

IOT and RF Controlled Smart Rescue Boat with Live Camera Feed and GPS Tracking

¹Mr. Mohit S. Dhembre, ²Mr. Pranav G. Harishchandre, ³Mr. Ashish V. Jagtap, ⁴Mr. Ketan A. Shingvi,

⁵Prof. P. R. Gaikwad

^{1,2,3,4} BE Student, Department of Electronics and Telecommunications Engineering Amrutvahini College of Engineering Sangamner, A.nagar, Maharashtra, India

⁵ Assistant Professor, Department of Electronics and Telecommunications Engineering Amrutvahini College of Engineering Sangamner, A.nagar, Maharashtra, India

ABSTRACT

Natural disasters such as floods, river overflows, and water accidents create serious challenges for rescue teams and emergency response systems. Conventional rescue boats generally require human operators to enter dangerous water conditions, which increases the risk to rescue personnel and reduces operational efficiency during emergency situations. To overcome these limitations, this paper presents an “IoT and RF Controlled Smart Rescue Boat with Live Camera Feed and GPS Tracking” that provides a safe, compact, and remotely operated rescue solution for water rescue operations. The proposed system combines RF-based navigation with IoT-enabled monitoring to achieve reliable communication and real-time rescue assistance. The boat is controlled using an ATmega328 microcontroller, which manages the operation of multiple modules including RF transceiver, GPS module, Wi-Fi camera, motor driver, touch sensor, buzzer, LED indicators, and propulsion motors. The RF communication system enables low-latency remote navigation, while the integrated Wi-Fi camera provides live video streaming for situational awareness. In addition, GPS tracking allows real-time location monitoring and coordinate uploading for rescue management. The proposed rescue boat reduces human involvement in hazardous environments, improves rescue efficiency, and provides a cost-effective alternative to traditional rescue systems. Experimental observations indicate that the system performs effectively in water navigation, remote monitoring, and emergency rescue support applications. The proposed design can be further extended with autonomous navigation and obstacle avoidance technologies for future smart disaster management systems.

Keywords: IoT, RF Communication, Smart Rescue Boat, GPS Tracking, Live Video Streaming, ATmega328, Disaster Management, Water Rescue System.

1. INTRODUCTION

Floods, water accidents, and natural disasters have become increasingly common due to climate change, rapid urbanization, and irregular environmental conditions. These disasters often lead to severe human casualties and property damage, especially in riverine and flood-prone regions. During such emergencies, rescue teams face major challenges including strong water currents, poor visibility, communication failures, and limited accessibility to affected areas. Traditional rescue boats are widely used for water rescue operations; however, they require onboard operators who are directly exposed to dangerous environmental conditions. This not only increases the risk to human life but also limits the speed and efficiency of rescue missions. Recent advancements in embedded systems, wireless communication, Internet of Things (IoT), and remote-control technologies have enabled the development of intelligent rescue systems capable of operating in hazardous conditions without risking human operators. IoT technology provides real-time communication, remote monitoring, and data transmission capabilities, while RF communication offers reliable short-range control even in areas where internet connectivity is unavailable. The integration of GPS tracking systems and live video streaming further enhances rescue effectiveness by improving situational awareness and navigation accuracy. These technologies together create an efficient and flexible rescue platform suitable for modern disaster management applications.

The proposed system, “IoT and RF Controlled Smart Rescue Boat with Live Camera Feed and GPS Tracking,” is designed to provide a compact, lightweight, and cost-effective rescue solution for flood and water emergency situations. The system uses an ATmega328 microcontroller as the main control unit to coordinate the operation of various hardware modules including RF transceiver, GPS module, Wi-Fi camera, motor driver, touch sensor, buzzer, LED indicators, and dual propulsion motors. The RF module allows wireless navigation control from a remote station, while the integrated camera provides real-time live video streaming to the operator for improved monitoring of rescue environments. Additionally, the GPS module continuously updates the location coordinates of the boat, enabling accurate tracking during rescue missions. The proposed rescue boat also includes emergency alert features such as LED indicators and buzzers to improve visibility and communication during low-light and critical rescue conditions. Touch sensors are integrated to enhance operational safety and victim interaction. Compared to conventional rescue systems, the proposed design offers reduced operational cost, improved portability, enhanced safety, and better rescue efficiency. The hybrid integration of RF and IoT technologies ensures reliable operation in both connected and disconnected communication environments, making the system highly suitable for disaster-prone regions and emergency water rescue applications.

Table 1: Major Technologies Used in Proposed Rescue Boat

Technology	Purpose in System
RF Communication	Remote navigation and control
IoT Module	Real-time monitoring and connectivity
GPS Module	Live location tracking
Wi-Fi Camera	Video streaming and surveillance
ATmega328	Central system control
Motor Driver	Boat movement control

2. LITERATURE SURVEY

Several researchers and developers have proposed intelligent rescue systems, unmanned water vehicles, and IoT-enabled monitoring platforms to improve disaster response and water rescue operations. Existing systems mainly focus on remote-controlled navigation, GPS-based tracking, live surveillance, and autonomous rescue mechanisms. Some research works have introduced RF-controlled rescue boats for short-range operations, while others have utilized IoT technologies for cloud-based monitoring and communication. Similarly, camera-assisted surveillance systems and GPS-enabled tracking platforms have been implemented to improve rescue accuracy and operational safety. Although these technologies contribute significantly toward modern rescue applications, many existing systems still face limitations related to communication reliability, high implementation cost, limited operational range, and lack of integrated safety mechanisms. Therefore, there is a need for a low-cost, compact, and hybrid rescue system that combines the advantages of IoT, RF communication, GPS tracking, and live monitoring within a single platform for efficient disaster management applications.

Table 2: Comparative Analysis of Existing Rescue Systems

Sr. No.	Author & Year	Proposed System / Method	Advantages	Limitations
1	N. Hossain et al., 2020	Amphibious Robot for Flood Rescue Surveillance	Improved flood monitoring and rescue support	High system complexity and implementation cost
2	B. L. A. C. Llanes et al., 2023	Remote Controlled Water Vehicle with Human Detection	GPS tracking and rescue assistance	Limited communication range

3	Yunwei i Shu et al., 2020	Disaster Rescue Robot	Enhanced rescue automation	Expensive hardware components
4	Raksha na Mohamed Ismail et al., 2020	Military Support and Rescue Robot	Remote rescue operation capability	Limited real-time monitoring features
5	S. A. Hussain et al., 2020	Wireless Robotic Rescue System	Wireless control in hazardous areas	Absence of GPS and live camera support
6	Proposed System	IoT and RF Controlled Smart Rescue Boat	Live video feed, GPS tracking, hybrid communication, compact design	Limited battery backup during long operations

Most existing rescue systems focus either on IoT-based monitoring or RF-based manual navigation individually, which limits their flexibility during disaster situations where network conditions are unstable. Some systems provide GPS tracking but lack real-time video monitoring, while others offer surveillance features without reliable communication support in offline conditions. In addition, many advanced rescue robots and unmanned surface vehicles involve expensive hardware and complex architectures, making them difficult to deploy in resource-limited regions. The major research gap identified is the absence of an affordable and integrated rescue platform that combines RF communication, IoT connectivity, live camera feed, GPS tracking, and emergency alert mechanisms within a compact and user-friendly design. The proposed smart rescue boat addresses these limitations by providing a hybrid communication approach, enhanced situational awareness, and improved operational safety suitable for practical disaster rescue applications.

3. PROBLEM STATEMENT

Floods, drowning incidents, and water-related disasters create serious challenges for emergency rescue teams due to unstable environmental conditions and limited accessibility. Conventional rescue boats generally require human operators to navigate directly into dangerous water regions, which increases the possibility of accidents and risks to rescue personnel. In many cases, rescue operations become difficult because of poor visibility, strong water currents, communication failures, and delayed response times. Large rescue boats are also expensive, difficult to transport, and require continuous maintenance, making them unsuitable for rapid deployment during emergency situations. Existing water rescue systems mainly focus on either manual remote control or internet-based monitoring individually, which limits their effectiveness during real disaster conditions. IoT-based systems depend heavily on internet connectivity, which may not always be available during floods and natural calamities. Similarly, RF-controlled systems provide reliable communication but often lack advanced monitoring features such as GPS tracking and live video streaming. Many currently available unmanned rescue systems are costly, complex, and unsuitable for rural or resource-constrained regions where low-cost and portable solutions are required. Additionally, the absence of integrated safety mechanisms, real-time location monitoring, and live surveillance reduces the overall efficiency and reliability of rescue operations.

Therefore, there is a strong need for a compact, lightweight, cost-effective, and remotely operated rescue system that can improve operational safety and rescue efficiency. The proposed “IoT and RF Controlled Smart Rescue Boat with Live Camera Feed and GPS Tracking” is developed to overcome these limitations by integrating RF communication, IoT connectivity, GPS tracking, live video monitoring, and emergency alert systems into a single rescue platform. The system aims to reduce human risk, improve navigation accuracy, provide real-time situational awareness, and support faster disaster response during flood and water rescue missions.

Table 3: Problems in Conventional Rescue Systems

Existing Problems	Impact on Rescue Operations
Human-operated rescue boats	Increased risk to rescue personnel
Poor visibility during floods	Difficult victim identification
Lack of GPS tracking	Inaccurate location monitoring
No live surveillance	Reduced situational awareness
High operational cost	Limited deployment capability
Dependence on internet only	Communication failure during disasters
Heavy and bulky systems	Slow transportation and deployment

4. OBJECTIVES OF THE PROPOSED

The primary objective of the proposed system is to design and develop a smart, compact, and remotely operated rescue boat capable of assisting rescue teams during floods and water-related emergencies. The system aims to improve operational safety, reduce human involvement in hazardous environments, and provide reliable monitoring and navigation support using integrated IoT and RF communication technologies. The rescue boat is designed to perform efficient rescue assistance through real-time video streaming, GPS tracking, wireless navigation, and emergency signaling mechanisms. By combining multiple technologies into a single platform, the proposed system enhances rescue efficiency, communication reliability, and disaster response capabilities.

Objectives of the Proposed Smart Rescue Boat

1. To design a remote-controlled rescue boat using RF communication for reliable wireless navigation.

2. To integrate an ATmega328 microcontroller for centralized control and coordination of all hardware modules.
3. To implement a live camera feed system for real-time video monitoring during rescue operations.
4. To incorporate GPS tracking functionality for accurate location monitoring and rescue coordination.
5. To provide IoT-based communication support using a Wi-Fi module for remote data transmission.
6. To develop an emergency alert system using buzzer and LED indicators for better visibility and signaling.
7. To integrate touch sensor mechanisms for improved operational safety and victim interaction.
8. To develop a lightweight, compact, and portable rescue platform suitable for disaster-prone regions.
9. To reduce the operational risk faced by rescue personnel during flood rescue operations.
10. To create a cost-effective and energy-efficient rescue solution for practical real-world applications.

5. PROPOSED SYSTEM & METHODOLOGY

The proposed “IoT and RF Controlled Smart Rescue Boat with Live Camera Feed and GPS Tracking” is designed as a compact and intelligent rescue platform capable of performing efficient water rescue operations during floods and emergency situations. The system combines RF-based wireless control with IoT-enabled monitoring to achieve reliable navigation, live surveillance, and real-time tracking. The rescue boat is controlled using an ATmega328 microcontroller, which acts as the central processing unit and coordinates the operation of all hardware modules integrated within the system. The major components include RF transceiver module, GPS module, Wi-Fi camera, motor driver, propulsion motors, touch sensors, buzzer, LED indicators, and power supply system.

The RF communication module enables wireless transmission of navigation commands from the remote controller to the rescue boat. Based on received signals, the ATmega328 microcontroller controls the

movement of dual propulsion motors through the motor driver circuit, allowing forward, backward, left, and right navigation. The integrated Wi-Fi camera continuously streams live video footage to the operator, improving situational awareness during rescue missions. Additionally, the GPS module provides accurate latitude and longitude coordinates for location tracking and monitoring. These coordinates can be transmitted through IoT platforms for rescue coordination and lost boat tracking applications.

The system also incorporates emergency alert mechanisms including LED indicators and buzzers, which improve rescue visibility during low-light and hazardous conditions. Touch sensors are integrated to enhance safety functionality and provide interaction support during rescue operations. The overall system is designed with lightweight and waterproof construction to ensure stable operation in flood-prone environments. The hybrid communication approach ensures that the rescue boat can operate efficiently in both internet-connected and disconnected disaster areas.

5.1 System Methodology

The methodology of the proposed system follows a structured sequence of operation for efficient rescue functionality:

1. The remote operator sends navigation commands using the RF transmitter module.
2. The RF receiver mounted on the boat receives the signals and forwards them to the ATmega328 microcontroller.
3. The microcontroller processes the received instructions and controls the motor driver circuit.

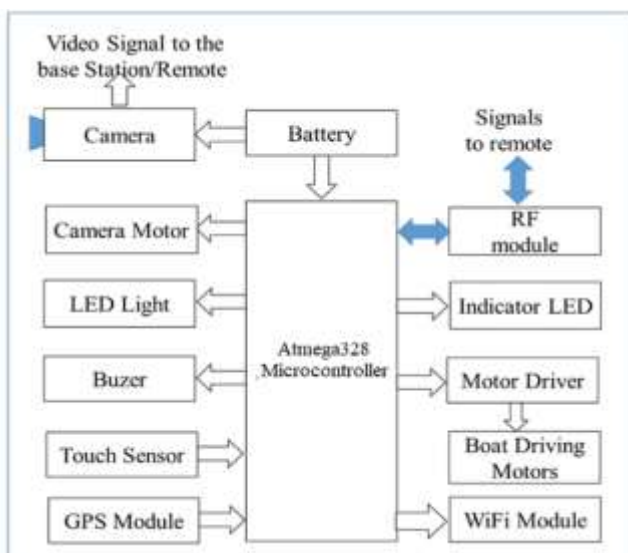
4. The motor driver activates the propulsion motors for directional movement of the rescue boat.
5. The Wi-Fi camera captures live video and transmits it to the remote monitoring device.
6. The GPS module continuously updates real-time location coordinates.
7. The buzzer and LED indicators provide emergency alerts and operational status indication.
8. Touch sensors detect user interaction and enhance operational safety.
9. The IoT module uploads GPS coordinates and monitoring data for tracking purposes.

Table 4: Major Modules Used in Proposed System

Module	Function
ATmega328 Microcontroller	Central system control
RF Transmitter & Receiver	Wireless navigation control
GPS Module	Real-time location tracking
Wi-Fi Camera	Live video streaming
Motor Driver	Motor movement control
DC Motors	Boat propulsion
Touch Sensor	Safety interaction
LED & Buzzer	Emergency indication
Battery Supply	Power management

5.2 Block Diagram Architecture

The block diagram architecture of the proposed smart rescue boat illustrates the interaction between the major hardware modules integrated into the system. The ATmega328 microcontroller acts as the central control unit and manages communication, navigation, monitoring, and safety operations. The system



combines RF communication, IoT connectivity, GPS tracking, live video streaming, and emergency alert mechanisms to achieve efficient rescue

Fig. 1: Block Diagram

Functionality during flood and water emergency situations. The complete architecture is designed to provide reliable remote operation, accurate tracking, and improved situational awareness while reducing human risk during rescue missions.

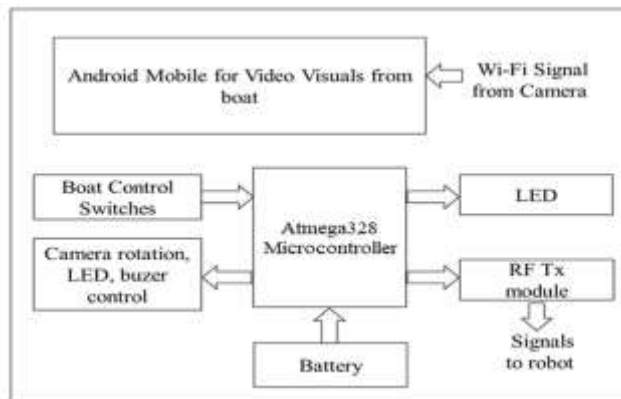


Fig. 2: Block Diagram of Remote

The above diagram represents the remote control unit architecture of the proposed smart rescue boat system. The remote unit is designed to provide wireless navigation control, live monitoring, and emergency operation management during rescue missions. The ATmega328 microcontroller acts as the central control unit of the remote system and coordinates communication between all connected modules.

The boat control switches are used by the operator to send navigation commands such as forward, backward, left, and right movement to the rescue boat. These commands are processed by the ATmega328 microcontroller and transmitted wirelessly through the RF transmitter module. The RF Tx module sends control signals to the rescue boat for remote navigation and operation.

The system also includes controls for camera rotation, LED operation, and buzzer activation. These functions help the operator monitor rescue conditions and activate emergency indications when required. The Android mobile device receives live video signals from the Wi-Fi camera mounted on the rescue boat, enabling real-time environmental observation and rescue monitoring.

The entire remote control unit is powered using a battery supply, which provides stable power to the microcontroller and communication modules. Overall, the remote control architecture enables efficient wireless operation, real-time monitoring, and improved rescue coordination during flood and water emergency situations.

Description of Functional Blocks

1. ATmega328 Microcontroller

The ATmega328 microcontroller is the main processing unit of the system. It receives navigation commands, processes sensor data, and controls all connected modules including motors, GPS, RF communication, LEDs, buzzer, and camera systems.

2. RF Module

The RF transmitter and receiver modules provide wireless communication between the operator and the rescue boat. These modules allow remote navigation control such as forward, backward, left, and right movement.

3. Camera Module

The camera module captures live video footage of the surrounding environment and transmits it to the remote monitoring station. This helps operators observe rescue conditions in real time.

4. Wi-Fi Module

The Wi-Fi module enables IoT-based communication and remote data transfer. It supports live video streaming and GPS data uploading to monitoring platforms.

5. GPS Module

The GPS module continuously tracks the real-time location of the rescue boat and provides latitude and longitude coordinates for rescue coordination and monitoring purposes.

6. Motor Driver

The motor driver acts as an interface between the microcontroller and the propulsion motors. It controls motor speed and directional movement based on received commands.

7. Boat Driving Motors

The propulsion motors provide movement to the rescue boat in water. They enable navigation in multiple directions during rescue operations.

8. Camera Motor

The camera motor controls the rotation and viewing angle of the camera module, improving visual coverage and monitoring flexibility.

9. Touch Sensor

The touch sensor is used for safety interaction and detection purposes. It helps identify contact during rescue operations and improves system responsiveness.

10. LED Light

The LED light provides illumination during night operations or low-visibility conditions, improving rescue visibility and operational safety.

11. Indicator LED

The indicator LED shows the operational status of the system and provides visual feedback during rescue operations.

12. Buzzer

The buzzer generates audio alerts and emergency warning signals to improve communication and rescue awareness.

13. Battery Supply

The rechargeable battery supplies power to all system components and ensures uninterrupted operation during rescue missions.

6. MATERIALS & IMPLEMENTATION

The implementation of the proposed smart rescue boat involves the integration of multiple hardware and communication modules to achieve efficient navigation, monitoring, and rescue support during water emergency situations. The system is developed using embedded system technology, RF communication, IoT connectivity, GPS tracking, and live video streaming mechanisms. The ATmega328 microcontroller acts as the central control unit responsible for processing navigation commands and coordinating the operation of all connected modules. The complete hardware setup is designed to be lightweight, portable, waterproof, and energy-efficient for reliable operation in flood and disaster-prone environments.

The rescue boat uses dual DC propulsion motors controlled through a motor driver module to achieve directional movement in water. RF transmitter and receiver modules provide wireless communication between the operator and the rescue boat for real-time

navigation control. The integrated Wi-Fi camera streams live video feed to the monitoring device, allowing the operator to observe environmental conditions and victim locations remotely. The GPS module continuously tracks the boat location and provides latitude and longitude coordinates for rescue coordination and monitoring purposes. Additional safety features such as touch sensors, LED indicators, and buzzers improve rescue interaction and emergency signaling capabilities.

The implementation process includes hardware assembly, microcontroller programming, wireless communication setup, sensor integration, and real-time testing under different operating conditions. The Arduino IDE is used for programming the ATmega328 microcontroller using Embedded C language. The complete system is powered using a rechargeable battery supply with regulated voltage distribution to ensure stable operation of all components.

6.1 Hardware Components

Table 5: Hardware Components Used in Smart Rescue Boat

Hardware Component	Purpose
ATmega328 Microcontroller	Central processing and control
NRF24L01 RF Module	Wireless communication
ESP32 Camera Module	Live video streaming
GPS Module (Neo-6M)	Real-time location tracking
Motor Driver Module	Motor control operation
DC Water Pump Motors	Boat propulsion
Servo Motor (SG90)	Camera angle adjustment
Touch Sensor (TTP223)	Safety interaction detection
LED Indicators	Emergency signaling
Buzzer	Audio alert system

Rechargeable Battery	Power supply
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6.2 Software Requirements

Table 6: Software Tools Used

Software / Tool	Function
Arduino IDE	Programming and code uploading
Embedded C	Microcontroller programming
ThingSpeak Platform	GPS data monitoring
Wi-Fi Application	Live camera monitoring
Serial Monitor	System testing and debugging

6.3 Component Description

1. ATmega328 Microcontroller

The ATmega328 microcontroller acts as the main control unit of the rescue boat system. It processes RF navigation commands and controls motors, sensors, LEDs, buzzer, GPS module, and communication modules. The microcontroller provides stable performance with low power consumption and supports easy interfacing with multiple peripherals.

2. RF Communication Module

The NRF24L01 RF transceiver module is used for wireless communication between the remote controller and the rescue boat. It operates at 2.4 GHz frequency and provides reliable low-latency communication for navigation control during rescue operations.

3. ESP32 Camera Module

The ESP32-CAM module provides live video streaming functionality for real-time environmental monitoring. The camera captures live footage and transmits video wirelessly to the monitoring device, improving situational awareness during rescue missions.

4. GPS Module

The Neo-6M GPS module continuously receives satellite signals and provides accurate latitude and longitude coordinates. The GPS information is useful for real-time boat tracking and rescue coordination.

5. Motor Driver and Propulsion System

The motor driver module controls the speed and direction of DC propulsion motors based on commands received from the microcontroller. These motors provide movement and steering control for the rescue boat.

7. RESULTS AND DISCUSSION

The proposed “IoT and RF Controlled Smart Rescue Boat with Live Camera Feed and GPS Tracking” was successfully implemented and tested for water rescue applications. The system demonstrated stable RF-based navigation control, accurate GPS location tracking, and smooth live video streaming during operation. The ATmega328 microcontroller efficiently coordinated communication between all hardware modules, ensuring reliable performance during rescue navigation. The propulsion motors provided stable directional movement, while the LED indicators and buzzer operated effectively for emergency signaling. The experimental testing confirmed that the hybrid integration of RF communication and IoT technology improves rescue efficiency and situational awareness during disaster conditions. The live camera feed allowed remote environmental monitoring, while GPS tracking improved rescue coordination and location identification. The system also reduced direct human exposure to hazardous flood environments, making rescue operations safer and more efficient.

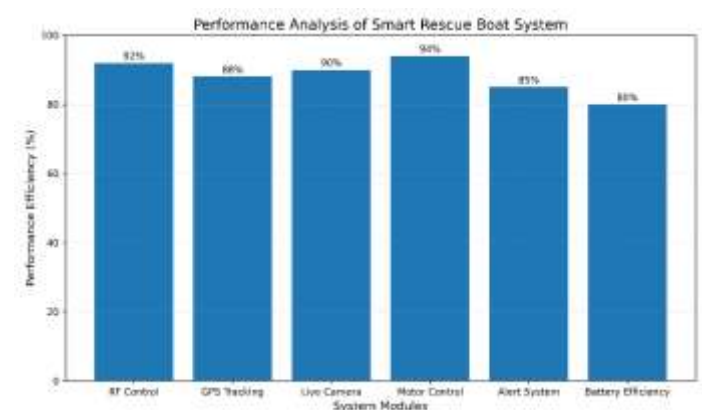


Fig. 3: Performance Analysis of Smart Rescue Boat System

The bar graph represents the performance efficiency of major modules used in the proposed smart rescue boat system. The analysis shows that the motor control and RF communication modules achieved stable operational performance during experimental testing. The live camera and GPS tracking modules also provided reliable monitoring and navigation support, demonstrating the effectiveness of the integrated rescue system.

Table 6: Experimental Results of Proposed System

Tested Function	Result
RF Navigation Control	Successful
GPS Coordinate Tracking	Successful
Live Camera Streaming	Successful
Motor Direction Control	Successful
Emergency Alert System	Successful
Touch Sensor Operation	Successful

7.1 Communication and Navigation Performance

The communication and navigation performance of the proposed smart rescue boat was analyzed during practical testing under different operating conditions. The RF communication module provided reliable wireless control with quick response to navigation commands such as forward, backward, left, and right movement. The GPS module continuously generated accurate location coordinates, which improved rescue tracking and monitoring efficiency. The live camera feed successfully transmitted real-time video footage to the remote operator with minimal delay, allowing better observation of surrounding environmental conditions. In addition, the propulsion motors maintained stable movement and directional control in water. The integrated operation of RF communication, GPS tracking, and live video monitoring significantly improved rescue coordination and operational safety during flood rescue applications.

7.2 System Functional Analysis

The functional performance of the proposed smart rescue boat was evaluated by testing the integrated modules under different operating conditions. The RF communication system provided stable wireless connectivity between the remote controller and the rescue boat, enabling smooth directional navigation

during operation. The GPS module continuously generated real-time location coordinates, which improved rescue tracking and monitoring capability. The ESP32 camera module successfully transmitted live video footage with minimal delay, allowing effective remote observation of surrounding environmental conditions during rescue activities. The propulsion motors responded accurately to navigation commands and maintained stable movement in water. In addition, the LED indicators and buzzer operated properly for emergency alert signaling and visibility support during low-light conditions. The coordinated operation of all integrated modules improved overall rescue efficiency, operational safety, and system reliability. The experimental observations confirmed that the proposed system can effectively assist rescue teams during flood and water emergency situations while reducing direct human exposure to hazardous environments.

The pie chart illustrates the contribution of major functional modules integrated into the proposed rescue boat system. RF communication and live monitoring modules contribute significantly toward navigation and rescue observation, while GPS tracking and safety systems improve rescue coordination and operational reliability.

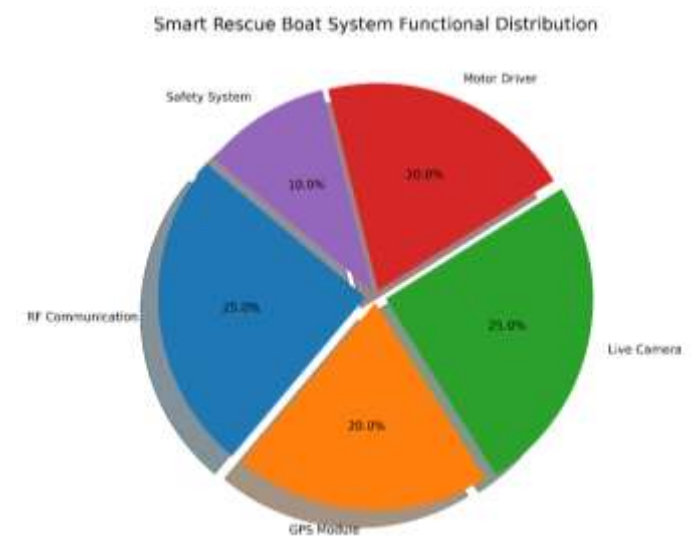


Fig 4: Functional Distribution of Smart Rescue Boat System

8. CONCLUSION & FUTURE SCOPE

8.1 Conclusion

The proposed “IoT and RF Controlled Smart Rescue Boat with Live Camera Feed and GPS Tracking” successfully provides a reliable and cost-effective solution for flood and water rescue operations. The system integrates RF communication for remote navigation, GPS technology for real-time location tracking, and a live camera module for continuous environmental monitoring. The ATmega328 microcontroller effectively controls all integrated modules and ensures smooth system operation during rescue activities. Experimental testing confirmed stable wireless communication, accurate navigation control, efficient video streaming, and proper emergency alert functioning. The compact and lightweight structure of the rescue boat helps reduce human risk and improves operational safety during disaster response situations. Overall, the proposed system enhances rescue efficiency, monitoring capability, and real-time coordination for emergency water rescue applications.

8.2 Future Scope

- Obstacle detection sensors can be integrated for safer navigation in flood conditions.
- Autonomous navigation technology can be implemented to reduce manual control dependency.
- AI-based victim detection can improve rescue accuracy and response time.
- Solar charging support can be added for longer operational duration.
- Long-range communication systems can improve rescue coverage in large disaster areas.
- Cloud-based monitoring can be integrated for real-time disaster management and tracking.

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