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Wave Sense: Smart Marine Boat Tracking and Fishing Assistance System using IoT and AI

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Abstract - Wave Sense is a smart marine monitoring system that makes small fishing boats safer and more efficient in their operations. The main goal of the system is to track boats in real time using Global Positioning System (GPS) technology, Internet of Things (IoT) sensors, and cloud-based monitoring infrastructure. The proposed system uses sensors on board that are connected to an ESP32 microcontroller to collect environmental data like water temperature, turbidity, pH level, and atmospheric pressure. A web-based dashboard lets you see and monitor these parameters in real time, along with GPS coordinates.

The system not only tracks boats, but it also uses a lightweight machine learning model to help fishermen by guessing where fish might be based on sonar data and environmental features. The system also sends out alerts when it sees bad weather or other unsafe conditions, which makes the seas safer. Combining IoT, cloud computing, and AI makes it possible to monitor the ocean in real time and help with fishing in a way that is both cheap and easy to grow.

Keywords
Wave Sense, Boat Tracking, IoT, GPS Monitoring, Smart Fishing System, Marine Safety, Environmental Monitoring, Machine Learning

INTRODUCTION

Coastal communities depend on marine fishing for their livelihoods. Many small-scale fishermen still use old-fashioned ways of finding their way around because they don't have access to reliable tracking systems. Without monitoring systems, there are big risks when the weather is bad, when machines break down, or when there is an emergency.

Fishermen in many coastal areas go far out to sea without any real-time monitoring or communication systems. Without accurate location information, rescue operations become harder in emergencies.

Recent improvements in Internet of Things (IoT) technologies have made it possible to make smart monitoring systems that can gather data about the environment and send it to cloud platforms. It is possible to make a real-time marine monitoring system that makes things safer and more efficient by using IoT sensors, GPS tracking, and cloud dashboards together.

Wave Sense aims to solve these problems by offering a low-cost, all-in-one solution that includes real-time boat tracking, environmental monitoring, and AI-assisted fish detection.

PROBLEM STATEMENT

Small-scale fishermen face several challenges while working at sea. One of the biggest problems is the absence of real-time monitoring systems for fishing boats.

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If a vessel moves far from the shore, it becomes difficult for family members or authorities to track its location. In emergency situations, this lack of information can delay rescue operations.

Weather conditions in the sea can also change quickly. Sudden pressure drops or strong winds can create dangerous situations for small boats.

Another issue is the time and fuel wasted while searching for fish. Fishermen often depend only on experience and intuition when deciding where to fish.

These problems highlight the need for a system that can track boats continuously, monitor environmental conditions, and provide basic assistance during fishing activities. Among these features, real-time boat tracking is the most critical requirement.

Literature Survey

Several research works have explored the use of IoT technologies for environmental monitoring. Sensor networks are often used to collect ocean data such as temperature, salinity, and water quality.

GPS-based tracking systems are widely used in transportation and fleet management. These systems allow vehicles to be monitored remotely and can provide location updates at regular intervals.

In marine research, machine learning models have also been used to analyze environmental data and sonar signals. Some studies attempt to predict fish habitats based on temperature patterns or underwater activity.

However, many of these systems are designed for large commercial operations and involve expensive equipment. Such systems are not always practical for small fishing communities.

Wave Sense attempts to bridge this gap by combining GPS tracking, IoT sensors, and a lightweight machine learning model in a system that is affordable and easy to deploy.

PROPOSED SYSTEM

The Wave Sense system focuses mainly on real-time boat tracking while also collecting useful environmental information from the surrounding marine environment.

The system uses several sensors to measure parameters such as water temperature, turbidity, pH level, and atmospheric pressure. These values help provide an idea about the current environmental conditions in the sea.

A GPS module continuously records the location of the fishing boat. The latitude and longitude coordinates are updated at regular intervals.

All the sensors and the GPS module are connected to the ESP32 microcontroller. The ESP32 collects the data and sends it to a cloud database through wireless communication.

The information can then be viewed through a monitoring dashboard where the movement of the boat and environmental readings are displayed.

METHODOLOGY

The working process of the system can be explained in four main stages.

First comes data collection. Environmental sensors measure parameters such as temperature, turbidity, pH level, and atmospheric pressure. At the same time, the GPS module records the boat’s location.

Next, the ESP32 microcontroller gathers all the sensor readings. The data is processed and prepared for transmission.

In the third stage, the information is sent to the cloud server where it is stored in a database.

Finally, the monitoring dashboard retrieves the stored data and displays it to the user. The dashboard shows the live location of the boat along with environmental information. Alerts can also be generated if abnormal conditions are detected.

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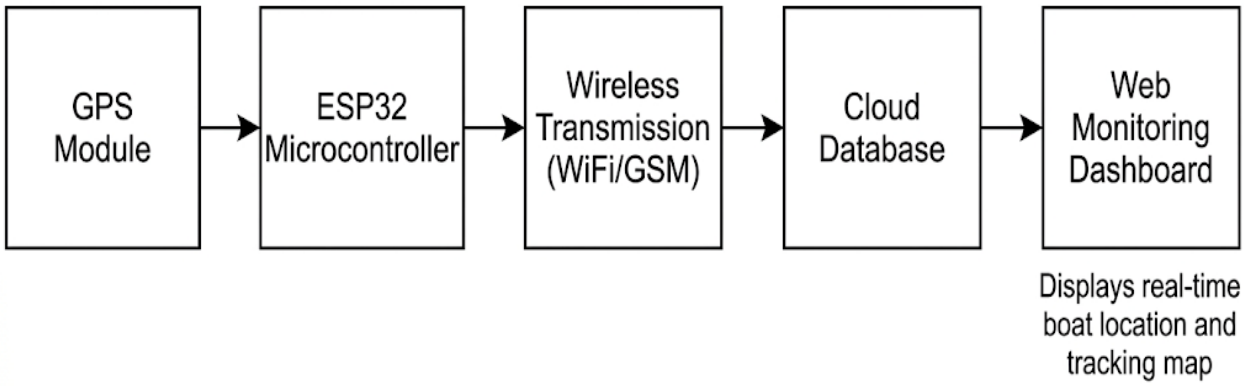


SYSTEM ARCHITECTURE

The Wave Sense system is organized into different layers that work together to provide monitoring and tracking.

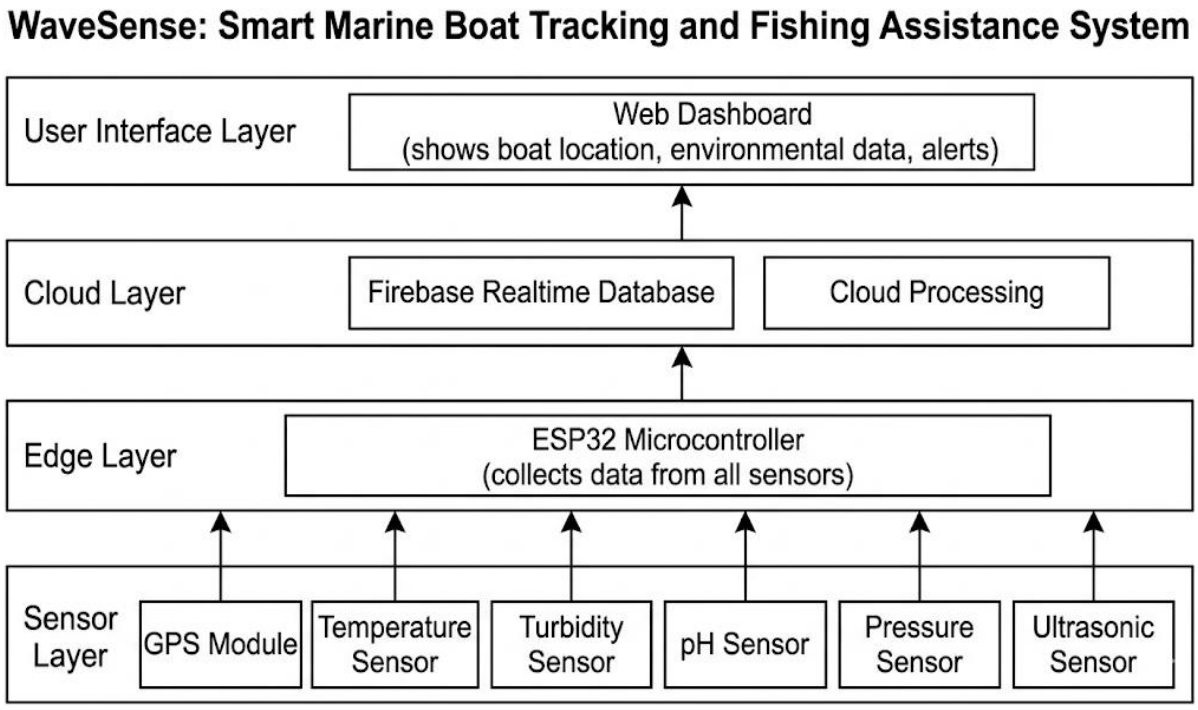
The first layer is the sensor layer. This includes environmental sensors and the GPS module.

The second layer is the edge processing layer. The ESP32 microcontroller operates in this layer and handles the communication between sensors and the cloud server.

The third layer is the cloud layer where all the collected data is stored. In this project, Firebase Realtime Database is used.

The final layer is the user interface layer. This consists of the web dashboard that allows users to view the boat location and environmental readings.

The overall structure of the proposed Wave Sense system is illustrated in Fig. 1. The architecture shows how the sensor layer, processing unit, cloud database, and monitoring dashboard interact to provide real-time boat tracking and environmental monitoring.



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IMPLEMENTATION

The hardware prototype of Wave Sense was built using commonly available electronic components.

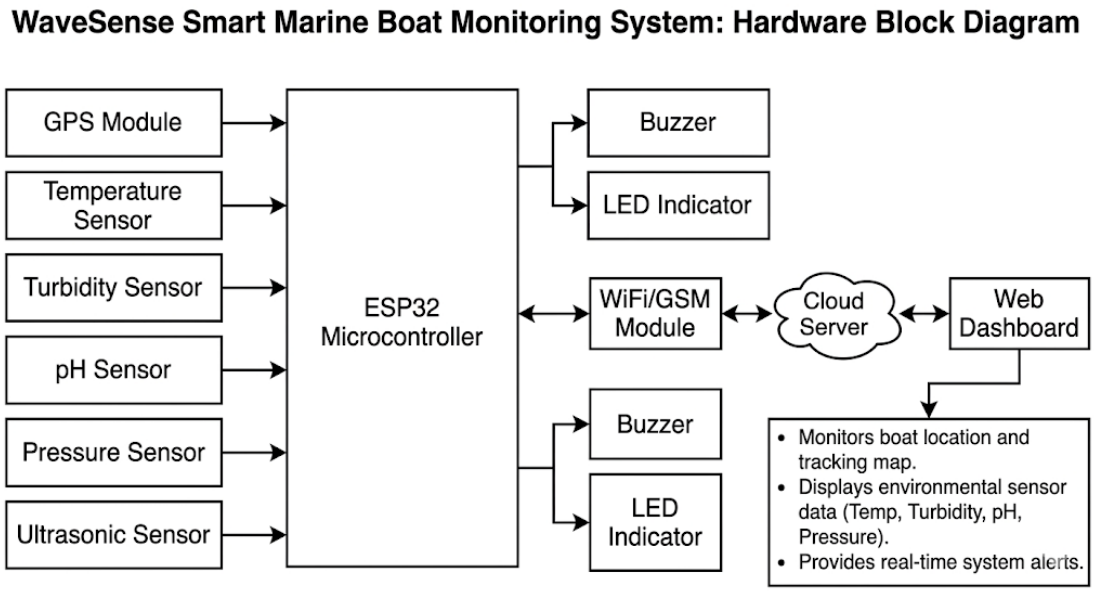
The ESP32 microcontroller acts as the central controller of the system. It connects to all sensors and manages the data collection process.

A NEO-6M GPS module is used to obtain the boat's location. Environmental parameters are measured using sensors for temperature, turbidity, pH level, and atmospheric pressure.

An ultrasonic sensor is used to detect underwater movement patterns. These readings are later used by the machine learning model to estimate fish presence.

All collected data is transmitted to the Firebase Realtime Database. The dashboard retrieves the information and displays it in real time.

The hardware components used in the Wave Sense system are represented in Fig. 3. The diagram illustrates the connection between the ESP32 microcontroller, environmental sensors, GPS module, and the cloud communication interface



The software and machine learning workflow used in the Wave Sense system is illustrated in Fig. 4. The process begins with sensor data acquisition from GPS, sonar, and environmental sensors. The collected data is transmitted to the cloud database where preprocessing and feature extraction are performed. The processed dataset is then used to train machine learning models such as Random Forest and Logistic Regression to predict possible fish presence. After model evaluation, the trained model is integrated into the system to generate predictions which are displayed on the monitoring dashboard.

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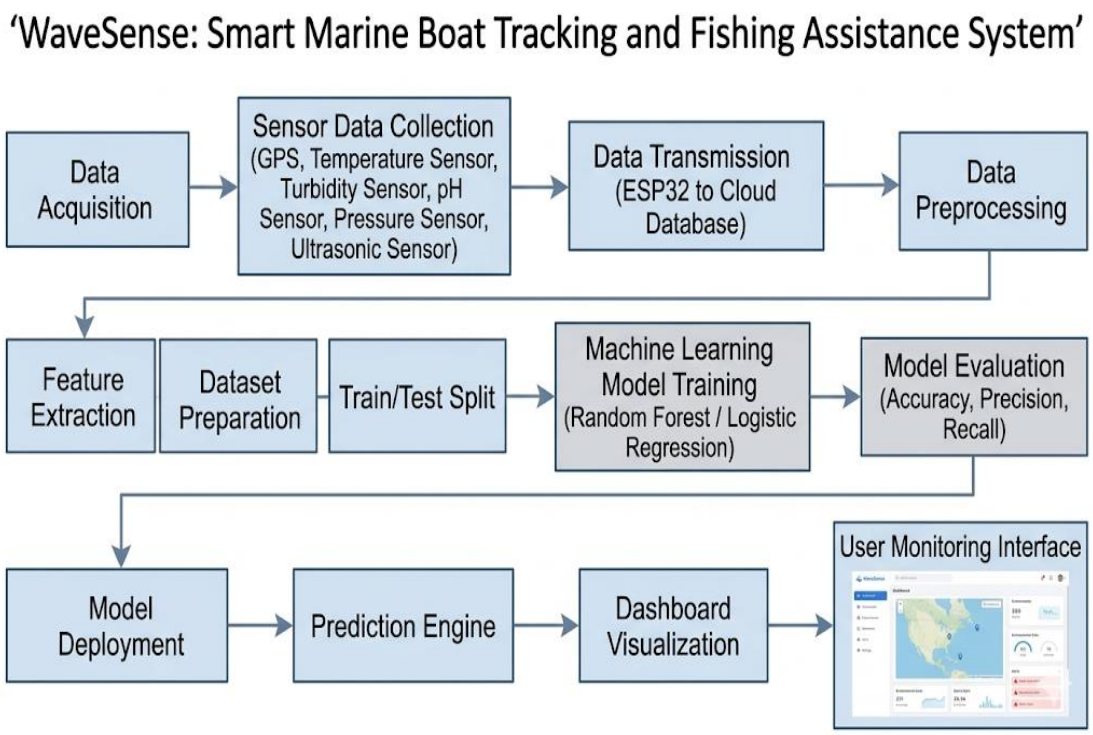

RESULTS AND DISCUSSION

The Wave Sense system was tested in a controlled environment to observe how well it performs.

The GPS tracking module was able to update the location of the boat every five to ten seconds. The accuracy of the coordinates was suitable for coastal monitoring.

Environmental sensors successfully collected real-time readings. When pressure changes were simulated, the system was able to trigger warning alerts.

The machine learning model used for fish detection achieved an accuracy of around 80 to 85 percent. While this is not perfect, it is sufficient for providing basic guidance to fishermen.

Overall, the most reliable part of the system was the boat tracking module. It consistently provided accurate location updates.

FUTURE SCOPE

The current version of Wave Sense can be improved in several ways.

One improvement would be the addition of GSM or satellite communication so that tracking continues even in areas where Wi-Fi is not available.

Another possibility is creating a fleet monitoring system that allows several fishing boats to be tracked at the same time.

The fish detection model could also be improved by using larger datasets and more advanced deep learning algorithms.

A mobile application could also make the system easier for fishermen to use while at sea

CONCLUSION

Wave Sense presents a practical system for monitoring fishing boats and improving safety at sea. The system combines GPS tracking, IoT sensors, and cloud-based monitoring to provide real-time information about boat location and environmental conditions.

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The main goal of the system is reliable boat tracking. Environmental monitoring and fish detection are additional features that support fishing operations.

Because the system uses affordable components such as the ESP32 microcontroller and common sensors, it can be implemented at relatively low cost.

This approach demonstrates that modern technologies like IoT and cloud computing can be used to create useful tools for small fishing communities.

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