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Smart Maritime Border Control System with Real-Time Environmental Monitoring

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Abstract: The Fishermen Maritime Border Control System was created as a safety and security measure to improve situational awareness at sea and stop illegal border crossings. To track the position of the vessel and the weather in real time, the system combines environmental sensors, motor control, alarm modules, and radio frequency transmission. To make sure fishing vessels stay inside approved fishing zones, their location is monitored using an RF transmitter–receiver combination. The motor is automatically turned off when a vessel breaches the predetermined border, and an LCD warning and buzzer give prompt alerts so that remedial action can be taken. Simultaneously, the device measures variables like temperature and humidity to conduct ongoing weather monitoring. In order to warn fishermen of possible dangers, alerts are produced if crucial thresholds are surpassed. The suggested approach reduces the possibility of illegal marine entrance, increases adherence to fishing laws, and protects fishermen from unfavorable sea conditions by fusing automated border enforcement with environmental monitoring.

Keywords: Maritime Control. RF transmitter, RF Receiver, Environmental Monitoring, Border Control

I. INTRODUCTION

For coastal communities, fishing is a vital source of income, providing millions of people with jobs and food security. However, there are constant hazards for fisherman, like inadvertent border crossings and abrupt environmental shifts. Unpredictable weather phenomena like storms and heavy waves pose a threat to life and property, and entering prohibited waters can result in penalties, arrest, or equipment loss. Anticipating or efficiently addressing these difficulties is challenging due to the traditional reliance on manual navigation and little technical support. This study suggests a Smart Maritime Border Control System with Real-Time Environmental Monitoring as a solution to these problems. The technology defines virtual marine boundaries and alerts fishermen when they approach restricted areas using RF communication and GPS-based geofencing. Automatic motor control and alarm systems step in to stop additional movement and notify the crew in the event of a violation. Environmental sensors simultaneously monitor variables including temperature, humidity, and wind speed, giving prompt updates on potentially dangerous situations.

An intuitive user interface provides real-time warnings, guaranteeing accessibility even in challenging circumstances. The suggested method improves marine safety, guarantees regulatory compliance, and facilitates better decision-making at sea by combining automated border enforcement with proactive weather monitoring.

II. LITERATURE REVIEW

To protect fishermen and guarantee regulatory compliance, current research on border control and maritime safety places a strong emphasis on combining cutting-edge tracking, communication, and monitoring technologies. A cost-effective security solution was developed by Kumar et al. [1] using a GPS and GSM-based marine boundary alert system that offers automatic alerts and real-time tracking to stop inadvertent border infractions. In order to reduce weatherrelated hazards at sea, Gunathilaka et al. [2] created an Internet of Things (IoT)-based weather monitoring system that uses a variety of sensors and cloud-based storage to provide timely environmental updates. In order to improve maritime security, Rajasekaran et al. [3] suggested an RFID-and GPS-integrated navigation system that verifies vessel movements and sends out notifications close to prohibited waters. Rahman et al. [4] presented a smart buoy system that combines weather monitoring and border surveillance, acting as a situational awareness tool and early warning system. The implementation of an automatic border warning system using wireless sensor networks was investigated by Prasad and Kumar [5], who emphasized the effectiveness of this technology in terms of real-time tracking, communication, and reducing legal disputes. When taken as a whole, these studies show how location tracking, sensor integration, and wireless communication technologies can be used to lower the dangers of border infractions and erratic weather, which would ultimately increase fishing efficiency and maritime safety.

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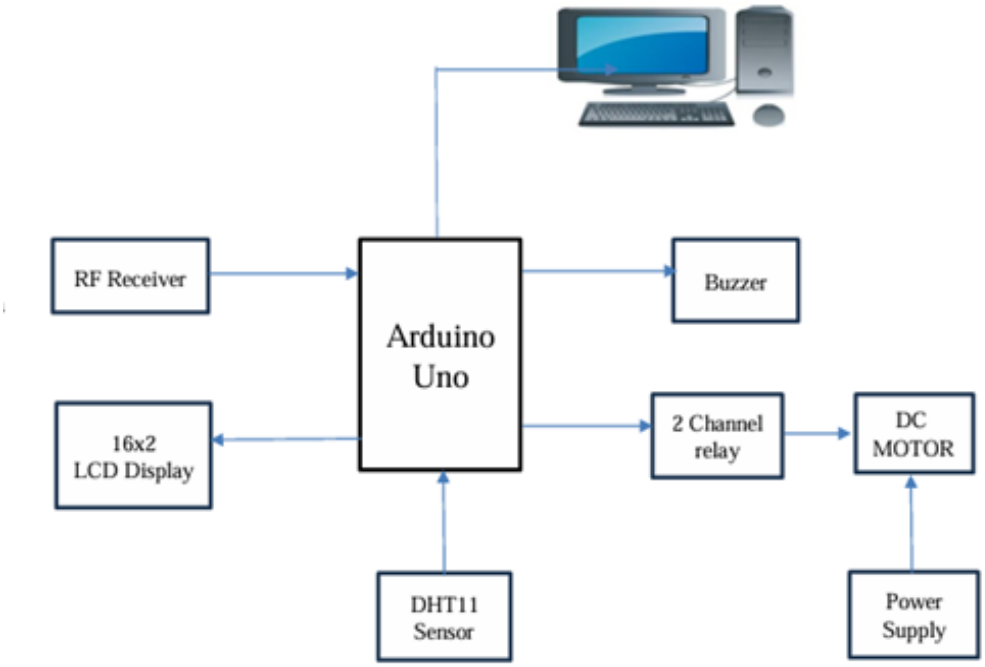
III. WORKING OF PROPOSED SYSTEM

A)Transmitter Side

Figure 1. Block diagram of the transmitter section



B)Receiver side

Figure 2. Block diagram of the Receiver section

Figures 1 and 2 show the transmitter and receiver system's operational schematics. To guarantee maritime safety, legal compliance, and effective fishing operations, this system combines RF communication, motor control, alarm systems, and environmental sensors. Real-time alerts for border violations or dangerous weather are provided by the system, which continuously tracks the location of vessels and environmental conditions. It serves as a dependable safety net that reduces hazards from unlawful crossings and erratic maritime settings by merging these technologies. An RF transmitter placed near the beach or maritime boundary and an RF receiver mounted aboard the boat make up the system's fundamental components. The receiver keeps signal contact with the transmitter as long as the boat stays inside the allowed area, ensuring safe operation. The RF link is cut off if the vessel leaves the designated range, indicating a boundary breach and prompting an emergency response. In certain situations, the motor is automatically turned off by the system to stop further movement into unapproved waters. To guarantee that fishermen receive both visual and auditory signals, a warning is shown on the LCD screen and an integrated buzzer sounds simultaneously. By enabling prompt remedial action, our multilayered alarm system lowers the possibility of legal repercussions and enhances navigation safety.

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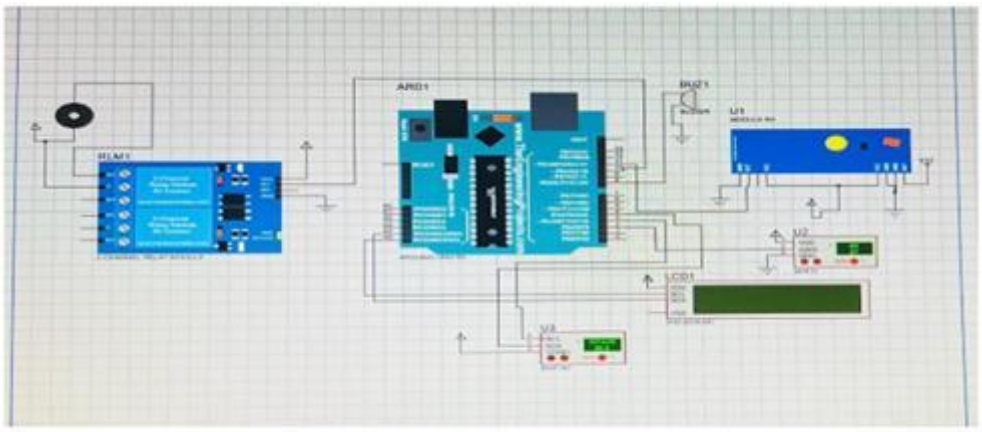

Fig 3. Circuit diagram simulation of the proposed system

The system uses environmental sensors that continuously measure temperature and humidity in addition to border enforcement. Alerts are sent to notify fisherman of unfavorable weather conditions if readings above predetermined safety criteria. This makes it possible to make preventative decisions like delaying activities, finding refuge, or altering routes. A completely automated, real-time safety solution is provided by the system's integration of RF-based geofencing with ongoing environmental monitoring.

IV. RESULTS AND DISCUSSION

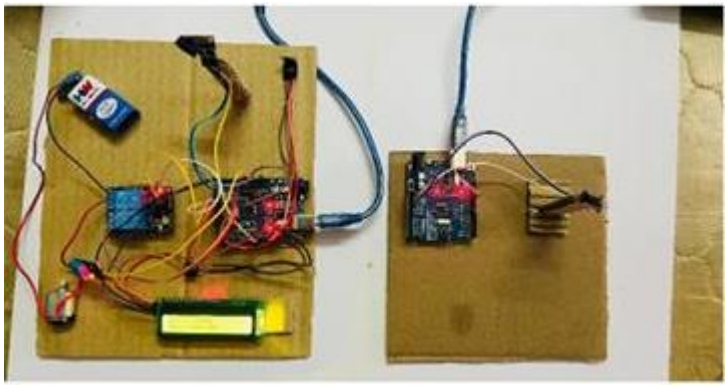

Fig 4 shows the prototype of the developed system.

It makes use of an RF Transmitter 433 MHz, a wireless communication module that operates in the radio frequency band at a frequency of 433 megahertz. For precise environmental readings, it has a thermistor and a capacitive humidity sensor. A cheap digital sensor for determining humidity and temperature is the DHT11 sensor which is used here for the environment monitoring. The sensor is simple to connect with microcontrollers such as Arduino because it runs on 3.3V to 5V DC and uses a single-wire digital signal for communication. A well-known microcontroller board built on the ATmega328P chip is the Arduino UNO. It runs at 5V and has 6 analog inputs and 14 digital I/O pins. A wireless module called the RF Receiver 433 MHz is made to pick up radio frequency signals at 433 MHz. These signals are frequently utilized in home automation, remote control systems, and Internet of Things applications. It decodes signals sent by a 433 MHz radio frequency transmitter using either frequency shift keying (FSK) or amplitude shift keying (ASK) modulation.

Based on the piezoelectric phenomenon, a compact piezoelectric buzzer is employed as a portable sound generator to produce audio signals, serving as the system's alert mechanism. When an electrical voltage is supplied, the piezoelectric material inside vibrates, producing sound waves. Low-power microcontrollers, such as the Arduino, can handle high-voltage or high-current loads thanks to an electrical switching device known as a 5V dual-channel relay module. It can control a wide range of devices, such as lights, fans, motors, and home appliances, thanks to its two independent relays. A tiny DC motor operates on a low voltage, often between 8 and 12 volts DC is used here in this study. Applications including wireless data transfer, home automation, remote controls, and Internet of Things devices all make extensive

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use of it. By precisely tracking the vessel's location, the device makes sure fishermen stay within approved fishing areas. The three cases that are being investigated are explained in the section that follows.

Case 1: A "HI" message is sent from the land-based transmitter to the boat-based receiver when they are within range of one another. "Safe Zone, Weather OK" is displayed on the LCD display (see Figures 5a and 5b). The system's control unit is an Arduino microcontroller. Figure 5(b) shows the output of the COM display.

Figure 5. (a) Output displayed on the LCD for Case 1; (b) Screenshot of the corresponding output on the COM por

Case 2: The system provides an instant response to stop illegal border crossings by immediately turning off the motor, sounding a buzzer, and displaying a warning message on an LCD screen if the boat leaves its range.The "Range Exceeded" message will appear on the screen when the transmitter and receiver are unable to communicate (Figure 6a. And 6b.).

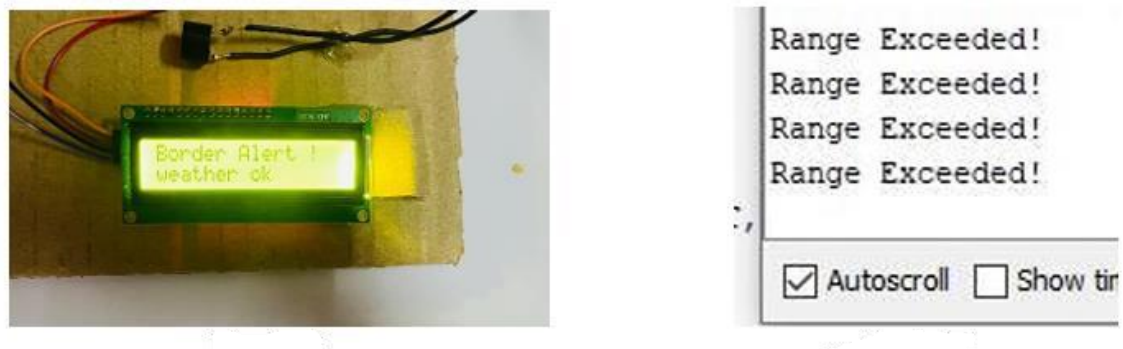

Figure 6 a) and b) illustrates the message generated under unsafe condition on LCD and COM Port

Case 3: In order to enable fisherman to take preventative action against dangerous weather, the temperature and humidity sensors also continuously monitor the surrounding environment, sending out alarms when values are above safety standards. The buzzer sounds and the words "WARNING: DANGER" appear when the environmental conditions surpass the safety standards. Unsafe Weather" will be displayed on the LCD Display. Weather alert is also showed on the display. (Fig 7a and 7b)

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Figure 7 a) and 7 b) illustrates the message displayed under unsafe conditions.

Additionally, this technology can be used by maritime authorities and coast guards for surveillance, enforcement of regulations, and marine resource protection. Additionally, it helps with navigation by making sure that fishermen plan their itineraries using real-time environmental data and stay within safe fishing zones.

V. CONCLUSION

Unpredictable maritime circumstances and inadvertent border transgressions can be effectively addressed with the Fishermen Border Control and Weather Monitoring System. Incorporating automated notifications, environmental sensing, and real-time monitoring not only protects fishermen from safety and legal hazards but also improves regulatory compliance and encourages sustainable fishing methods. The system ensures that fishing vessels remain within designated zones by continuously monitoring their location using an RF transmitter–receiver setup. When a vessel crosses the predefined boundary, the motor is automatically deactivated, and real-time alerts are provided through an LCD display and buzzer, enabling immediate corrective action. In addition to helping authorities and coast guards safeguard marine resources, its capacity to deliver real-time notifications guarantees prompt decision-making, lowering accidents and increasing efficiency. This system is a vital tool for upgrading fishing operations and bolstering maritime safety standards because it is affordable, dependable, and easy to use.

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