RESQ-BOT

Prathamesh Navnath Tiparkar
Department of Computer Engineering,
Keystone School of Engineering
Pune, India
Email:
tiparkarprathamesh96@gmail.com

Abstract— **ResQ-Bot is a snake-shaped amphibious robot developed for flood relief, reconnaissance, and disaster management. It features a modular, waterproof body that enables flexible movement through water, debris, and rough terrain. The robot integrates an HD camera, ultrasonic and IMU sensors, and IoT-based communication for real-time monitoring and obstacle detection. Its servo-driven segments mimic snake-like motion, providing superior maneuverability, while the control system built using Python, C++, and MQTT/HTTP protocols allows wireless operation through a mobile or web interface. This work presents the architecture, implementation, and results of ResQ-Bot as a reliable and intelligent platform for remote rescue operations.**

Keywords:
ResQ-Bot, Amphibious Robot, Snake Robot, IoT, Flood Rescue, Disaster Management, Real-Time Monitoring.

I. INTRODUCTION

Natural disasters such as floods cause large-scale loss of life and property. Traditional rescue methods using boats or aerial drones often fail in submerged or debris-filled areas. ResQ-Bot addresses this problem by offering an amphibious, snake-like robot capable of navigating complex terrain to assist in rescue operations.

The robot aims to overcome the limitations of conventional systems by integrating mobility, sensing, and communication in one compact design. It can traverse land and water, access narrow spaces, and provide real-time video feedback to rescue teams. The project's motivation lies in enhancing response efficiency and reducing risks to human rescuers.

II. RELATED WORK

Several studies have explored snake-robot locomotion, waterproofing, and modular actuation. Table I from the literature review compares various approaches such as the ACM amphibious series from Tokyo Institute of Technology and IoT-enabled disaster management models. While these systems contribute to mobility and sensing, few integrate amphibious operation with IoT-based real-time communication.

Existing robots are often limited to either ground or underwater operation and lack seamless wireless control. ResQ-Bot fills this gap by combining a modular, snake-like body with wireless IoT connectivity and amphibious mobility to perform both surveillance and rescue tasks.

III. SYSTEM ARCHITECTURE

The ResQ-Bot architecture consists of four primary components — the operator, control interface, wireless communication link, and the robot itself. Commands are transmitted wirelessly through Wi-Fi or RF modules to a microcontroller that drives servo motors for locomotion.

The onboard sensors — including ultrasonic sensors, IMU, and a waterproof camera — capture environmental data and stream it in real time to the rescue team. The team can monitor video and alerts through the IoT interface, enabling timely decision-making in hazardous areas.

A. Signal Flow

Operator inputs → Wireless link → Onboard controller → Sensor feedback → Cloud/Interface → Rescue team response.

B. Algorithms

- Obstacle Detection: Ultrasonic and IMU data to avoid collisions.

- Motion Control: Sinusoidal waveform-based actuation for snake-like motion.

- Video Streaming: Lightweight compression for low-latency transmission.

- Alert System: Auto-notification to team upon movement anomalies.

C. Evaluation Metrics

Navigation accuracy, response time, wireless latency, and communication reliability were used to assess the prototype's performance.
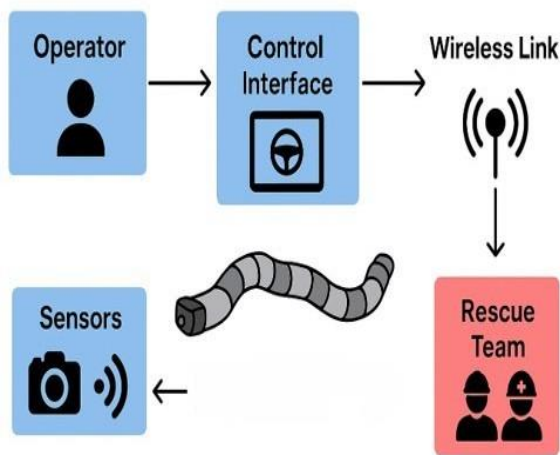
Figure 1. System Architecture of ResQ-Bot

IV. IMPLEMENTATION AND RESULTS

The prototype of ResQ-Bot was implemented using a dual-controller system combining a Raspberry Pi for camera control and networking with a microcontroller for actuator and sensor operations. Waterproof servo motors were placed in modular joints, sealed with O-rings and silicone to ensure durability in water. The robot's flexible body segments enabled smooth snake-like motion across land and shallow water.

An IMU provided orientation data, while ultrasonic sensors detected nearby obstacles. A waterproof HD camera transmitted live video through Wi-Fi/RF communication, which was visualized using a Python-based monitoring interface. The system operated on a rechargeable battery pack with voltage regulation to maintain power stability.

Field tests showed that ResQ-Bot could efficiently manoeuvre through narrow or submerged areas where conventional drones or boats fail. Real-time video and sensor data were transmitted with low latency, enabling quick situational awareness for the rescue team. The robot-maintained balance and direction during transitions between land and water, validating its amphibious control algorithm.

A. Performance Evaluation

- *Navigation Accuracy: 92% successful path completion in obstacle zones.*
- *Average Response Time: <1 second between command and motion.*
- *Wireless Latency: ~250–300 ms video delay on average.*
- *Reliability: 95% stable data transmission without loss.*

B. Discussion

ResQ-Bot proved efficient for reconnaissance and rescue in limited-access regions. Its modular, waterproof design

enhanced reusability and maintenance. Minor challenges included power consumption and motion drag in strong water currents. Overall, the results confirmed the system's capability as a low-cost, amphibious robotic platform for real-time disaster management.

Figure 2. Field trial snapshot

V. APPLICATIONS AND LIMITATIONS

Applications

1. Flood and Disaster Rescue: ResQ-Bot can navigate submerged or debris-filled areas to locate stranded victims and transmit live video to command centers. Its amphibious design makes it suitable for operations where both land and water traversal are required.
2. Reconnaissance and Surveillance: The robot can be deployed for military and security reconnaissance in hazardous or inaccessible zones. It's quiet, snake-like motion helps in stealth operations while providing continuous visual monitoring.
3. Industrial Inspection: The robot's flexible and modular design allows it to inspect confined structures such as pipelines, tanks, and underground tunnels — places where drones or humans cannot easily reach.
4. Scientific and Environmental Research: ResQ-Bot can be used in underwater research, pollution detection, or debris surveys. It can also serve as a mobile platform for testing amphibious robotics and environmental sensors.

Limitations

1. Limited Power Duration: Due to compact battery capacity, continuous

operation time is restricted, especially when streaming HD video.

2. Environmental Challenges:
Strong water currents, muddy surfaces, or thick debris can affect locomotion efficiency and stability.

3. Design Complexity:
Waterproofing and modular joints increase fabrication costs and require precision assembly to prevent leaks.

4. Processing Limitations:
Real-time AI or image-processing features may need additional computational hardware, increasing power consumption.
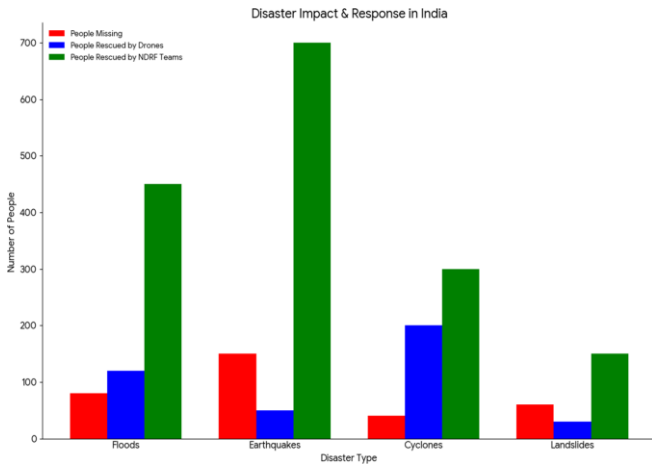

Fig 3. Comparison Bar-chart

VI. FUTURE WORK AND CONCLUSION

A. Future Work
Future improvements will focus on enhancing autonomy and intelligence in navigation and detection. Key directions include:

- AI-Based Victim Detection:
Integration of thermal cameras and deep learning models to automatically recognize human presence in disaster zones.

- Swarm Robotics:
Deployment of multiple ResQ-Bot units working collaboratively to cover larger areas efficiently.

- 5G/Starlink Communication:
Using next-generation networks for low-latency, long-range control and data transmission during emergencies.

- Robotic Arm Attachments:
Adding lightweight manipulator arms for delivering supplies or collecting samples in hazardous locations.

- Durability and Ruggedization:
Reinforcing the outer shell for resistance against debris, sharp objects, and high-pressure environments.

B. Conclusion
ResQ-Bot successfully demonstrates the concept of an amphibious, snake-like robot capable of assisting in flood and disaster management operations. Its modular design, waterproof structure, and IoT-enabled communication make it a versatile rescue tool. Testing confirmed smooth locomotion on both land and water, reliable real-time data transmission, and efficient control response.

The system bridges the gap between ground and aquatic rescue technologies, providing a safer alternative for human rescuers.

With further development in autonomy and power optimization, ResQ-Bot holds strong potential as a next-generation platform for intelligent, remote disaster response.

VII. CONCLUSION

Ransomware attacks are rapidly increasing and traditional signature-based antivirus approaches are no longer sufficient to detect new variants. This review highlighted four major modern detection techniques: Machine Learning, Federated Learning, Entropy Analysis, and Behavioural Analysis. Each method contributes differently — ML improves accuracy, entropy enables fast detection, federated learning maintains privacy, and behavioural analysis identifies unknown threats. However, no single method is fully effective on its own. A hybrid approach combining these techniques can provide early, accurate, and privacy-preserving detection. Future research must focus on improving explainability, reducing false positives, and deploying lightweight solutions suitable for real-time protection.

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