International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 10 Issue: 10 | Oct - 2026 SJIF Rating: 8.659 ISSN: 2582-3930

Smart Multi Sensor Marine Security & Surveillance System.

1. Gujar Mousami P., 2. Gore Shruti S., 3. Jadhav Madhura S., 4. Kalange Akanksha D.
Assistant Professor , Student Member , Student Member , Student Member of
DR.ASHOK GUJAR TECHNICAL INSTITUTE'S
DR. DAULATRAO AHER COLLEGE OF ENGINEERING, KARAD
Department Of Electronics & Telecommunication Engineering Shivaji University,Kolhapur

---

ABSTRACT

Maritime security and surveillance require continuous monitoring of large and dynamic marine environments, where conventional methods can be costly, time-consuming, and dependent on manual observation. This paper proposes a **Smart Multi Sensor Marine Security and Surveillance System** that integrates a camera module, GPS, Inertial Measurement Unit (IMU), distance sensor, environmental sensor, and water-level sensor with an ESP32-based microcontroller for real-time data collection and processing. The system uses Wi-Fi and 4G/LTE communication to transmit sensor data, location information, video, and alerts to a centralized monitoring platform. AI/ML-based object detection is incorporated to identify and classify potentially suspicious objects, while sensor fusion improves overall situational awareness. A centralized dashboard provides real-time information regarding sensor parameters, object detection, location, threat status, and alerts, while historical data can be stored for further analysis. The proposed prototype also includes simulated response mechanisms such as a buzzer, LED indicators, servo motor, and searchlight for demonstration purposes. The system can be applied to coastal surveillance, harbour security, restricted-area monitoring, and marine infrastructure protection, providing a cost-effective and scalable approach to intelligent marine surveillance through the integration of embedded systems, IoT, sensor fusion, AI/ML, and real-time monitoring.

Key Words: Marine Security, Surveillance System, IoT, Multi-Sensor Fusion, ESP32, AI/ML, Object Detection, Computer Vision, USV, Real-Time Monitoring.

INTRODUCTION

Maritime environments are important for transportation, trade, fishing, defence, tourism, and critical infrastructure, creating a need for reliable and continuous surveillance in coastal and harbour regions. Conventional marine surveillance systems generally rely on cameras, radar, human operators, or individually deployed sensing systems, which can make continuous monitoring of large marine areas costly and challenging, particularly under changing environmental conditions. Recent developments in the **Internet of Things (IoT)** have enabled distributed sensors, communication networks, embedded processors, and monitoring platforms to work together for marine sensing, data processing, wireless communication, and remote monitoring. Similarly, computer vision and deep-learning techniques have improved automated marine object detection, with approaches such as YOLO being widely explored for maritime surveillance and object detection. However, camera-based surveillance can be affected by poor visibility, waves, weather conditions, distance, occlusion, and changes in illumination, making multi-sensor integration important for improving situational awareness. The proposed **Smart Multi Sensor Marine Security & Surveillance System** addresses these challenges by integrating a camera, GPS, IMU, distance sensor, environmental sensor, and water-level sensor with an ESP32-based central microcontroller, along with wireless communication, AI/ML-based object detection, sensor fusion, and a centralized monitoring dashboard. The proposed system is designed as a boat/Unmanned Surface Vehicle (USV)-mounted prototype for continuously collecting and transmitting sensor information to a monitoring station. It focuses on monitoring, object detection, alert generation, and simulated response mechanisms rather than autonomous weapon operation, making it suitable as an academic prototype for demonstrating the integration of embedded systems, IoT, AI/ML, sensor fusion, and real-time data visualization.

BASIC IDEA OF PROJECT

The need for the proposed intelligent marine surveillance system arises from the challenges of monitoring large marine areas continuously and efficiently. The major requirements are:

2.1 Continuous Marine Monitoring

- Marine areas are large and difficult to monitor continuously through manual observation.
- An automated system can continuously collect information about the marine environment and nearby objects.
- This helps improve monitoring efficiency and reduce dependence on continuous human observation.

2.2 Reduction in Manual Monitoring

- Manual surveillance can be time-consuming and may lead to delays in identifying suspicious objects or activities.
- Automated data collection and alert generation can assist monitoring personnel in taking timely action.

2.3 Multi-Sensor Monitoring

- Different sensors provide different types of information about the surroundings.
- The proposed system integrates a **camera, GPS, IMU, distance sensor, environmental sensor, and water-level sensor**.
- Combining these sensor inputs provides better overall situational awareness compared with using a single sensor.

2.4 AI-Based Object Detection

- Identifying marine objects manually from continuous camera footage can be difficult.
- AI/ML-based object detection can help detect and classify potentially suspicious objects.
- This can support faster identification and monitoring of objects in the marine environment.

2.5 Real-Time Communication

- A marine surveillance system requires reliable transmission of collected information to a monitoring station.
- The proposed system uses **Wi-Fi and 4G/LTE communication** to transmit sensor data, video, location information, and alerts.
- This enables remote and real-time monitoring.

2.6 Early Threat Detection

- Early identification of potentially suspicious objects or activities can improve response time.
- The proposed system combines sensor information, object detection, threat analysis, and alerts to support early detection.

2.7 Cost-Effective Development

- Conventional marine surveillance systems can require expensive infrastructure and equipment.
- The proposed prototype uses commercially available components such as **ESP32, sensors, camera, GPS, communication module, and actuators**.
- The estimated project cost is approximately **₹10,000–₹12,500**, making it suitable for academic prototype development. Synopsis final

2.8 Centralized Monitoring

- A centralized dashboard can display **live sensor values, location, video, object tracking, threat status, and alerts** in one interface.
- This reduces the need to monitor multiple independent systems and improves overall situational awareness

LITERATURE REVIEW

3.1 IoT-Based Marine Monitoring

- IoT enables the integration of **sensors, microcontrollers, wireless communication, and remote monitoring** for marine applications.
- It supports continuous collection and transmission of marine data.
- Challenges include **water resistance, energy consumption, hardware reliability, and communication issues**.
- The proposed system extends IoT-based monitoring toward **marine security and surveillance**. Synopsis final

3.2 Deep Learning-Based Marine Object Detection

- Deep learning techniques are increasingly used for **marine object and vessel detection**.
- YOLO-based methods provide fast and effective object detection.
- Detection performance can be affected by **object size, environmental conditions, and available datasets**.
- The proposed system uses AI/ML-based detection to identify potentially suspicious marine objects.

3.3 Computer Vision for Maritime Surveillance

- Camera-based computer vision enables **real-time object detection and tracking**.
- It can assist in identifying vessels and other objects in marine environments.
- Performance may decrease under **poor visibility, haze, waves, occlusion, and low-light conditions**.
- Therefore, the proposed system combines camera data with other sensors for improved monitoring.

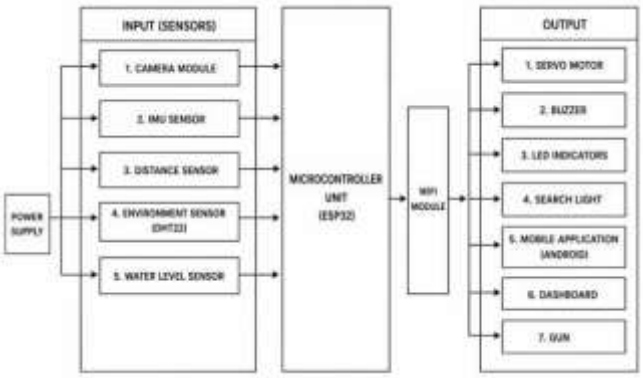
3.4 Multi-Sensor Fusion

- Multi-sensor fusion combines information from different sensors to improve **situational awareness and detection reliability**.
- Maritime applications can benefit from combining navigation, environmental, and surveillance data.
- The proposed system integrates **camera, GPS, IMU, distance, environmental, and water-level sensors** using an ESP32-based controller. Synopsis final

3.5 Wireless Communication in Marine Applications

- Wireless communication enables **remote transmission of sensor data, video, location, and alerts**.
- Wi-Fi and cellular technologies can support real-time marine monitoring.
- Communication can be affected by **distance, environmental conditions, and power limitations**.
- The proposed system uses **Wi-Fi and 4G/LTE** for communication between the marine prototype and monitoring platform.

BLOCK DIAGRAM



BLOCK DIAGRAM DESCRIPTION

The proposed system consists of the following major blocks:

1. Sensors

Camera, GPS, IMU, distance sensor, environmental sensor, and water-level sensor collect real-time marine and environmental data.

2. ESP32 Microcontroller

ESP32 acts as the **central processing unit**.

It receives data from all connected sensors, processes the information, and coordinates system operations.

3. AI/ML Object Detection

Camera data is analyzed using AI/ML techniques.

Potentially suspicious objects are detected and classified.

4. Sensor Data Processing & Fusion
Data from multiple sensors is combined to obtain better information about the surroundings.This improves overall situational awareness.

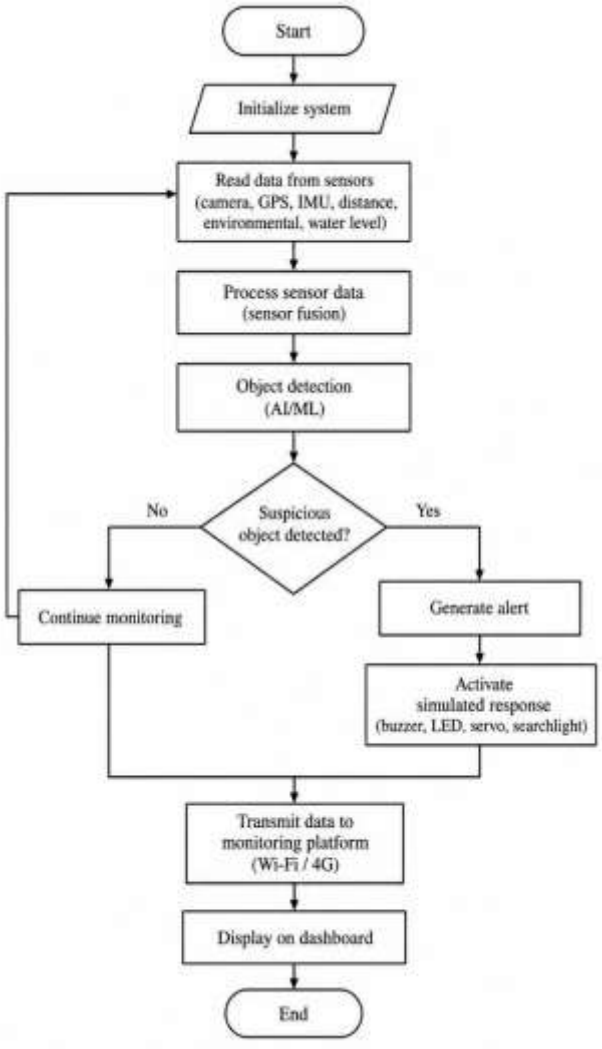
5. Communication Module
Wi-Fi and 4G/LTE are used to transmit sensor data, location, video, and alerts to the monitoring station.

6. Centralized Monitoring Dashboard
Displays live sensor values, GPS location, video, detected objects, threat status, and alerts. Data can also be stored for historical analysis.

7. Alert & Simulated Response
Based on detected conditions, the system activates buzzer, LEDs, servo motor, and searchlight as simulated response mechanisms.

8. Boat/USV Platform
The complete system is mounted on a boat/Unmanned Surface Vehicle (USV) for continuous marine surveillance.

FLOWCHART



CONCLUSIONS

The proposed Smart Multi Sensor Marine Security & Surveillance System provides an integrated approach to intelligent marine monitoring by combining embedded systems, IoT communication, multi-sensor data acquisition, computer vision, and AI/ML-based object detection. The ESP32-based system collects and processes information from the camera, GPS, IMU, distance, environmental, and water-level sensors, while Wi-Fi and 4G/LTE enable real-time transmission of sensor data, location, video, and alerts to a centralized dashboard. The integration of multiple sensors and AI-based object detection can improve situational awareness and assist in identifying potentially suspicious marine objects. The proposed system also provides simulated response mechanisms using a buzzer, LED indicators, servo motor, and searchlight for demonstration purposes. Overall, the system demonstrates the potential of integrating IoT, sensor fusion, AI/ML, embedded systems, and real-time communication for marine security and surveillance. Future development can focus on extensive real-world testing, improved AI models, reliable communication under marine conditions, optimized power consumption, larger marine datasets, and advanced sensor-fusion techniques.

REFERENCES

[1]G. Xu, Y. Shi, X. Sun, and W. Shen, “Internet of Things in Marine Environment Monitoring: A Review,” Sensors, vol. 19, no. 7, p. 1711, 2019. doi: 10.3390/s19071711. MDPI

[2] W. Zhang et al., “Survey on Deep Learning-Based Marine Object Detection,” Journal of Advanced Transportation, vol. 2021, Article ID 5808206, 2021doi: 10.1155/2021/5808206. Wiley Online Library

[3] G. Potamos, E. Stavrou, and S. Stavrou, “Enhancing Maritime Cybersecurity through Operational Technology Sensor Data Fusion: A Comprehensive Survey and Analysis,” Sensors, vol. 24, no. 11, p. 3458, 2024. doi: 10.3390/s24113458. MDPI

[4] “Ship Detection of Unmanned Surface Vehicle Based on YOLOv8,” 2024 IEEE 13th Global Conference on Consumer Electronics (GCCE), 2024.doi: 10.1109/GCCE62371.2024.10760724. DOI

[5] “YOLOv8 Neural Network Application for Noncollaborative Vessel Detection Using Sentinel-1 SAR Data: A Case Study,” IEEE Geoscience and Remote Sensing Letters, vol. 22, 2024. doi: 10.1109/LGRS.2024.3508462. IEEE Xplore

[6] “Vessel Detection Leveraging Satellite Imagery and YOLO in Maritime Surveillance,” Remote Sensing Applications: Society and Environment, vol. 40, Article 101730, 2025. doi: 10.1016/j.rsase.2025.101730. ScienceDirect

[7] J. Mu et al., “M2S-YOLOv8: Multi-Scale and Asymmetry-Aware Ship Detection for Marine Environments,” Sensors, vol. 26, no. 2, p. 502, 2026. doi: 10.3390/s26020502.