to the bottom of the graph. The digraph for drivers and barriers is drawn after removing the transitivity and is shown in Figures 2 and 3, respectively. Quality [A1] and safety [A2] concerns, positioned at the bottom of the hierarchy, are the drivers with the highest driving power leading to food safety regulation. The results agree with the findings of Pant et al. (2015) that traceability is primarily considered a tool for food safety and quality by offering a mechanism for recall



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and confirmation of food authenticity. Also, lack of support from the government [B10] is identified as the most critical barrier to implementing the dry fish traceability system. Gaining competitive advantage [A6], suppliers/consumer's requests [A7], and product information [A8] are the drivers positioned at last, with no driving power to drive any other barriers above their level. Similarly, information limitation [B4] is the least essential traceability barrier since it occupies the first level of the digraph. The digraph of drivers and barriers is then converted into the ISM model, as shown in Figures 4 and 5, respectively.

Figure 3 Diagram of barriers

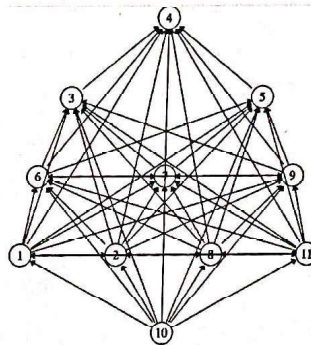
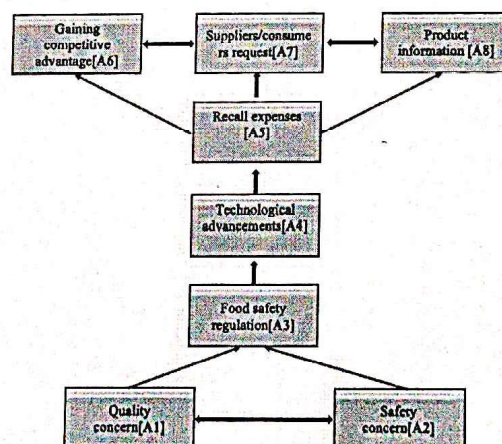


Figure 4 Multilevel hierarchy structure through ISM model for drivers (see online version for colours)

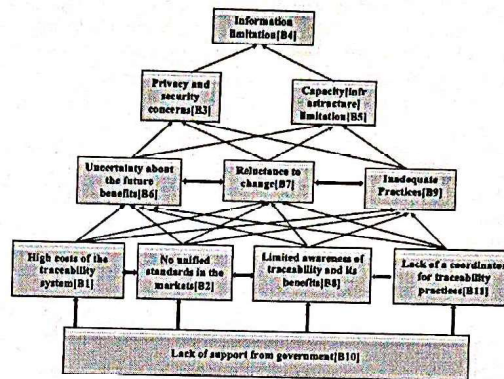


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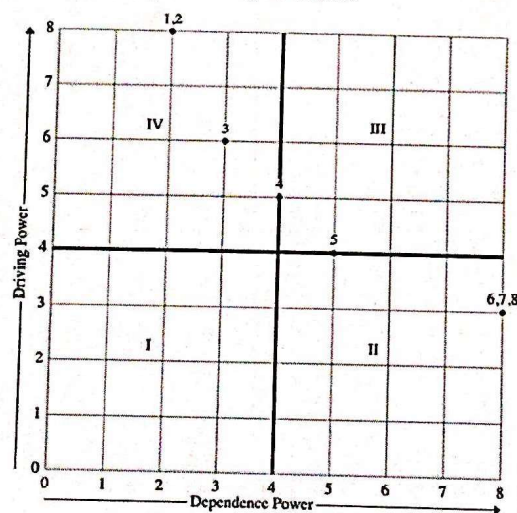




**Figure 5** Multilevel hierarchy structure through ISM model for barriers (see online version for colours)



**Figure 6** Driving power and dependence diagram of drivers



I-Autonomous Variables II-Dependent Variables  
III-Linkage Variables IV-Independent Variables



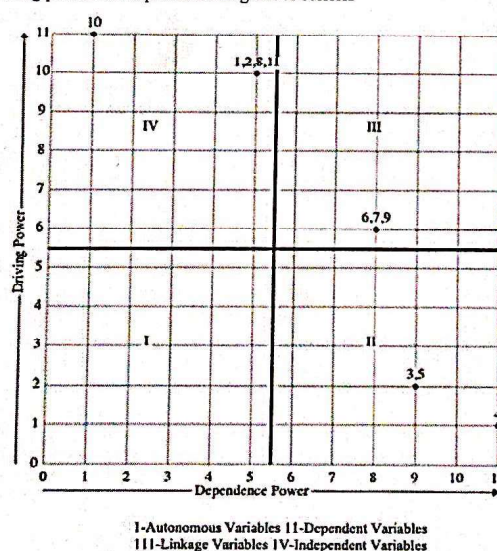
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#### 4.6 MICMAC analysis

The MICMAC analysis aims to analyse the driving power and dependence variables. In this research, the drivers and barriers of the MSE dry fish traceability system are classified into four clusters, as shown in Figures 6 and 7. The first cluster consists of the 'autonomous variables' that have poor linkages and are disconnected from the system. In this work, the barriers, high cost of the traceability system [B1] is in cluster one, and due to its weak power and dependence, it is relatively disconnected from the system. The 'autonomous variables' are considered as those having weak driving power and dependence. The second cluster consists of 'dependant variables' with a weak driving power and strong dependence. In the second cluster, the research identified the drivers such as gaining competitive advantage [A6], supplier's/consumer's request [A7] and product information [A8] with strong dependence and weak driving power. Also, the barriers, privacy and security concerns [B3], and information [B4] and capacity [B5] limitations are coming in the second cluster. They are located at the top level of the hierarchy and are considered essential dry fish traceability drivers. Their strong dependence illustrates that they need all other drivers to minimise the force of these traceability drivers.

Figure 7 Driving power and dependence diagram of barriers



The third cluster contains 'linkage variables' that include the traceability driver reduced recall expenses [A5], which has strong dependence and high driving power. Furthermore, the third cluster includes the barriers such as uncertainty about the future benefits [B6],



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reluctance to change [B7] and inadequate Practices [B9]. These drivers and barriers are considered fluid in nature since any changes will affect the others and be fed back into themselves. These traceability drivers and barriers are essential in forming linkages between two layers of the hierarchy. The fourth cluster comprises 'independent variables' having a solid driving force and weak dependence and includes quality and safety concerns and food safety regulations. Also, the barriers such as high costs of the traceability system [B1], no unified standards in the markets [B2], limited awareness of traceability and its benefits [B8] and lack of a coordinator for traceability practices [B11] are in the fourth cluster. These traceability drivers and barriers are at the bottom of the hierarchy, which is of considerable importance. The obtained results agreed with the findings by Choi et al. (2008) that to create the maximised system's profit and successful strategies, the interests of individual members, should be coordinated by a supply chain coordinator. These independent drivers form the bottlenecks for traceability implementation and must be addressed cautiously.

## 5 Results and discussion

This research's findings offer several insights into adopting a traceability system in the MSE dry fish supply chain. The findings also imply that the drivers and barriers to implementing the dry fish traceability system in MSE sectors are of crucial relevance and will increase the significance of the traceability system in the dry fish supply chain if effectively handled. This study will assist business strategists and supply chain managers by providing first-hand knowledge on the factors that have a larger driving power so that they can be instantly addressed, as the research on traceability systems in India is still in its early stages. This study ranked the eight most important drivers and the eleven most significant barriers to dry fish traceability systems according to the strength and dependability of each one. Quality and safety concerns come out as the most critical traceability drivers. These findings align with those of Mattevi and Jones (2016), who assert that quality and safety concerns are the drivers that best describe the concept of traceability of a product in a supply chain. Furthermore, the most vital barrier to the dry fish traceability implementation is identified as the lack of support from the government. According to Dediu et al. (2016), providing a policy guarantee for the adoption of a traceability system by the government is crucial for adopting traceability system. The government can also support the MSEs by providing training, essential financial support, and promoting capability building on traceability requirements and designs (Jardon, 2022; Harel and Kaufmann, 2022).

The drivers, gaining competitive advantages [A6], supplier's/consumer's requests [A7] and product information [A8] do not have much importance because of their weak driving power and high dependence on other traceability drivers. Similarly, information limitation [B4], privacy and security concerns [B3], and capacity limitations [B5] are the barriers that are not very important while designing a traceability system. The driver, reduced recall expenses [A5] is relatively more important with high driving power and low dependence, which is considered a linkage variable, influencing the middle of the hierarchy. Also, the barriers such as uncertainty about the future benefits [B6], reluctance to change [B7] and inadequate practices [B9] are the linkage variables and should give more attention when designing a traceability system for the dry fish MSE sectors. This research offers several implications while implementing the traceability system in the



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MSE dry fish supply chain. The most significant finding of this research is that drivers, quality [A1] and safety [A2] concerns of the stakeholders in the dry fish supply chain and the barrier lack of support from the government [B10] have a high driving power and therefore need to be addressed in the supply chain primary. This barrier further leads to other barriers, such as high costs of the traceability system [B1], no unified standards in the markets [B2], limited awareness of traceability and its benefits [B8] and lack of a coordinator for traceability practices [B11].

### *5.1 Theoretical and practical implications*

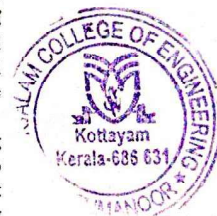
This research has both theoretical and managerial implications and is as follows:

- 1 This article contributes to the literature on supply chain traceability by proposing a framework to address the MSEs dry fish supply chain in India. From the MSE perspective, this study illustrates the need to implement traceability practices by identifying the most critical drivers and barriers.
- 2 The practitioners could explore the contextual relationships among these drivers and barriers in order to develop a traceability system for dry fish supply chain.
- 3 Implementation of a dry fish traceability system will become a reality in the MSE sector if these drivers and barriers are addressed adequately.
- 4 Insights from the multilevel hierarchy structural model of the drivers/barriers obtained in this study can be helpful to analyse the supply chain traceability for other industry sector.

## **6 Conclusions**

Increasing concern for food safety and quality issues at national and international levels puts pressure on organisations to implement the traceability system. This research proposes an ISM approach to analyse the variables and their inter-relationships that impact the adoption of traceability in the Indian MSE dry fish supply chain. The drivers and barriers to traceability implementation have been identified through an extensive literature review. Their relevance is ascertained through a questionnaire survey and expert interviews. ISM and MICMAC analysis have been used to model the contextual relationships among the drivers and barriers. The finding shows that the most critical drivers in implementing the traceability system are quality and safety concerns. Also, the lack of support from the government is identified as a significant barrier.

The unique contribution of this research is that it offers factors that the fishing industry, programmers, and the government can take into account before planning to develop a traceability system for the supply chain of dry fish. The practitioners must figure out how to customise their supply chain strategies by putting the traceability system in place, which will set them apart from their current and potential competitors. There are a few limitations to this research. Although the established model aids in identifying important drivers and barriers to adopting traceability in the dried fish supply chain, it does not quantify the magnitude of each driver's and the barrier's influence. More drivers and barriers can be included in the future study using various methods, such



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as fuzzy total interpretive structural modelling (fuzzy-TISM), to incorporate the immediate effects of each driver and barrier to the adoption of traceability in the supply chain.

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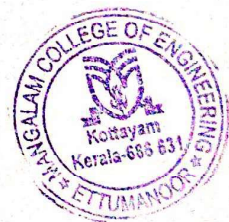
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## Traceability adoption in dry fish supply chain SMEs in India: exploring awareness, benefits, drivers and barriers

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## Traceability adoption in dry fish supply chain SMEs in India: exploring awareness, benefits, drivers and barriers

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**Abstract.** The illegal harvesting of seafood and the mislabelling of dry fish products have become more prominent in recent years. Traceability in the dry fish supply chain deserves research attention, especially among small and medium enterprises (SMEs) in a developing country like India. To implement the traceability system, it is necessary to identify the variables and their inter-relationships that influence traceability in a food supply chain. This research aims to identify the awareness, benefits, drivers, and barriers that affect traceability adoption in the dry fish supply chain. Data were collected from 226 dry fish supply chain stakeholders through a cross-sectional survey (both online and offline) in Kerala and Tamil Nadu, two central maritime states of India. A conceptual model is developed, and the inter-relationship among the factors underlying the traceability implementation is analysed through correlation matrices and multiple regression modelling. The results show that the Indian dry fish stakeholders moderately understand the traceability system. Product safety and quality are identified as the primary benefits of traceability, while quality concerns and food safety regulations are observed as primary drivers. The significant barriers are the cost of a traceability system, lack of a co-ordinator and lack of government support.

**Keywords.** Traceability; food safety; dry fish supply chain; Indian SME; multiple regression

### 1. Introduction

India ranks second in the world in fish production, with 14.16 million metric tons produced during 2019–20 and provides livelihood to more than 28 million people [1]. Fisheries have become a significant socio-economic force in the Indian economy owing to their massive coastline of over 8,000 km and vast river network. However, fish are perishable and should be processed within a couple of hours of being caught because no handling or processing can improve the quality of spoiled fish. Ahmad and Bhuimbar [2] assessed that for one ton of fish consumed, an equivalent volume is disposed of either as waste or a low-value product. In India, the consumption of dried fish is about 32 percent of the total marine landings and about 17 percent of the total catch used to produce dry fish [3]. Sun drying is considered the most economical method for fish preservation [4] and an elective aspect of decreasing the actual post-harvest loss of bycatch and further improving value addition [5]. Salted and sun-dried fish products are most common in the country's coastal region, wherein the population is around 560 million. Several studies have evaluated the economics and marketing of dry fish production in India [4, 6]. Christian *et al* [7] analysed the business performance

determinants of dry fish distribution during Covid-19. A few research articles are focussed on the types of fish used for drying [5], drying methods [8], and the yield of dried fish [3]. Pradhan *et al* [9] conducted a study on an SME-based dry fish supply chain that focuses on the social well-being of dried fish workers.

The illegal harvesting of seafood and the mislabelling of dry fish products have become more prominent in recent years [10, 11]. Typically, seafood products change hands 6 to 10 times before reaching the consumer. Since most fishing vessels lack adequate records, the primary challenge is identifying the first receiver in the seafood supply chain [12]. A survey of the authenticity of fresh and processed fish from the domestic market showed that 22 percent of seafood samples in India are mislabelled [13]. Food and Drug Administration found the presence of salmonella in sampling strips of frozen fish products exported from India and recalled them [14]. Traceability in the dry fish supply chain deserves research attention, as food scandals and scares worldwide have reduced consumer confidence. Numerous incidents like misinterpreting food characteristics, food adulteration, and recently the Covid-19 pandemic spread incidents in the food supply chain have shaken consumer's trust [15, 16]. Traceability is recognized as a mechanism for quality and safety, reducing the overall cost and improving the sustainability of the food product since it

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reduces recall [17]. The consumer's increased demand for complete visibility of food quality and history along the supply chain also supported traceability adoption in the food supply chain. However, most of India's dry fish supply chain stakeholders are Small and Medium Enterprises (SMEs), have very poor affordability, and often rely mainly on paper documentation at the distributors and wholesalers level [18]. Bharda *et al* [3] identified that SMEs in the dry fish supply chain make less profit due to poor product quality, safety and hygienic conditions and lack of market access. Adopting the traceability system is one of the main factors that significantly influence the quality of the SME food sector [19]. A recent survey by Rao *et al* [14] identified a low awareness of the importance of food traceability, especially among India's micro and small-scale food industries. Hence, awareness, benefits, drivers, and barriers must be explored to implement a traceability system in the dry fish supply chain. Literature has yet to provide evidence of a published work that identifies and explores the awareness, benefits, drivers and barriers to traceability adoption in dry fish supply chain SMEs in India. This research aims to understand the awareness, benefits, drivers, and barriers to effectively implementing the traceability system in dry fish SMEs in India.

The research objectives are as follows:

- To identify the awareness, benefits, drivers and barriers that affect the traceability adoption in the dry fish supply chain.
- To develop a conceptual model that formally states the relationship among perceived benefits, drivers, barriers and awareness to implement the traceability system.
- To test the conceptual model using the data gathered from 226 stakeholders in India's dry fish supply chain.
- To present the results and research implications.

The rest of this paper is organized as follows. Section 2 narrates the literature review. Section 3 presents the conceptual model and hypotheses. The illustration of the dry fish supply chain and the survey methods employed in this research are highlighted in section 4. The result and discussion are reported in section 5. Finally, in section 6 the conclusions and areas of further research are discussed.

## 2. Literature review

Donnelly and Karlsen [20] identified the critical points for traceability during the production of wet and dried salted fish and its practical challenges. To implement the food traceability system, it is necessary to identify the drivers and their inter-relationships that impact traceability in the value chain [21]. The recent literature on traceability adoption in the food supply chain is shown in table 1. Among the reviewed articles, it is observed that Agri-food products have received significant attention, followed by fishery products. Also, most studies tend to identify and summarise the barriers [12, 22–26] to implementing the food traceability system. Research about the awareness of food traceability [27–31] also has received considerable attention. It is noted that the drivers [12, 23, 32] and benefits [23, 33] of the traceability system have yet to receive much attention. From table 1, it is clear that none of the previous literature has paid attention to the Indian dry fish SMEs' awareness, benefits, drivers and barriers and their intention to implement it.

From the published literature, the identified benefits, drivers and barriers of food traceability are listed below in tables 2, 3 and 4, respectively.

**Table 1.** Recent studies on the traceability adoption in the food supply chain.

References	Traceability adoption				Product	Country
	Awareness	Benefits	Barriers	Drivers		
[22]			□		Agri-food	Indonesia
[27]	□				Agri-food	Sri Lanka
[24]		□			Fish	Norway
[23]		□	□	□	Agri food	Italy
[28]	□				Agri-food	China
[29]	□				Cheese	Brazil
[32]				□	Agri-food	India
[12]			□	□	Fish	Indonesia
[30]	□				Meat	Malaysia
[24]			□		Fish	America
[25]			□		Ice cream	Africa
[26]			□		Fish	Romania
[31]	□				Drinks	UK





**Table 2.** Benefits of food traceability identified from the literature

Benefits	References
<i>Business benefits of implementing effective traceability system</i>	
Improve product safety [A <sub>1</sub> ]	[34, 35]
Improve product quality [A <sub>2</sub> ]	[34, 36]
Identify product characteristics [A <sub>3</sub> ]	[35]
Increase access to overseas markets [A <sub>4</sub> ]	[37]
Attract new customers [A <sub>5</sub> ]	[18, 38]
Differentiate your products from others [A <sub>6</sub> ]	[39]
Increase profit [A <sub>7</sub> ]	[38]
Increase the ability to retain existing customers [A <sub>8</sub> ]	[35]
Reduce customer complaints [A <sub>9</sub> ]	[40]
Reduce liability claims and lawsuits [A <sub>10</sub> ]	[31]
Reduce the cost of product recall [A <sub>11</sub> ]	[41]
Enable rapid recall of food product [A <sub>12</sub> ]	[34]
Reduce the probability of product recall [A <sub>13</sub> ]	[31]

**Table 3.** Drivers of food traceability identified from the literature.

Drivers	References
<i>Drivers of implementing effective traceability system</i>	
Quality concern [B1]	[34, 35, 37, 46, 47]
Safety concern [B2]	[34, 35, 37]
Food safety regulation [B3]	[19, 35, 44]
Technological advancements [B4]	[35]
Recall expenses [B5]	[34]
Gaining competitive advantage [B6]	[41, 45]
Suppliers/consumers request [B7]	[37]
Product information [B8]	[35]

The benefits of traceability include improved food safety and quality [34–36], which differentiate traceable products from others [18, 39]. Traceability increases the profit by retaining the existing customer and attracting new customers [18, 38] and reduces the cost associated with a product recall.

Also, regarding the drivers of food traceability, the most noticeable drivers are quality and safety concerns [34, 35, 37], food regulation [19, 35, 44] and getting competitive advantages [41, 45].

Furthermore, high costs of application of the traceability system [26, 34], lack of unified standards [39, 41, 42], privacy and security concerns [24, 43], lack of infrastructure [26, 42], uncertainty about the future benefits [26, 42], limited awareness of traceability and its benefits [31, 35], lack of support from the government [19, 37], and lack of a traceability coordinator [12, 45] are the commonly listed barriers to traceability systems from the various literature.

**Table 4.** Barriers of food traceability identified from the literature.

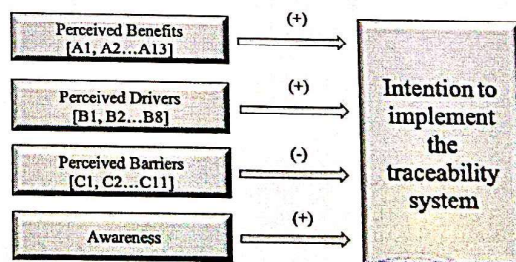
Barriers	References
<i>Barriers of implementing effective traceability system</i>	
High costs of the traceability system [C1]	[26, 34]
No unified standards in the markets [C2]	[39, 41, 42]
Privacy and security concerns [C3]	[24, 43]
Information limitation [C4]	[31]
Capacity[infrastructure] limitation [C5]	[26, 42]
Uncertainty about the future benefits [C6]	[26, 42]
Reluctance to change [C7]	[26]
Limited awareness of traceability and its benefits [C8]	[31, 35]
Inadequate Practices [C9]	[19]
Lack of support from government [C10]	[19, 37]
Lack of a coordinator for traceability practices [C11]	[12, 45, 56]

### 3. Theoretical framework and hypotheses development

A conceptual model that formally states the relationship among the perceived benefits, drivers, barriers and awareness to implement the traceability system is shown in figure 1.

#### 3.1 Perceived benefits and intention to implement the traceability system

The rational choice theory states that firms are rational actors, and before decision-making and taking action, they evaluate the costs and benefits of a process [38]. Previous studies show that perceived benefits influence attitudes and behavioural intentions [48]. Furthermore, empirical research proposed the constructive outcome of perceived benefits on intention toward online self-exposure. The above arguments exhibit how perceived benefits influence preferences and function in different contexts. Thus it is

**Figure 1.** The proposed research framework states the relation among benefits, drivers, barriers and awareness.



postulated that H1, the higher the perceived benefits of a traceability system, the higher their readiness to implement it.

**H1:** Perceived benefit will have a positive influence on the intention to implement the traceability system.

### 3.2 Perceived drivers and intention to implement the traceability system

Drivers are factors that cause a system to be the way it is or guide decisions around a system [31]. The perceived drivers can positively influence an organization's ability to execute a new practice and promote a new initiative [50]. Furthermore, the identification of the drivers assists the food industries in assessing their initiatives to implement a traceability system [51]. Thus the following hypothesis is developed.

**H2:** Perceived drivers will have a positive influence on the intention to implement the traceability system.

### 3.3 Perceived barriers and intention to implement the traceability system

Implementing traceability in the food supply chain is challenging due to many barriers. Perceived barriers have a

significant relationship with entrepreneurial intention. Sandhu *et al* [52] identified that perceived barriers have a negative impact on entrepreneurial inclination. The study between perceived barriers and a firm's intention reveals that based on anticipated barriers, people who wish to start their businesses decide to wait to start it anymore or even postpone until they can manage these barriers [53]. Doern [54] reported that perceived barriers could hinder, postpone and even slow down the process of realizing growth intentions. Therefore, it is hypothesized that:

**H3:** Perceived barriers will have a negative influence on the intention to the traceability system.

### 3.4 Awareness of traceability and intention to implement it

Awareness is the degree to which a target population is cognizant of innovation and frames a general perception of what it entails. Identifying food traceability awareness among stakeholders is essential, and lack of awareness is one of the significant negative factors towards improved traceability [27]. Awareness about traceability is a precondition for deciding it [55]. In addition, if a stakeholder is aware of the problems and precautions to take, they are more likely to have a favourable attitude toward using protective technologies. Thus, awareness is an antecedent

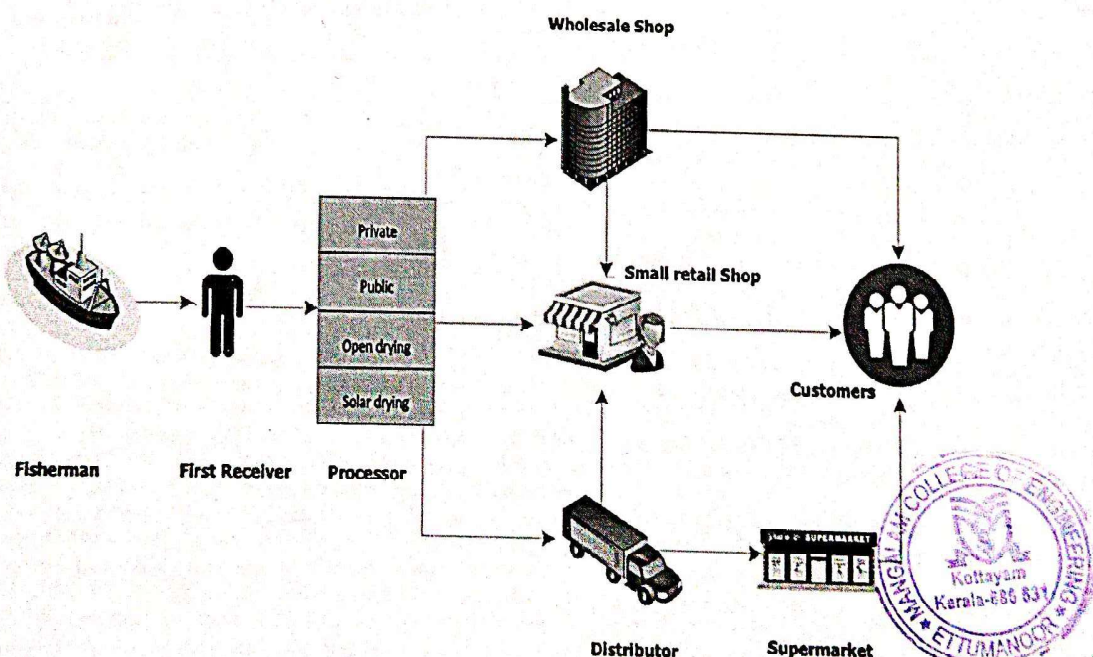


Figure 2. Illustration of dry fish supply chain in two major Indian states.



Table 5. Demographic data of survey respondents.

Variables	Categories	Frequencies	Percentage
Gender	Male	192	84.96
	Female	34	15.04
Age	Under 20	4	1.77
	20–35	96	42.48
	36–50	70	30.97
	51–65	50	22.12
	66 or older	6	2.65
Educational Background	Elementary School	65	28.76
	High School	130	57.52
	Diploma	2	0.88
	Undergraduate (i.e. Bachelor)	6	2.65
	Postgraduate (i.e. Master)	5	2.21
Demographic data excluding Customers and Government employees	Doctoral or equivalent	18	7.96
	No. of employee	132	94.29
	1 to 5	8	5.71
	6 to 50	0	0.00
	51 to 100	0	0.00
Year of establishment	Less than 3 years	19	13.57
	3 to 5 years	86	61.43
	6 to 10 years	35	25.00
	Greater than 10 years	0	0.00
Status of firm	Locally owned	82	58.57
	Partnership	58	41.43
Export status	Yes	0	0.00
	No	140	100.00
Yearly turnover	< or = Rs. 25 lakh	96.43	96.43
	> Rs. 25 lakh, < or = Rs 5 crore	5	3.57
	> Rs. 5 crore, < Rs 10 crore	0	0.00

for the attitude formation stage of innovation diffusion. Based on the statements mentioned above, the following hypothesis is developed.

H<sub>4</sub>: There is a significant positive relationship between traceability awareness and intention to implement it.

#### 4. Methodology

The food supply chain possesses unique characteristics of products and processes, whose data recording and information flow are essential for all the stakeholders to ensure transparency of the products [35]. Data were collected through a cross-sectional survey (both online and offline) administered in Kerala and Tamil Nadu, two central maritime states of India, to a sample of 226 stakeholders in the dry fish supply chain network shown in figure 2. It starts with the fisherman carrying their fish to the first receiver, who acts as a delivery agent between the fisherman and the processor. The processor is responsible for storing, processing, preserving, and subjecting them to steps that deem the dry fish healthy and fit for consumption. The processor also ensures that the dried fish are packaged into separate

boxes based on the features such as variety, size, shelf life and processing methods. Open or sun drying is one of the world's oldest and most widely practiced methods [57]. Meanwhile, more than 50 percent of the time can be saved by using solar drying methods [58]. Although most of the fish processors belong to the private sector, by identifying the potential of dry fish products, the government of Kerala initiated dry fish processing and marketing units under the brand name "DRISH Kerala". Furthermore, to ensure safety and quality ICAR-Central Institute of Fisheries Technology (CIFT), Cochin has developed low-cost and energy-efficient solar dryers for the hygienic drying of fish. The wholesaler/retailer/distributor collects the dry fish from the processor and makes the products available to customers.

The demographic data are shown in table 5. The sample covered fishermen (15.5% of the sample), first receivers (7.1%), processors (12.4%), distributors (10.6%), wholesale and retail shops (16.4%), government agencies (10.2%) and finally, consumers (27.8%). This research employs a survey strategy as it is found to be the best method to gather information from a population such as SMEs in India, which is too large to observe



directly [31]. The authors identified awareness levels, benefits, drivers, and barriers to adopting a traceability system in Indian dry fish SMEs through the extensive literature review. As the initial step, a preliminary survey questionnaire in English is prepared and further, to minimize any colloquialism wording and maintain a high degree of consistency of the original questionnaire, a back-translation technique [61] was employed to translate the questionnaire into Malayalam and Tamil, two Indian languages. Second, the scale items included in the questionnaire, their relevance, wording and directions, and the format were refined based on comments from researchers and practitioners. Third, to further assess and refine the survey instrument, it was pre-tested through a pilot study among 21 dry fish stakeholders in Kerala and Tamil Nadu. The pilot survey was carried out in November/December 2019. The expert's comments were incorporated into the final version of the questionnaire.

The survey is conducted in two parts; online and offline mode. The study managed an online survey for government employees and customers, and 750 questionnaires were sent via e-mail. The initial mailing and three follow-ups from February 20 2019-January 31, 2021 (Delayed due to Covid-19) generated 106 usable responses, yielding a relatively high response rate of about 14.13 percent. For other stakeholders, an offline, face-to-face survey is conducted due to their need for more technical knowledge and infrastructure to respond. Furthermore, Szolnoki and Hoffmann [61], recommended that face-to-face surveys deliver the most representative result and are structured, flexible and adaptable. The total number of responses received through offline mode is 120. The main questions included are related to the topic of this paper and are reported below. It should be noted that some background questions are asked at the beginning of the survey to understand whether the stakeholders (except government agencies and customers) belong to a small and medium sector. Also, to identify the dry fish supply chain shown in figure 2, two questions are included for each stakeholder: "Who are your direct/immediate customers?" and "Who are your direct/tier1 suppliers? To understand the level of awareness of the traceability system, we included two questions for the stakeholders following Mattevi and Jones [31], as shown in table 6. Furthermore, the respondents were asked to rate the benefits, drivers, and barriers that impact implementing the traceability in the Indian dry fish SMEs on a 5- point Likert scale.

Data were statistically analysed using IBM SPSS version 20. In order to enhance the robustness of the results, correlation matrices are generated for the traceability system's perceived benefits, drivers and barriers. Furthermore, multiple regression modelling was used to assess the effect of these variables for the intention to implement the dry fish traceability system.

**Table 6.** Questionnaire to understand the level of awareness of the traceability system.

Are you familiar with the word "traceability" of a dried fish product? (Tick ✓ one)

- ☐ Know very well
- ☐ Know well
- ☐ Know
- ☐ Some information
- ☐ No Information

[IF YES] Which of the element below best describe the concept of traceability of a fish product? (Tick ✓ one or multiple choices)

- ☐ Tracking (Follow downstream path of a product)
- ☐ Tracing (Determine the origin of a product)
- ☐ Safety control
- ☐ Quality control
- ☐ Information (capture, and/or store, and/or transmit)

## 5. Results and discussion

A correlation matrix enables reproducing (and confirming) a study's results or conducting secondary analyses. The correlations among the perceived benefits, drivers and barriers were examined individually, and the results are shown in the correlation matrices (tables 7, 8 and 9). Prior to this, the scales of measurement for the variables were tested using a Cronbach reliability test. They were 0.9720, 0.9840 and 0.9680 for the benefits, drivers, and barriers, respectively, indicating a high level of reliability. From table 7, it is identified that the perceived traceability benefits "increase profit and attract new customers" ( $r = 0.420$ ,  $p = 0.00$ ), "reduce liability claims and lawsuits and reduce customer complaints" ( $r = 0.433$ ,  $p = 0.00$ ), "reduce the probability of occurrence of product recall and reduce liability claims and lawsuits" ( $r = 0.441$ ,  $p = 0.00$ ), and "increase the ability to retain existing customers and increase profit" ( $r = 0.423$ ,  $p = 0.00$ ) have a high positive correlation. Similarly, table 8 shows that the traceability drivers "reduced recall expenses and technological advancements" have a very high correlation value ( $r = 0.725$ ,  $p = 0.00$ ). This finding aligns with Karlsen *et al* [49], who assert that better product documentation and lower recall costs result from a willingness to invest in the technology. Table 9 indicates that barriers "inadequate practices and reluctance to change" ( $r = 0.504$ ,  $p = 0.00$ ) and "uncertainty about the future benefits and reluctance to change" ( $r = 0.445$ ,  $p = 0.00$ ) are strongly correlated. When multiple independent variables exist in a regression, the regression coefficient  $\beta$  shows how much the dependent variable is expected to change when one of those independent variables changes while the other independent variables stay constant. The R-squared value ( $R^2$ ) of the regression is the fraction of the change in the dependent variable that is accounted for by independent variables. The t-value is used in regression to determine whether the response and predictor variables



**Table 7.** Correlation matrix (for the perceived benefits for traceability implementation in dry fish SME).

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Improve product safety	1												
2 Improve product quality	.299**	1											
3 Identify product characteristics	.329**	.337**	1										
4 Increase access to overseas markets	.207**	.159*	.408**	1									
5 Attract new customers	0.006	0.038	0	.342**	1								
6 Differentiate your products from others	0.08	-0.056	0.063	0.412	0	1							
7 Increase profit	.218**	-0.018	-0.011	0.147	.326**	0	1						
8 Increase the ability to retain existing customers	0.034	0.819	0.883	0.054	0	.367**	0	1					
9 Reduce customer complaints	0.131	-0.032	0.046	.328**	.420**	0	.423**	0	1				
10 Reduce liability claims and lawsuits	.161*	.181*	.231**	.275**	.249**	.275**	.372**	.306**	0	1			
11 Reduce the cost of product recall	.267**	.217**	.303**	.382**	.240*	.164*	.391**	.322**	.433**	0	1		
12 Enable rapid recall of food product	.151*	0.126	.202**	.358**	.329**	.190*	.196*	.357**	.291**	.297**	0	1	
13 Reduce the probability of occurrence of product recall	.247**	.166*	.315**	.413**	.194*	.127	.172	.172	.172	.172	.172	.387**	1
	0.001	0.029	0	0	0.011	0.098	0.01	0	0	0	0	0	0
	.288**	0.145	.276**	.264**	.167*	.170*	.284**	0.12	.174*	.300**	.303**	.359**	0
	0	0.053	0	0	0.028	0.026	0	0.118	0.023	0	0	0	0
	.307**	0.083	0.062	.179*	.175*	.325**	.373**	.278**	.343**	.441**	.303**	.359**	1
	0	0.277	0.422	0.019	0.022	0	0	0	0	0	0	0	0

\*Significant at the  $p = 0.05$  level. \*\* Significant at the  $p = 0.01$  level

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**Table 8.** Correlation matrix (for the perceived drivers for traceability implementation in dry fish SME).

Pearson correlation coefficients and significance levels (listed top to bottom in each cell)

	1	2	3	4	5	6	7	8
1 Quality concern	1							
2 Safety concern	.452**	1						
3 Food safety regulation	0	.335**	1					
4 Technological advancements	0	.448**	0	1				
5 Reduced recall expenses	.424**	.395**	.445**	0	1			
6 To obtain competitive advantage	0	.360**	.324**	.725**	0	1		
7 Suppliers/consumers request	.250**	.171*	.269**	.369**	.301**	0	1	
8 Product information	0.001	0.025	0	0	0	0.09	0.243	1
	.208**	.410**	0.149	.266**	.287**	.331**	.405**	
	0.006	0	0.052	0	0	0	0	
	.327**	.495**	.413**	.394**	.353**			
	0	0	0	0	0	0	0	

\*Significant at the  $p = 0.05$  level. \*\* Significant at the  $p = 0.01$  level**Table 9.** Correlation matrix (for the perceived barriers for traceability implementation in dry fish SME).

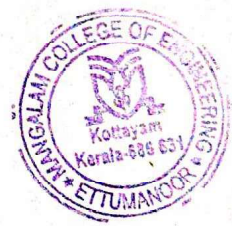
Pearson correlation coefficients and significance levels (listed top to bottom in each cell)

	1	2	3	4	5	6	7	8	9	10	11
1 High costs of application of the traceability system	1										
2 No unified standards in the markets	.206**	1									
3 Privacy and security concerns	0.007	.296**	1								
4 Information limitation	.209**	.296**	0	1							
5 Capacity[infrastructure] limitation	0.133	.408**	.402**	0	1						
6 Uncertainty about the future benefits	0.083	0	0	.268**	0	1					
7 Reluctance to change	0.081	.202**	0.008	0.327	0	.371**	1				
8 limited awareness of traceability and its benefits	0.067	.297**	.228**	.267**	.371**	0	0	1			
9 Inadequate Practices	0.383	0	0.003	0	0	.445**	0	.369**	1		
10 Lack of support from government	.182*	.340**	.383**	.355**	.239**	.356**	.504**	0.142	0.063	1	
11 Lack of a coordinator for traceability practices	0.122	.352**	.166*	.347**	.359**	.267**	.369**	.315**	.272**	.387**	1
	0.111	0	0.03	0	0	0	0	0	0	0	
	.190*	.297**	.199**	.326**	.245**	.356**	.504**	0.142	0.063	.387**	
	0.012	0	0.009	0	0.001	0	0	0	0	0	
	— 0.003	.315**	0.041	.207**	.161*	.286**	.356**	.315**	.272**	.387**	
	0.964	0	0.594	0.006	0.035	0	0	0	0	0	
	.150*	.220**	0.127	.260**	.357**	.319**	.358**	.225**	.389**	.387**	
	0.05	0.004	0.097	0.001	0	0	0	0.003	0	0	

\* Significant at the  $p = 0.05$  level. \*\* Significant at the  $p = 0.01$  level

have a linear correlation. In the structural model,  $R^2$  values of 0.75, 0.50, or 0.25 for endogenous latent variables can be explained as substantial, moderate, or weak, respectively. Critical t-values for a two-tailed test are 2.58 (significance

level is equal to 1 percent), 1.96 (significance level is equal to 5 percent), and 1.65 (significance level is equal to 10 percent). The correlation matrix of perceived benefits, drivers and barriers are shown in tables 7, 8 and 9.



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Table 10. Regression results, Hypothesis 1-3.

Intention to implement the traceability system			
<b>H1: Benefits of traceability</b>	<b>R<sup>2</sup> = 0.808</b>		
	<b>F=55.69 (000)</b>		
	Standard $\beta$	t	Significance
Improve product safety	0.597**	9.021	0.000
Improve product quality	0.275**	3.233	0.001
Identify product characteristics	0.012	0.279	0.781
Increase access to overseas markets	-0.001	-0.021	0.983
Attract new customers	0.521**	8.445	0.000
Differentiate your products from others	0.501**	8.287	0.008
Increase profit	0.175	2.536	0.221
Increase the ability to retain existing customers	0.009	0.188	0.451
Reduce customer complaints	0.111	1.343	0.181
Reduce liability claims and lawsuits	0.010	0.267	0.790
Reduce the cost of product recall	0.227	6.889	0.120
Enable rapid recall of food product	0.010	0.250	0.103
Reduce the probability of occurrence of product recall	-0.131	-1.535	0.127
<b>H2: Drivers of traceability</b>	<b>R<sup>2</sup> = 0.631</b>		
	<b>F=32.68(000)</b>		
	Standard $\beta$	t	Significance
Quality concern	0.588**	8.942	0.000
Safety concern	0.245*	1.871	0.023
Food safety regulation	0.404*	5.986	0.028
Technological advancements	0.031	0.277	0.782
Reduced recall expenses	0.071	0.646	0.519
To obtain competitive advantage	0.337**	4.437	0.000
Suppliers/consumers request	0.065	0.781	0.436
Product information	0.050	0.546	0.586
<b>H3: Barriers of traceability</b>	<b>R<sup>2</sup> = 0.473</b>		
	<b>F=13.148(001)</b>		
	Standard $\beta$	t	Significance
High costs of application of the traceability system	-0.343*	-4.597	0.012
No unified standards in the markets	-0.012	-0.179	0.858
Privacy and security concerns	0.02	0.296	0.768
Information limitation	-0.063	-0.888	0.376
Capacity[infrastructure] limitation	-0.402**	-5.303	0.000
Uncertainty about the future benefits	0.009	0.148	0.883
Reluctance to change	0.021	0.285	0.776
limited awareness of traceability and its benefits	-0.604**	-8.482	0.000
Inadequate Practices	-0.102	-1.507	0.134
Lack of support from government	-0.514**	-7.65	0.000
Lack of a coordinator for traceability practices	-0.216**	-3.001	0.003
<b>H4: Awareness of traceability</b>	<b>R<sup>2</sup> = 0.765</b>		
	<b>F= 47.76(.000)</b>		
	Standard $\beta$	t	Significance
	0.604**	9.887	0.000

\* Significant at the p = 0.05 level. \*\* Significant at the p = 0.01 level

respectively. The regression models had significant ( $p < 0.05$ ) F-values, as shown in table 10.

Hypothesis 1 holds that perceived benefit will positively influence the intention to implement the traceability system. The results in table 10 provide support for this hypothesis. The results are solid for the benefits of the traceability system, with the model R-squared implying that the

independent variables explain 80.8 percent of the variation in intention to implement the traceability system. Examining the individual model results yields some additional insights. The benefits such as improved product safety [A1] ( $\beta = 0.597$ ,  $t = 9.021$ ,  $P = 0.000$ ), quality [A2] ( $\beta = 0.275$ ,  $t = 3.223$ ,  $P = 0.001$ ), attracting new customers [A5] ( $\beta = 0.521$ ,  $t = 8.445$ ,  $P = 0.000$ ) and differentiate your



products from others [A6] ( $\beta = 0.501$ ,  $t = 8.287$ ,  $P = 0.008$ ) have a significant positive impact on the intention to implement the traceability system. Contrarily, apart from the benefits outlined above, none of the other factors significantly affect the implementation of the traceability system. The result of reducing the cost of product recall [A11] ( $\beta = 0.227$ ,  $t = 6.889$ ,  $P = 0.120$ ) is found to be less significant. While the authors expected this variable positively impacts the intention to implement the traceability system, the results suggest otherwise. One possible explanation is that most stakeholders in India believe that the recall cost includes the notification cost of the recall, the cost of shipping the recalled product and the cost of holding the recalled product is relatively high. In our survey, most dry fish supply chain stakeholders are small and medium sectors, market a limited quantity of products, and deal with few recalls. Memon *et al* [59] reported that a minor product recall would not affect the profit and sales of firms.

Hypothesis 2 argues that perceived drivers will positively influence the intention to implement the traceability system. The results in table 10 support this hypothesis. The model  $R^2$  implies that the independent variables explain 63.1 percent of the variation in the intention to implement the traceability system. The traceability drivers such as quality concern [B1] ( $\beta = 0.588$ ,  $t = 98.942$ ,  $P = 0.000$ ), safety concern [B2] ( $\beta = 0.245$ ,  $t = 1.871$ ,  $P = 0.023$ ), food safety regulation [B3] ( $\beta = 0.404$ ,  $t = 5.986$ ,  $P = 0.028$ ) and to obtain competitive advantage [B6] ( $\beta = 0.337$ ,  $t = 4.437$ ,  $P = 0.000$ ) have a profoundly favourable effect on the decision to implement the traceability system. The results agree with the findings of Pant *et al* [34] that traceability is primarily considered a tool for food safety and quality by offering a mechanism for recall and confirmation of food authenticity. Several nations over the past few years have established specific regulations or policies for domestic products and implemented mandatory regulations for food traceability systems, excluding India Dandage *et al* [19]. India must cooperate with these nations and adhere to their established standards in order to export goods to those countries where a traceability system is required and get competitive advantages.

Hypothesis 3 holds that perceived barriers will negatively influence the intention to adopt the traceability system. The results in table 10 support this hypothesis, albeit not as strongly as for Hypotheses 1 and 2. High cost [C1] ( $\beta = -0.343$ ,  $t = -4.597$ ,  $P = 0.012$ ), capacity limitation [C5] ( $\beta = -0.402$ ,  $t = -5.303$ ,  $P = 0.000$ ), limited awareness [C8] ( $\beta = -0.604$ ,  $t = -8.482$ ,  $P = 0.000$ ), lack of government support [C10] ( $\beta = -0.514$ ,  $t = -7.65$ ,  $P = 0.000$ ) and lack of a coordinator [C11] ( $\beta = -0.216$ ,  $t = -3.001$ ,  $P = 0.003$ ) are the independent variables with a significant, negative impact on the intention to dry fish traceability system implementation and all other barriers have no significance. Not surprisingly,

as the stakeholders believe that financial support for building capacity or infrastructure development by the government is inevitable, lack of government support has a high negative  $\beta$  value ( $\beta = -0.514$ ). Furthermore, while the authors expected the lack of a coordinator for traceability practices to have little impact on implementing the dry fish traceability system, the result was surprising. The regression models yield some interesting insights. In India, most dry fish supply chain members are located in coastal area and prone to low literacy and technical knowledge levels. Therefore, they need support from external sources to provide training and support services and work closely with the supply chain team. The results validated the findings by Choi *et al* [60] say that to create the maximised system's profit and successful strategies, the interests of individual members, should be coordinated by a supply chain coordinator. Additionally, coordinating the traceability system positively impacts quality in food industry value chains since most entities act based on their activity and integration of these units is possible only through a coordinator [12].

Hypothesis 4 states a significant positive relationship between the level of traceability awareness and the intention to implement it. It is crucial to gauge stakeholders' awareness of food traceability, and a lack of awareness is one of the critical barriers to adopting traceability. Traceability awareness is a requirement before choosing it Blaauboer *et al* [55]. Indeed, the more knowledgeable a stakeholder is about issues and how to protect against them, the more likely they will develop a positive attitude toward using protective technologies. Therefore, awareness is a prerequisite for the innovation diffusion stage of attitude formation. The results in the table support this hypothesis, with the awareness of traceability explaining 76.5 percent of the variance in the implementation of the traceability system. The findings agreed with Samarasinghe *et al* [27] that poor awareness is a limiting factor for implementing a traceability system since a lack of awareness implies a lack of consciousness of something.

Finally, the overall result suggests that the main benefits are to improve product safety [A1], attract new customers [A5] and differentiate your products from others [A6]. The main traceability drivers are the quality concern [B1] and food safety regulation [B3]. The significant barriers are high cost [C1], limited awareness [C8], lack of government support [C10] and lack of a coordinator [C11]. To overcome the barriers, the Indian government must establish specific regulations or policies for food traceability and define the roles and responsibilities of stakeholders and regulators. The researchers and decision-makers must focus on developing an inexpensive traceability system to promote food traceability. The suggested recommendations can help to resolve the significant barriers and also helps to achieve the benefits of traceability implementation, such as food safety and quality.



## 6. Conclusion

Traceability in the dry fish supply chain deserves research attention, especially among small and medium enterprises (SMEs) in India. The extensive literature review identified the awareness levels, benefits, drivers, and barriers to adopting a traceability system in Indian dry fish SMEs. Also, a conceptual model that formally explains the impact of these variables to establish a dry fish traceability system was constructed. In order to test the model, data were collected through a cross-sectional survey of 226 stakeholders in the dried fish supply chain network from the central maritime Indian states of Kerala and Tamil Nadu and were statistically analysed using IBM SPSS version 20 software. Correlation matrices are developed for the traceability system's benefits, drivers, and barriers to enhance the robustness of the findings. Additionally, the impact of these variables on the decision to deploy the dry fish traceability system was evaluated using multiple regression modelling.

The findings revealed that barriers to implementing a traceability system in the dried fish industry are negatively correlated, while perceived benefits, drivers, and awareness are positively correlated. The benefits, such as improving product quality, attracting new customers and differentiating your products from others, have a significant positive impact on the intention to implement the traceability system. As far as the perceived driver's effect on the traceability system is considered, the leading elements are quality and safety concerns, food safety regulations, and to obtaining competitive advantages. Finally, the critical barriers to traceability are identified as high cost, capacity limitations, limited awareness, lack of government support and lack of a coordinator. From the survey, it is found that Indian dry fish stakeholders appear to have a moderate understanding of the definition and meaning of traceability as provided by the literature, like tracking, tracing, safety, and quality. A few minor contradictions remain, such as the low number of supply chain members who have chosen "information" as a concept associated with traceability.

The unique contribution of this research is that it developed a supply chain network for the SME dry fish sector in India. Furthermore, it provides information that may be considered by the government, programmers, and the fishing sector before making plans to create a traceability system for the supply chain of dry fish. This research can help to understand the various elements to implement traceability practices within dry fish SMEs and can be extended to any other food industry. Before developing a prototype of the traceability system for dry fish SMEs, this work offers several points to consider. Implementation of a dry fish traceability system will become a reality in the SME sector if these drivers and barriers are addressed adequately.

The following are the limitations of the present research. The findings and the business implications presented in this study are based on a sample size of 226 stakeholders in two states of India (Kerala and Tamil Nadu), which may restrict the generalisation of results. Therefore, future research can expand the sample size and improve representativeness from other coastal states. Notwithstanding its limitation, this study delivers a starting point for several future research streams. This research is limited to SME dry fish sector and may be extended to other food sectors such as fruit and vegetables, meat, live fish etc. Future research may utilise methodologies, such as interpretive structural modelling (ISM) and Decision making trial and evaluation laboratory (DEMATEL), to incorporate the direct effects of each driver and barrier to the adoption of traceability in the supply chain.

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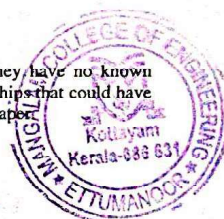
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## Declarations

**Conflict of interest** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## **A QR code based traceability system for dry fish supply chain of micro and small enterprises in India**

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**Abstract:** This research proposes a quick response (QR) code-based supply chain traceability system to control the quality and safety of Marine Dry Fish in India. Micro and small enterprises (MSEs) are the main stakeholders of the dry fish supply chain in India. These MSEs rely mainly on paper documentation for traceability, and technology adoption is still in an early stage due to poor affordability. The proposed QR code stores information such as source/origin, product/variety, location and time of processing, and packaging into a real-time database server. The proposed system was tested among dry fish supply chain stakeholders in Emakulam, one of the marine districts of Kerala-India. The results showed significant benefits to dry fish value chain members and customers by integrating information collected along the supply chain and tracking the products from fisherman to the end consumer.

**Keywords:** supply chain traceability; MSE; QR code; dry fish; quality and safety.

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## 1 Introduction

Indian fisheries and aquaculture are essential food production sectors, providing nutritional security, and employment to around 14 million people. India is the second-largest fisheries maker after China, with a total fish production of 12.59 million metric tonnes (Fisheries Statistics Division, 2019). Over 11,40,000 MT (metric tons) worth 5.96 billion US dollar fisheries were exported in the last financial year 2020–2021, despite the market uncertainties raised by the COVID-19 (Ivanov and Das, 2020). The processing of fisheries products should be done within a few hours of being caught as the preservation or processing methods determine the shelf life and quality of the final product. The drying technique is admitted as the most common and affordable technique for preserving fish (Payra et al., 2016) and decrease the post-harvest loss due to contamination (Madan et al., 2018). In India, the dry fish consumption is about 32% of the marine landings and about 20% of the total catch used to produce dry fish (Bharda et al., 2017). Also, the contribution of the Indian dry fish export sector is 8% of all forms of fish exports and acquired a value of 1148.38 crores (INR) during 2020–2021 (mpeda.gov.in). However, the implications of illegal harvesting of seafood and the mislabelling of dry fish products have become more prominent in recent years. A survey conducted among the Indian domestic fish market to examine the authenticity of fresh and processed fish showed that 22% of seafood samples are mislabelled (Nagalakshmi et al., 2016). The food safety issues are concealed in many countries and are frequently overlooked (Hoque et al., 2022). In India mandatory regulations or policies for food safety are not completely enforced resulting in the occurrence of fraudulence incidents (Dandage et al., 2017). Poor supply chain visibility is one of the critical factors that influences the effectiveness of product quality and safety assurance (Wang et al., 2017). From a consumer perspective quality refers to both the properties of the food products and how those properties have been achieved (Aung and Chang, 2014). Nowadays consumers are being concerned about the origin of food products, production methods, raw materials, environmental impact, etc., (Kamble et al., 2020; Wolfert et al., 2017; Moovendhan et al., 2019). The increased awareness is positively contributing towards developing traceability in the dry fish supply chain. In order to assure the quality and safety of the dry fish supply chain, fishery companies need to adopt the traceability systems (Wang et al., 2009). The lack of regulations and serious enforcement in the traceability of fishery products in some countries is one cause of food fraud (Panprommin and Manosri, 2022). Traceability and product quality in the dry fish supply chain deserve research attention, as food scandals and scares worldwide have resulted in reduced consumer confidence. Singh et al. (2021) reported that proper traceability is essential along the supply chain to improve the quality, safety, and minimise the wastage of food products.

Traceability is defined as the capability to access information related to things that are to be considered throughout their whole life cycle using recorded identification (Olsen and Borit 2013; Mattevi and Jones, 2016; Dandage et al., 2017). The term 'traceability' includes both 'tracing' and 'tracking' (Dandage et al., 2017; Khan et al., 2018). Tracing is a reverse process in which origin is identified, and tracking is a forward process where the location in the supply chain identifies the end-users. Traceability is recognised as a mechanism for quality and safety, improving sustainability and reducing the overall cost of the food product since it reduces the recall's probability (Jose and Shanmugam, 2020). Traceability gives continuous information about the raw material sources, the process



  
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involved, logistics and location of products along the supply chain. The more precise the tracing system, the faster a producer can identify and undertake food safety and quality problems. Food traceability has long been a focus among scholars in different countries. The traceability framework for food products has been created using various methods, among which radio frequency identification (RFID) is the most well-known technique (Alfian et al., 2020). Although the members in the supply chain can trace back data about the food products through RFID technology, the tags are costly (Fan et al., 2019). Blockchain, a type of distributed ledger, is another modern traceability technology through which different institutions functioning on a distributed network can share information (Kamble et al., 2020; Leong et al., 2018). Due to its distributed, decentralised, and changeless characteristics, blockchain is considered as a curer of traceability issues in the supply chain. Although very promising, the RFID and blockchain technologies may not be economically sensible, particularly in India, where most dry fish supply chain stakeholders belong to the micro and small enterprises (MSEs) and have poor affordability and nominal awareness (DasGupta and Sarkar, 2022). People involved in dry fish production at MSEs add less value and make less profit due to poor product quality, safety and hygienic conditions and lack of market access (Bharda et al., 2017). Also, these MSEs depend mainly on a paper documentation system for traceability where the information sharing is limited to tier one up-stream and downstream partners (Marchante et al., 2014). The e-traceability empowers information sharing along the entire supply chain as it goes beyond the traditional 'one step forward, one step backwards' paper documentation approach to track and trace fish products (Srivastava and Kavva, 2021). This research aims to develop an economically viable traceability system to improve the quality and safety of the dry fish supply chain in India.

The remaining paper is organised as follows: Section 2 presents a literature review on the supply chain traceability system. Section 3 and 4 describes the existing dry fish supply chain and the design and architecture of the proposed traceability system respectively. The developed traceability system is validated and the findings are presented in Section 5. Finally, section 6 concludes the paper with future research.

## **2 Literature review**

Food supply chain networks are getting more complex and fragmented which makes the identification of the products and processes along the networks more difficult (Casino et al., 2020). In this context, traceability system is inevitable for ensuring not only safety and quality but also better understanding of the food product's life cycle, regulatory compliance and conscientious consumption. The increasing number of food scandals and wastage events have called the attention of both scholars and practitioners to devise the methods to improve the traceability and food safety (Maity, 2021; Vardhan and Gupta, 2022; Subramanian et al., 2022; Théolier et al., 2021). This section enriches the present study of food traceability solutions from an implementation perspective. The literature is categorised based on the proposed traceability system, product category and country as shown in Table 1. Among the reviewed articles, the highest number of publications belongs to the authors that are affiliated with institutions in China. It is also observed that fishery, beef and fruit and vegetables have received significant attention for traceability applications. RFID, internet of things (IoT), Blockchain and quick response (QR) code based traceability systems have been proposed to track food products such as fishery



  
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(Larissa and Parung., 2021; Zhang et al., 2019; Cruz and Cruz, 2020), meat (Shew et al., 2022; Chen et al., 2020; Lin et al., 2020; Fan et al., 2019; Peng et al., 2018), coffee (Miatton and Amado, 2020), wine (Biswas et al., 2017), and fruit and vegetables (Tharatipyakul and Pongnumkul, 2021; Qian et al., 2021; Yang et al., 2021; Alfian et al., 2020; Gautam et al., 2017) along the supply chain. Traceability system based on Blockchain (Shew et al., 2022; Tharatipyakul and Pongnumkul, 2021; Larissa and Parung, 2021; Yang et al., 2021; Cruz and Cruz, 2020; Miatton and Amado, 2020; Biswas et al., 2017), RFID (Alfian et al., 2020; Fan et al., 2019; Zhang et al., 2019; Gautam et al., 2017) and QR codes (Qian et al., 2021; Chen et al., 2020; Peng et al., 2018) have received considerable attention as shown in Table 1.

**Table 1** Recent studies on the traceability system in food supply chain

<i>Author and year</i>	<i>Traceability system proposed</i>				<i>Product category</i>	<i>Country</i>
	<i>RFID</i>	<i>Blockchain</i>	<i>IoT</i>	<i>QR code</i>		
Shew et al. (2022)		✓			Beef	USA
Tharatipyakul and Pongnumkul (2021)		✓			Fruit and vegetable	Thailand
Qian et al. (2021)				✓	Fruit and vegetable	China
Larissa and Parung (2021)		✓			Fishery	Indonesia
Yang et al. (2021)		✓			Fruit and vegetable	China
Alfian et al. (2020)	✓		✓		Kimchi	Korea
Chen et al. (2020)				✓	Pork	China
Cruz and Cruz (2020)		✓			Fishery	Portugal
Miatton and Amado (2020)		✓			Coffee	Colombia
Lin et al. (2020)	✓				Beef	China
Fan et al. (2019)	✓	✓			Beef	China
Zhang et al. (2019)	✓			✓	Fishery	China
Peng et al. (2018)				✓	Pork	China
Biswas et al. (2017)		✓			Wine	Australia
Gautam et al. (2017)	✓				Fruit and vegetable	New Zealand

Although blockchain technology is a promising innovation for traceability systems, its reception is still in the beginning phase, particularly in MSEs. Similarly, RFID labelling enjoys several benefits that assist companies with working on the speed of the data stream and reduce fraudulence, but many labels are required along the inventory network, which increases the expense (Aung and Chang, 2014). The traceability system in the dry fish production and distribution process is significant as every actor in the supply chain is responsible for ensuring the quality and safety through processing, handling, packaging, and transporting. It is seen from the literature that the traceability system for dry fish have not been considerably advanced since partners in the supply chain are mainly MSEs

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(Kaushik and Singh, 2022; DasGupta and Sarkar, 2022; Vijayakumar, 2021; Singh et al., 2021) and have poor affordability (Bharda et al., 2017). Smartphones and the internet could be used to solve the issue of high cost associated with the traceability system (Aung and Chang, 2014). Motivated by this research gap, a QR code-based, cost-effective traceability system for the dry fish supply chain in India. The major contributions of this research are:

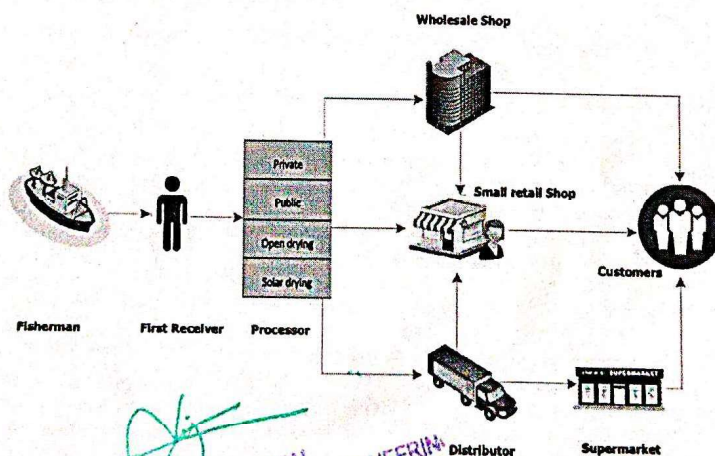
- 1 To identify and analyse the dry fish supply chain of MSEs in India.
- 2 To design and develop an architecture of a simple, inexpensive, and easy to use QR code-based, traceability system of dry fish supply chain
- 3 To validate the developed traceability system using the real-time data obtained from the supply chain stakeholders.

### 3 Modelling the fisheries value chain

#### 3.1 Dry fish supply chain in two major Indian states

The traceability of dry fish is essential to get information along the value chain to consumers and recall it in case of threats to public health (Oliveira et al., 2021; Thota et al., 2020). To understand the dry fish supply chain, data were collected from 226 stakeholders in Kerala and Tamil Nadu, two major maritime states of India (Kumarran, 2012), through a cross-sectional survey. The stakeholders include fishermen, brokers/first receivers, distributors, wholesale/ retail shops, consumers, and government supervisors.

**Figure 1** Illustration of dry fish supply chain in two major Indian states (see online version for colours)



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The typical dry fish supply chain is shown in Figure 1. It starts with the fisherman carrying their fish to the first receiver, who acts as a delivery agent between the fisherman and the processor. The processor is responsible for storing, processing, preserving, and subjecting them to steps that deem the dry fish healthy and fit for consumption. The processor also ensures that the dried fishes are packaged into separate boxes based on the features such as variety, size, processing methods and shelf life. The wholesaler/retailer/distributor collects the dry fishes from the processor and makes the products available to customers. The proposed traceability system is designed to be compatible with the existing supply chain and enables the stakeholders to adapt the traceability framework for exchange of information.

### 3.2 *Various information included in the dry fish supply chain*

Indian dry fish supply chain includes the activities such as collecting raw fish, washing, salting, dressing and splitting raw fish, solar drying / open drying, sorting, packaging, storage, transportation and marketing, and each link includes much information. However, practically, every information collected from the supply chain members is not connected with safety and quality and cannot impact customers' safety perceptions. In a traceability system, identifying critical information ensures quality and safety (Chen et al., 2020). In general, product and process information are captured (Thakur and Donnelly, 2010). The following information should be collected for an effective traceability system (Lavelli 2013):

- a who is the responsible person or firm at that stage? (supplier, transporter, or company)
- b what is the definition of that product?
- c What kind of business transactions are going on?
- d when does the stage (eg., processing, packing, distribution/retail) occur? (date and time)
- e where does the stage occur? (Name of the plant in which the product is processed?)

In the proposed traceability system, QR code is used for tracking and tracing the dry fish products along the supply chain since the costs of using the QR codes are affordable to MSEs involved and they do not incur additional costs to the price of a single product (Tarjan et al., 2014). Compared to 2D barcodes, QR Code was chosen because of its merits such as large capacity, small size and high scanning speed, etc. (Yang et al., 2016). Information like origin of the product, variety, packaging date and other relevant information can be stored in the QR Code. In order to achieve referential integrity and accurate traceability, the traceable units shall be uniquely identified and later on, this data may be accessed through a unique identification number (Storoy et al., 2013).

In this research, a 15 digits ID is proposed as a product code, as shown in Figure 2. It consists of five sections, of which the first six digits identifies the location of supply chain partners, and the following three digits classify the fish. There are twelve variety of fish included in this study as shown in Table 2. The last three sections consist of two digits each for the date, month and year on which the fish was captured/processed. For example, the information of a fisherman who captured Butter Fish at Kannur (670013) on 21st April 2021 is coded as 670013004210421.

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Figure 2 Illustration of product identification code

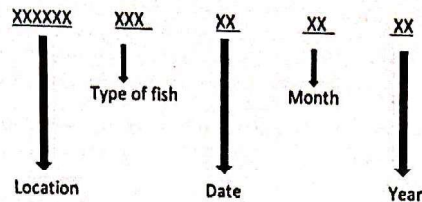


Table 2 Classification of the fish for product identification

Sl. no.	Fish name	Fish code
1	Nethili /Indian Anchovy	001
2	Rawas/Indian Salmon	002
3	Bhetki/Barramundi	003
4	Butter Fish/Pomfret	004
5	Surmai/Seer Fish	005
6	Bangda/Indian Mackerel	006
7	Tarali/Indian Oil Sardine	007
8	Bangus/Milkfish	008
9	Mangrove Red Snapper	009
10	Bombay Duck	010
11	Tuna Fish	011
12	Pangas Catfish	012

#### 4 Design and architecture of the proposed traceability system

The architecture of the proposed traceability system is shown in Figure 3. The traceability system framework comprises all the possible stages in the dry fish value chain, where the potential participants are: fisherman, first receiver, processing industries, retailer/wholesaler and the end-consumer. Each participant in the supply chain signifies a specific stage in the transformation of dry fish products. In this system a firebase real-time database server is used to store the complete information from the initial to final stages of processing. The mobile application is developed with Android Studio platform, the official integrated development environment for Google's Android operating system (Esmacel, 2015).

The proposed traceability system requires a signup process from each stakeholder by providing mandatory information such as name, email address, contact number, role in the supply chain and postal code. The signup and login screen is shown in Figure 4. Using the developed mobile application partners in the dry fish supply chain can submit information about their internal processing or view information submitted by other entities. When a new fish product is registered, the server generates a unique ID for that particular fish product, which facilitates further tracking and tracing. All information

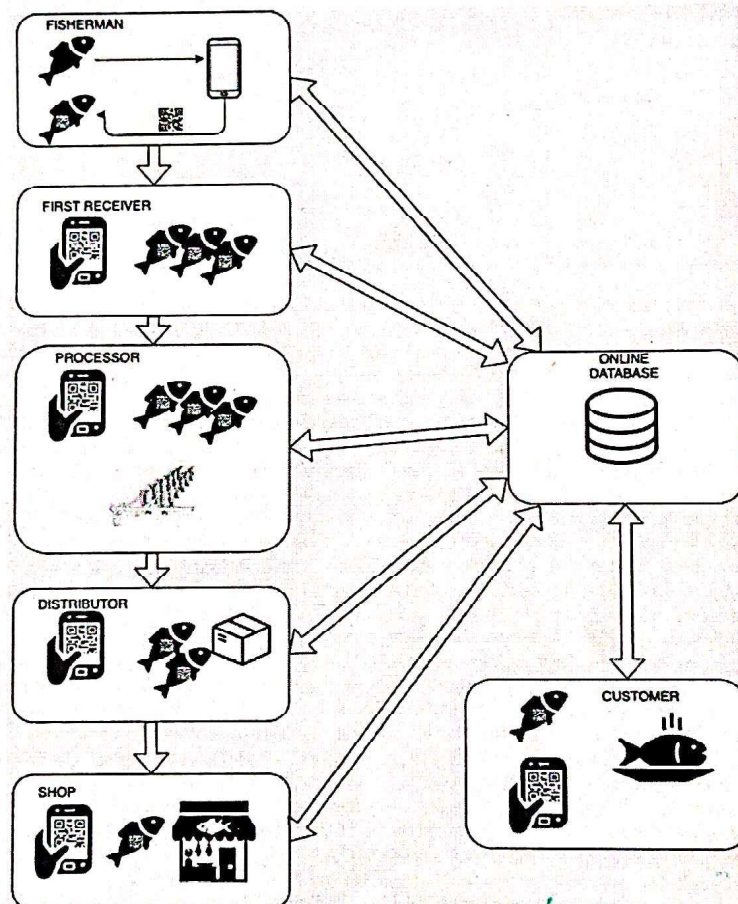


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related to that fish product will be associated with that unique ID. The developed mobile application includes a 'receive' function to scan the previous member's user code and receive all the information submitted by them. Similarly, a 'dispatch' function allow the participant to view their product user code and transfer it to the other participants along the value chain who need to receive product information.

Figure 3 Architecture of the proposed dry fish supply chain traceability system



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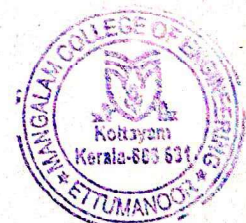


Figure 4 Snapshot of sign up and login screens (see online version for colours)

The figure displays three mobile application screens. The first screen, titled 'Welcome', features input fields for 'Email Address' and 'Password', a 'Login' button, an 'Or' separator, and a 'Sign Up' button under the heading 'Create a new account below.'. The second screen, titled 'Create an Account', includes fields for 'Name', 'Email Address', 'Mobile No', 'Select Type' (a dropdown menu), 'Password', and 'Confirm Password', with a 'Sign Up' button at the bottom. The third screen, also titled 'Create an Account', shows a 'Select role.' section with six buttons: 'Fisherman', 'First Receiver', 'Processor', 'Distributor', 'Shop', and 'Customer'. A checkmark is visible at the bottom of this screen.

After catching the fish, the required information such as product category, date and time is fed as input into the mobile application and registered in the firebase real-time database server, and the server generates a unique ID number. The mobile application installed with the fisherman receives the ID number and generates a QR code for the ID, as shown in Figure 5. This QR code can either be printed onto a label and put on the fish crates, or sent to the following supply chain partner through digital media. The first receiver upon receiving the fish crates reads the QR code tag using the mobile application scanner, and the application sends the code to the database server. The server checks the validity of the code and records all the necessary information such as location, date, time, and name of the first receiver. Similarly, information from the processor, wholesaler and retailer at each stage is updated and sent to the server, where the transit information is registered by validating the code. After the supply chain members store the information about the traceability, a consumer who buys the dry fish can access the database server by scanning the QR code, as shown in Figure 6. Generally, the dry fish packs in low-density polypropylene or polythene in the consumer market and packets of different sizes and weights ranging from 50 grams up to 2 kilograms are available. Reduced oxygen packaging techniques such as vacuum packaging (maintaining vacuum inside the packet) and modified atmosphere packaging can be used for storing the dry fish for a long time.

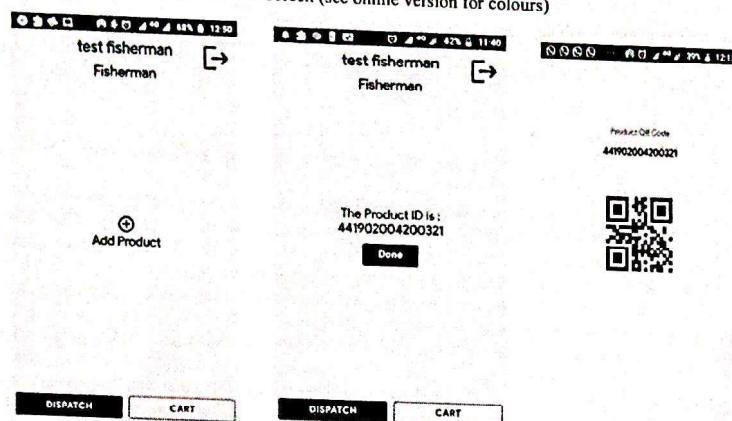
The traceability system is designed in such a way that all supply chain partners can access and update the required information through the central information system using a mobile application. A governing partner of the supply chain (e.g., a processor) or an application service provider is responsible for handling and operating the centralised information system. With the help of an IP network, the information collected through a QR code scanner/reader installed in supply chain partners' mobile phones is transferred to the central information system. After filtering and organising the data, the required traceability information is made accessible to all supply chain partners.



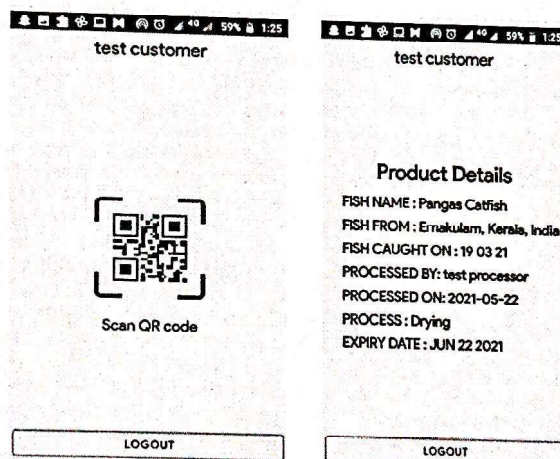
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**Figure 5** Snapshot of fishermen screen (see online version for colours)



**Figure 6** Snapshot of customer screen (see online version for colours)



Using the proposed traceability architecture, only producers in the chain (e.g., processor) are responsible for handling complex information about the product and process and organising the complete information system. On the other hand, other dry fish network partners (e.g., distributors, retailers) need to furnish the location and time data of the fish products held at their sites. Information is passed down from one supply chain member's



to another's in an efficient, authentic, and reliable manner utilising QR code. In this way, both efficient information management and information security are achieved. Also, in the developed traceability system there is no scope for altering the data previously entered by the supply chain members regarding the product; hence, data manipulation is eliminated.

## **5 Validation of the developed traceability system**

The developed traceability system is validated in Ernakulam, one of the marine districts of Kerala-India where all the processes along the supply chain are carried out. The pilot study was deployed with an existing dry fish distribution network that includes five fishermen, one first receiver/broker, two processors, three distributors, five retailers and ten customers. After a brief training on the proposed traceability system they were asked to register and log in to the traceability mobile application, and pilot findings are promising. The application results of this program have been well-recognised by supply chain members. However, a practical difficulty encountered in the mobile application during the validation experiment is that some fisherman goes deep-sea fishing and returns only after one or two weeks. During that period, they do not have either a mobile phone or network, and as a result, they may not be able to enter the data on time. An automatic updating facility of date and time in the fisherman's window is changed to a manually operating system to solve this issue.

Throughout the experiment, application installed in the mobile phone was tested for receipt registration. It was observed that the mobile phone-based receipt system is sufficient for practical use. Also, it is concluded that smartphones presently available in the market have sufficient capabilities to combine their regular operation while simultaneously performing as gateways to transmit traceability information to the server. Furthermore, the traceability system was evaluated by consumers and allowed them to check fish traceability data on their smartphones during the demonstration at the point of sale to get feedback. Customer perceptions show rising anxiety about the safety and ingredients of the dry fish they purchase and consume. The different information and data obtainable from the existing labelling conventions are limited and do not always make much confidence to the consumers. Indeed, an raising demand is there for clear information on the quality and safety of the entire dry fish supply chain, assisted by modern tracking and tracing methods.

The initial deployment results of the proposed framework indicate that it can convey various advantages to partners in the supply chain. First, it enables the fulfilment of market requirements through building customer trust and brand image and complying with regulations. Second it decreases spoilage and contamination of the dry fish supply by identifying hazards before affected products make it to end consumer markets. When insecure dry fish slip through the cracks and enter the system, traceability systems allow market actors to identify and isolate the source to mitigate the consequences immediately. In the event of a recall, traceability simplifies a targeted withdrawal of the dry fish most likely to have been affected, thereby reducing wastage and market distortions. Third, the successful implementation of the proposed system in the dry fish supply chain motivates other supply chain members to adopt a traceability framework and adhere to required quality standards through which the additional expense for quality management can be avoided. Finally, it empowers the provision of quality guaranteed dry fish products at a



  
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decreased price along with additional information for customers facilitating higher customer satisfaction, which brings additional profits through improved customer loyalty.

## 6 Conclusions

Based on QR code technologies, this paper proposed an integrated tracking and tracing platform for dry fish products and validated it to examine the practical usability of the traceability system. The system can provide information regarding all aspects of the dry fish supply chain, from the fisherman to consumers. The proposed QR code stores data such as origin, product/variety, location and time of processing, and packaging into a real-time database server.

This research contributes to the supply chain traceability literature in the following aspects: First, a mobile solution based on QR technology is developed, which significantly reduces the user's costs; second, the developed application enables information sharing among all the stakeholders, which will further facilitate their cooperation on guaranteeing the quality and safety of the dry fish; third, it could realise fine-grained tracking and tracing and is flexible to adapt in many other areas.

In addition, this paper has both theoretical and managerial implications. This article contributes to the literature on MSEs and food supply chain management by proposing a theoretical framework to address the dry fish product traceability issues. This novel framework fills the research gaps by designing a QR code-based dry fish traceability system, which supports cost-effective and secure product information sharing. From MSE owners' perspective, this study illustrates the need to implement traceability practices to minimise challenges such as product contamination, high cost of traceability system implementation, and decreasing consumer confidence in dry fish products.

The proposed research has a few limitations. The developed traceability system is validated in Ernakulam, one of the marine districts of Kerala-India, which may restrict the generalisation of results. Also, the proposed traceability framework is based only on the context of MSE sectors. Notwithstanding its limitation, this study delivers a starting point for several future research streams. Future research can expand into developing a traceability system for large-scale industries using other platforms such as RFID or blockchain technology. In addition, an adequate warning system can be developed to prevent the occurrence of food incidents.

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