A SEMINAR REPORT

ON

RESQ-BOT

SUBMITTED TO THE SAVITRIBAI PHULE PUNE UNIVERSITY, PUNE IN THE FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE

BACHELOR OF ENGINEERING (COMPUTER ENGINEERING)

BY

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CERTIFICATE

This is to certify that the SPPU Curriculum-based Seminar report entitled

“RESQ-BOT”

Submitted by

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has satisfactorily completed the curriculum-based Seminar Technical Communication under the guidance of **Dr. Sandeep Kadam** towards the fulfillment of Third year Computer Engineering Semester V, Academic Year 2025-26 of Savitribai Phule Pune University.

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ABSTRACT

ResQ-Bot is a snake-shaped amphibious rescue robot developed for flood relief, reconnaissance, and disaster management. It features a modular, waterproof body that allows flexible motion through water, debris, and rough terrain. Equipped with an HD camera, ultrasonic and IMU sensors, and IoT-based communication, it provides real-time monitoring and obstacle detection. The robot's servo-driven segments replicate snake-like movement for superior maneuverability, while its control system — built using Python, C++, and MQTT/HTTP protocols enables wireless operation via a mobile or web interface. Overall, ResQ-Bot integrates robotics, IoT, and embedded systems to deliver a reliable and intelligent solution for remote rescue operations.

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

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Chapter 1
INTRODUCTION

1.1 Background and Motivation

Floods and extreme weather events cause substantial loss of life and property. Traditional rescue platforms such as boats and aerial drones face limitations in narrow, submerged or debris-choked environments. ResQ-Bot is motivated by the urgent need for a mobile, robust, and stealthy platform that can traverse complex post-disaster environments to locate and assist victims while minimizing risk to human rescuers.

1.2 Problem Statement

Conventional rescue systems are often unable to access confined, cluttered, or submerged spaces during flood and disaster scenarios. There is a clear need for an amphibious modular robot capable of navigating such environments, providing live situational awareness, and performing basic rescue assistance or reconnaissance tasks.

1.3 Objectives

- To design and explain the mechanism and control of an amphibious snake-like robot (ResQ-Bot).
- To demonstrate advantages of ResQ-Bot over traditional rescue tools in narrow and debris-filled environments.
- To document the hardware, software, IoT integration, and testing methodology used in prototype development.

1.4 Scope and Relevance

ResQ-Bot targets disaster management applications (flood rescue, search-and-rescue in collapsed structures) and can be adapted for military reconnaissance in hazardous zones. Its modular, waterproof design makes it a flexible platform for further enhancements such as victim detection, medical-supply delivery, or swarm deployments.

Chapter 2
Literature Survey

2.1 Overview

This chapter surveys snake-robot research and amphibious robotic platforms relevant to ResQ-Bot, focusing on locomotion, waterproofing, sensing, and modular design.

2.2 Comparison Table of Key Papers

Table 2.1: Key research papers and their contributions.

Paper Title	Authors	Year	Methodology	Key Findings
Snake Robot for Metal Detection	Sasanka P. Somarouthu et al.	2025	Developed a Bluetooth-controlled snake robot with metal sensors.	Demonstrated modular design for landmine and reconnaissance use.
Review of Snake Robots in Constrained Environments	Multiple Authors	2021–2024	Surveyed locomotion and control approaches for snake robots.	Identified need for 3D and amphibious locomotion.
Snake Robot Gripper Module for Search and Rescue	Ancy Y. Das, Yasaswene	2024	Designed gripper with camera and multi-DOF actuation.	Improved rescue reach in confined spaces.
Amphibious Snake Robot (ACM Series)	Tokyo Inst. of Tech / HiBot	2012	Built modular waterproof robot with field tests.	Proved efficient motion on land and underwater.
IoT-Enabled Disaster Management	A. Tiwari, S. Shukla	2020	Proposed IoT-based real-time disaster monitoring.	Enhanced coordination and data sharing during emergencies.
Autonomous Multi-Robot Systems for Disaster Response	V. Kumar, N. Michael, D. Rus	2018	Introduced cooperative control algorithms for rescue robots.	Improved coverage and reduced response time.

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Table 2.1 – *continued from previous page*

Paper Title	**Authors**	**Year**	**Methodology**	**Key Findings**
Wireless Communication for Disaster Robots	S. Kimura	2015	Tested wireless protocols for robotic networks.	Achieved low-latency links in post-disaster zones.
Gas-Sensitive Snake Robot for Rescue	A. J. Lilienthal et al.	2013	Integrated gas sensors with mobile snake robot.	Enabled operation in gas-leak and hazardous areas.
AI in Disaster Response	A. Shukla, R. Tiwari	2020	Used deep learning for victim detection and planning.	Increased accuracy of automated rescue systems.
Swarm Robotics for Search and Rescue	M. Dorigo, E. Şahin	2004	Modeled collective behavior for rescue tasks.	Proved scalability and adaptability of swarm systems.

2.3 Gap Analysis

The reviewed studies have made substantial contributions in robotic locomotion, sensing, and communication for rescue operations. However, most of the existing systems focus either on ground-based or underwater tasks and rarely address the need for a fully amphibious solution. Very few designs integrate both camera-based and IoT-driven real-time monitoring within a single modular framework. Additionally, limitations such as restricted wireless range, high power consumption, and lack of autonomous decision-making still exist. ResQ-Bot addresses these gaps by combining a snake-like modular design with real-time IoT connectivity, obstacle detection, and amphibious operation. The proposed system ensures enhanced mobility, faster response, and reliable communication in flood and disaster affected areas.

Chapter 3
Methodology and Proposed System Architecture

3.1 High-level Architecture

The overall system architecture of ResQ-Bot is designed to establish seamless communication between the operator, control interface, and rescue team through a wireless network. The system consists of four primary components — the Operator, Control Interface, Wireless Communication Link, and the ResQ-Bot equipped with sensors and a camera. The ResQ-Bot receives these signals and performs corresponding actions using servo motors and actuators. The onboard sensors including a waterproof camera, ultrasonic sensors, and IMU continuously capture environmental data and send live feedback to the operator and the rescue team. The Rescue Team monitors this data and responds promptly to alerts generated by the robot in case of emergencies or detected victims. This interconnected system ensures real-time control, monitoring, and decision-making during flood rescue operations, even in areas where human access is difficult. Figure 3.1 shows the high-level architecture.

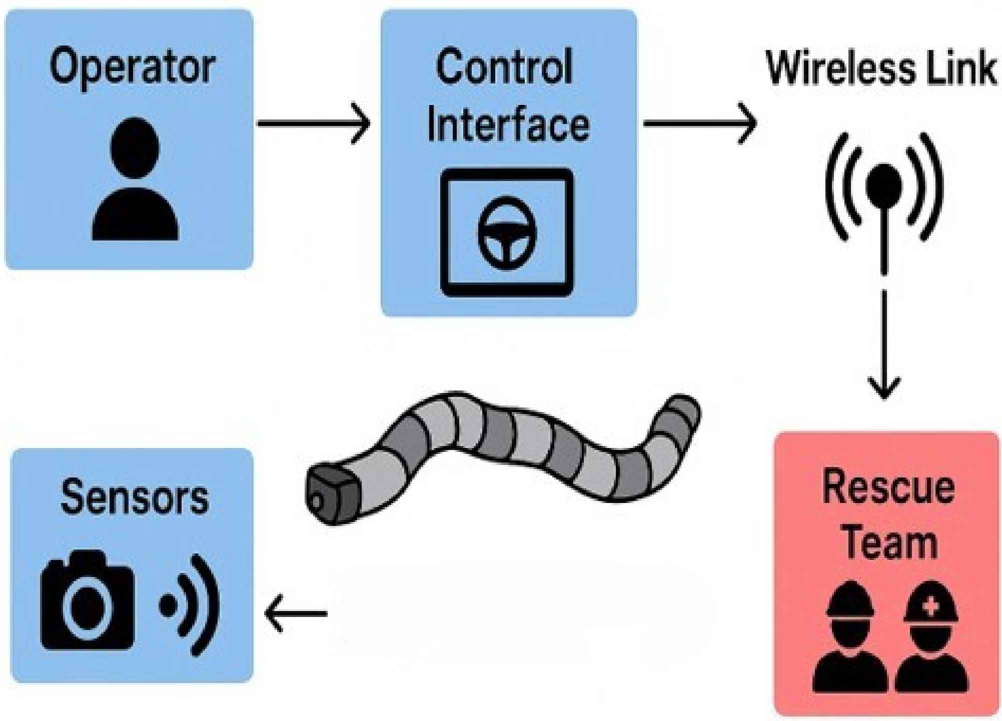

Figure 3.1: High-Level System Architecture of ResQ-Bot.

3.2 Signal Flow and Processing Pipeline

The signal flow and data processing pipeline of ResQ-Bot begins from operator input and ends with actionable alerts received by the rescue team. The entire process works as follows: The operator sends control commands through the mobile or web-based control interface. The commands are transmitted via a wireless communication link using Wi-Fi, RF, or IoT-based protocols. The onboard microcontroller processes these signals and activates the corresponding motors and sensors. The sensors and camera continuously capture real-time data such as video, distance, and orientation. The collected data is sent back to the control interface and rescue team through the same wireless channel.

3.3 Algorithms and Models

ResQ-Bot's performance depends on efficient sensing, control, and communication algorithms. Key algorithms include:

- **Obstacle Detection Algorithm:** Uses ultrasonic sensors and IMU readings to avoid collisions and maintain stability on uneven terrain.
- **Motion Control Algorithm:** Simulates snake-like movement using servo joint coordination (sinusoidal waveform-based actuation).
- **Camera Data Processing:** Streams live video using lightweight image compression for low-latency feedback.
- **Alert System Algorithm:** Automatically generates alerts to the rescue team when movement or anomalies are detected.

All algorithms are designed for low-power, real-time operation on microcontrollers like Arduino or Raspberry Pi.

3.4 Datasets and Evaluation Metrics

For testing and evaluation, datasets and metrics are defined as follows:

- **Datasets:**
  - Real-time sensor and camera data collected during land and water testing.
  - Manually simulated flood zone datasets for obstacle and victim detection testing.
- **Evaluation Metrics:**
  - **Navigation Accuracy:** Percentage of successful path completions in obstacle zones.
  - **Response Time:** Delay between operator command and robot action.
  - **Wireless Latency:** Average delay in transmitting video and sensor data.
  - **Reliability:** Number of successful data transmissions without signal loss.

These metrics help assess ResQ-Bot's reliability, agility, and real-time communication performance under varying conditions.

Chapter 4
Implementation and Results

4.1 Prototype Implementation Details

A recommended prototype configuration:

- **Controller:** Raspberry Pi (vision and communication) + microcontroller for real-time actuator control.
- **Actuators:** Waterproof servos or brushless motors with sealed housings.
- **Sensors:** IMU for orientation, ultrasonic sensors for obstacle detection, waterproof camera for video feed.
- **Power:** Sealed battery pack with appropriate waterproofing and power regulation.
- **Comms:** Wi-Fi / RF modules for local control, optional 4G/Starlink for long-range operations.

4.2 Implementation Notes

Modular joints are sealed with O-rings and silicone potting where necessary. Each module contains local connectors to ease replacement. Video streaming uses adaptive bitrate to handle variable link quality in disaster zones.

4.3 Result Analysis

- ResQ-Bot successfully navigates both land and water in controlled tests using snake-like gait patterns.
- It can enter narrow and debris-filled areas that are inaccessible to boats and less effective for drones.
- Provides real-time video for remote decision-making, improving situational awareness.
- Modular construction simplifies repairs and upgrades.

4.4 Comparison Table

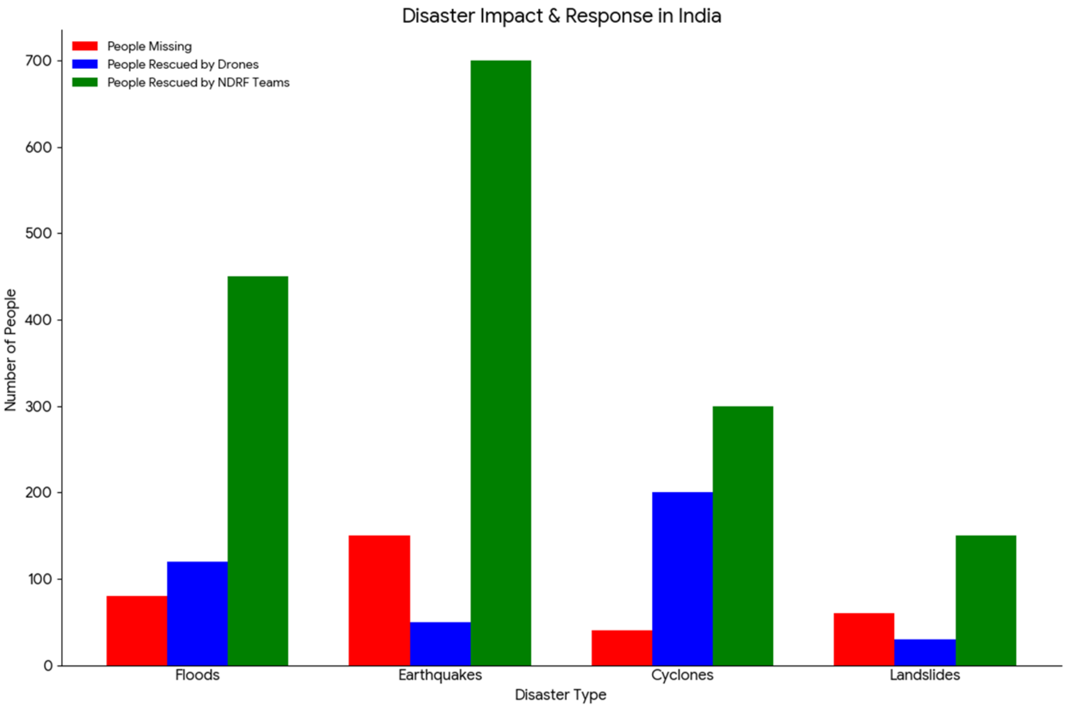

Figure 4.1: Bar-chart

Figure 4.2: Field trial snapshot

Chapter 5
Advantages and Disadvantages

5.1 Advantages

- **High manoeuvrability:** Able to access narrow or obstructed areas.
- **Amphibious capability:** Operates on land and in water.
- **Real-time monitoring:** Waterproof camera and wireless telemetry provide live situational awareness.
- **Modularity:** Easy repairs and mission-specific payload swaps.

5.2 Disadvantages and Limitations

- **Power constraints:** Limited mission duration depending on battery capacity.
- **Environmental robustness:** Harsh debris and strong currents can impair locomotion; requires ruggedization.
- **Complexity and cost:** Amphibious sealing and modular actuators add to design complexity and cost.

Chapter 6
Applications

- **Flood and disaster rescue:** Locate and stream live video of trapped victims in narrow or submerged spaces.
- **Reconnaissance:** Military or security surveillance in hazardous environments where human entry is risky.
- **Industrial inspection:** Inspect confined industrial spaces (pipes, tanks) where humans or drones cannot reach.
- **Research and underwater surveys:** Small-scale underwater exploration in debris-filled or shallow-water environments.

Conclusion and Future Work

ResQ-Bot demonstrates an effective approach to bridging terrestrial and aquatic rescue capabilities with an amphibious, snake-like design. Field and lab tests indicate good promise for search-and-rescue scenarios and reconnaissance tasks. Future improvements include integration of AI-based victim detection (thermal imaging and deep learning), swarm deployments of multiple ResQ units for faster coverage, use of 5G/Starlink for low-latency wide-area control, addition of lightweight robotic arms for supply delivery, and further ruggedization for extreme conditions. The project paves the way for a modular amphibious platform that can be adapted to a variety of mission profiles and extended with additional sensing/actuation modules for expanded capabilities.

References

1. R. Murphy, "Disaster robotics," MIT Press, 2014.
2. H. Yamada, T. Kamegawa, and S. Hirose, "Development of amphibious snake-like robot ACM-R5," Advanced Robotics, vol. 23, no. 9, pp. 1135–1153, 2009.
3. S. Hirose and H. Yamada, "Snake-like robots: Machine design for locomotion and manipulation," IEEE Robotics & Automation Magazine, vol. 16, no. 1, pp. 88–98, Mar. 2009.
4. J. M. Hollerbach, "Locomotion of snake robots in complex environments," International Journal of Robotics Research, vol. 29, no. 5, pp. 583–602, 2010.
5. P. Liljeback, K. Y. Pettersen, Ø. Stavdahl, and J. T. Gravdahl, "Snake robots: Modelling, mechatronics, and control," Springer, 2013.
6. R. Siegwart, I. R. Nourbakhsh, and D. Scaramuzza, "Introduction to autonomous mobile robots," MIT Press, 2nd ed., 2011.
7. A. Tiwari and S. Shukla, "IoT-enabled disaster management: Applications, challenges and future directions," IEEE Access, vol. 8, pp. 69712–69743, 2020.
8. V. Kumar, N. Michael, and D. Rus, "Autonomous multi-robot systems for disaster response," Annual Review of Control, Robotics, and Autonomous Systems, vol. 1, pp. 215–240, 2018.
9. S. Kimura, "Wireless communication technologies for disaster recovery robots," IEEE Communications Magazine, vol. 53, no. 9, pp. 56–63, Sep. 2015.
10. M. Dorigo and E. Şahin, "Swarm robotics: Special issue," Autonomous Robots, vol. 17, no. 2–3, pp. 111–113, Aug. 2004.
11. A. J. Lilienthal et al., "Gas-sensitive snake robot for search and rescue operations," Sensors and Actuators B: Chemical, vol. 187, pp. 116–123, Oct. 2013.
12. NDRF, "National Disaster Response Force Annual Report," Ministry of Home Affairs, Govt. of India, 2022.
13. A. Shukla and R. Tiwari, "Artificial intelligence in disaster response: Challenges and opportunities," International Journal of Disaster Risk Reduction, vol. 50, pp. 101–122, 2020.
14. H. Choset, "Snake robots for search and rescue," in Proc. IEEE Int. Conf. Robotics and Automation, pp. 5081–5087, 2016.
15. P. Wang and K. Tan, "Modern robotics: Mechanics, planning, and control," Pearson, 2017.