

Smart Drainage Monitoring System with Alert

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Abstract: Urban drainage systems often face issues such as blockages, toxic gas accumulation, overflow, and structural damage. Traditional inspection methods rely on manual labor, exposing workers to hazardous underground environments. To overcome these challenges, this project presents an IoT-Based Autonomous Drainage Inspection and Blockage Removal Robot with Live Monitoring and Overflow Alert System. The system uses an ESP32 microcontroller integrated with sensors, a camera module, and a drilling mechanism for blockage removal. DHT11 and MQ-series sensors monitor temperature, humidity, and harmful gases such as methane inside drainage pipelines. When dangerous gas levels or overflow conditions are detected, the system generates instant alerts through LEDs and a web-based interface. An ESP32-CAM or USB camera provides live video streaming for remote inspection and monitoring. The robot can be controlled remotely through a web dashboard developed using Flask, allowing operators to navigate the robot safely without entering hazardous drainage environments. The proposed system improves worker safety, enables real-time monitoring, reduces maintenance time, and provides an efficient and cost-effective solution for smart drainage management in modern urban areas.

Keywords: Keywords: Internet of Things (IoT), Autonomous Robot, Drainage Inspection System, Sewer Cleaning Robot, Blockage Removal, Smart Drainage Monitoring, ESP32 Microcontroller, Gas Detection System, Live Video Monitoring.

I. INTRODUCTION

Urban drainage systems are essential for managing wastewater, rainwater, and industrial effluents in modern cities. However, these systems often face problems such as blockages, overflow, toxic gas accumulation, and structural damage, which can lead to flooding, sanitation issues, and environmental hazards. Traditional drainage inspection and maintenance methods mainly depend on manual labor, exposing workers to dangerous underground environments containing harmful gases, infectious materials, and confined spaces. These limitations create the need for intelligent and automated solutions that improve safety and efficiency. The rapid development of the Internet of Things (IoT) and robotics has enabled advanced monitoring and maintenance systems for urban infrastructure. By integrating sensors, wireless communication, and robotic technologies, drainage systems can now be inspected and maintained remotely with minimal human intervention. This project, titled “IoT-Based Autonomous Drainage Inspection and Blockage Removal Robot with Live Monitoring and Overflow Alert System,” aims to develop a smart robotic solution for drainage inspection, hazard detection, and blockage removal.

The proposed system uses an ESP32 microcontroller integrated with sensors, a camera module, and a high-torque drilling mechanism. Sensors such as DHT11 and MQ-series modules are used to monitor temperature, humidity, and harmful gases like methane inside drainage pipelines. In dangerous situations, the system provides alerts through LEDs and a web-based interface. An ESP32-CAM or USB camera connected to a Raspberry Pi enables live video streaming for remote inspection and monitoring.



The robot is capable of navigating through drainage pipelines, detecting blockages, and removing obstructions using a motor-driven drill mechanism. Through a Wi-Fi-based web interface, operators can remotely control the robot, monitor live sensor readings, and receive overflow or hazard alerts in real time. The integration of IoT, robotics, and live monitoring enhances worker safety, reduces maintenance time, and improves drainage management efficiency. Overall, the proposed system provides a smart, cost-effective, and scalable solution for modern drainage maintenance. By reducing human exposure to hazardous environments and enabling real-time monitoring and automated maintenance, the system contributes to the development of safer and more sustainable smart-city infrastructure.

II. LITERATURE REVIEW

1. Design of real-time automatic drainage cleaning and monitoring system using iot Authors: v. Gerlin, y. Gnana priya, k. R. Swetha, r. Kaladevi, hariharan shanmugasundaram, a. Rajesh kumar Summary: this paper presents an iot-based system for real-time monitoring and cleaning of drainage systems. The system integrates gas sensors, ultrasonic sensors, and gsm modules for detecting blockages and hazardous gas levels. The data is processed and visualized on thingspeak, enabling effective drainage management and mitigating potential issues. The proposed system aims to improve urban sanitation by automating the monitoring and cleaning processes, reducing the risks associated with manual inspections.
2. Iot based automatic drainage cleaning robot Authors: s. Sreejith, s. S. Saaddin, s. Mohammad, n. A. Md azmi, s. Salim Summary: this paper discusses the development of an automatic drainage cleaning robot utilizing iot technology. The robot is designed to detect and remove blockages within drainage systems autonomously. It employs sensors to identify obstructions and uses mechanical actuators to clear them. The integration of iot allows for remote monitoring and control, enhancing the efficiency and safety of drainage maintenance operations. This approach aims to reduce the dependency on manual labor and improve the overall sanitation infrastructure.
3. Intelligent drainage cleaning and monitoring system Authors: z. Mohd hussin, s. S. Saaddin, s. Mohammad, n. A. Md azmi, s. Salim Summary: the paper proposes an intelligent drainage cleaning and monitoring system that employs iot devices to track vital signs, toxic gas exposure, and skin conditions of manual scavengers. The system integrates wearable iot devices with the drainage infrastructure to monitor environmental conditions and worker safety. The collected data is analyzed to ensure safe working conditions and to prevent health hazards associated with manual sewage cleaning. This integrated approach aims to improve public sanitation and protect the safety of manual scavengers.
4. Underground pipeline sewage cleaning robot Authors: not specified Summary: this paper presents the design and implementation of an iot-based sewage cleaning robot developed to minimize human exposure to unsafe and unsanitary conditions. The robot is equipped with infrared (ir) cameras and ir sensors for real time detection of blockages inside sewage pipelines. The system aims to automate the cleaning process, reducing the risks associated with manual sewage cleaning and improving the efficiency of urban sanitation systems. The integration of iot allows for remote monitoring and control, enhancing the overall effectiveness of the system.
5. Drainage cleaning robotic arm system Authors: not specified Summary: the paper introduces a drainage cleaning robotic arm system designed to address urban sanitation challenges in india. The system involves a smart toilet cleaning robot equipped with sensors and actuators to detect and remove blockages within drainage systems. The robotic arm is capable of navigating through pipes and performing cleaning operations autonomously. The integration of iot technology allows for real-time monitoring and control, improving the



efficiency and safety of drainage maintenance activities. This innovative solution aims to enhance urban sanitation and reduce the dependency on manual labor.

6. Pipe crawling robot Authors: prof. Sowmya met. Al. Summary: this research paper explores the use of robots for tasks in labor-intensive, hazardous, and unreachable work environments, specifically focusing on pipeline systems. The paper discusses the design and implementation of a mobile robot capable of inspecting the inner surface of pipes to detect defects. The robot employs sensors and actuators to navigate through pipelines and perform inspection tasks autonomously. The study highlights the potential of robotic systems in improving the efficiency and safety of pipeline inspections, reducing the risks associated with manual labor.

III.METHODOLOGY

1. Microcontroller Setup

- The esp32 microcontroller serves as the brain of the robot.
- It is powered via a li-ion or li-po battery pack, regulated through a 7805 voltage regulator to supply stable 5v to sensors and modules.
- The esp32 is connected to all sensors, camera, and motor driver modules.

2. Motor Integration

- Dc gear motors are connected to the l298n motor driver module, which provides
- direction and speed control.
- Motors are mounted on the robot chassis to drive the wheels and the front mounted drill for blockage removal.

3. Sensor Installation

- Dht11 sensor is mounted for temperature and humidity monitoring.
- Mq-2 gas sensor is installed to detect hazardous gases such as methane or smoke.
- Both sensors are connected to the esp32 via analog or digital pins.

4. Camera Setup

- The esp32-cam module or external usb camera is installed at the front of the robot for live visual inspection.
- Camera is connected to the esp32 for video streaming.

5. Alert Indicators

- High-brightness leds are mounted for local hazard indication.
- Leds are connected to digital pins of the esp32 and synchronized with the web interface for remote alerts.

6. Power Management

- All components are powered using a single battery pack.
- The 7805 voltage regulator ensures stable 5v output for sensitive electronics.

IV. WORKING OF THE SYSTEM

The proposed IoT-Based Autonomous Drainage Inspection and Blockage Removal Robot operates through a sequence of monitoring, inspection, communication, and maintenance processes to ensure efficient drainage management.

Initially, when the system is powered on, the ESP32 microcontroller initializes all connected components, including the DHT11 sensor for temperature and humidity monitoring, the MQ-2 gas sensor for hazardous gas detection, the camera



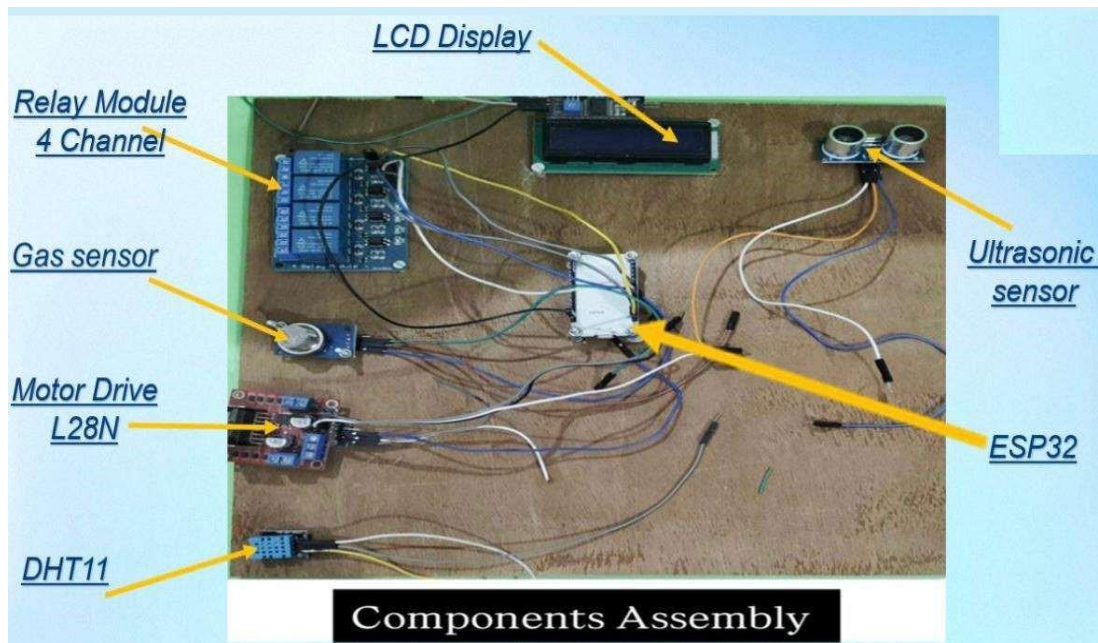
module for live video streaming, motor drivers, and the drilling mechanism. After initialization, the robot begins collecting real-time environmental and visual data from inside the drainage pipeline.

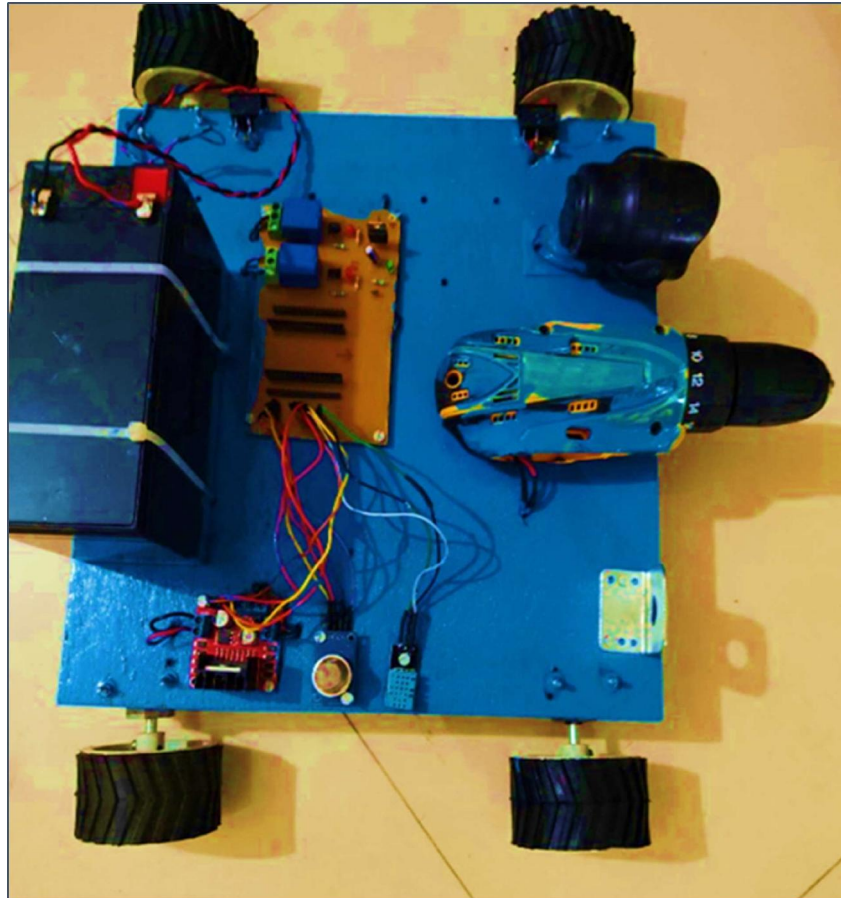
The DHT11 sensor continuously monitors temperature and humidity levels to identify abnormal environmental conditions, while the MQ-2 sensor detects harmful gases such as methane or smoke present in the drainage system. Simultaneously, the camera captures live video footage for remote inspection. The ESP32 processes all sensor data and compares the readings with predefined safety thresholds. If dangerous gas concentrations are detected, the system immediately activates LED alerts and sends warning notifications to the web interface for operator awareness.

During operation, the robot navigates through the drainage pipeline using motor-controlled wheels. It continuously checks for obstacles or blockages through sensor feedback and visual monitoring. When debris or sludge accumulation is identified, the high-torque drilling mechanism is activated to break and remove the blockage, restoring proper water flow within the drainage system.

All collected sensor data and live camera feeds are transmitted through Wi-Fi to a web-based monitoring interface. This interface allows operators to remotely monitor pipeline conditions, view live video streams, control robot movement, and receive emergency alerts in real time.

Additionally, the robot continuously monitors its battery level. If the battery charge falls below a preset limit, the system automatically initiates a return-to-base operation for recharging. Through the integration of IoT, robotics, live monitoring, and autonomous blockage removal, the proposed system provides a safe, efficient, and intelligent solution for modern drainage maintenance and inspection.





IV. RESULTS AND DISCUSSIONS

RESULT

The proposed IoT-Based Autonomous Drainage Inspection and Blockage Removal Robot was successfully designed and tested for underground drainage monitoring and maintenance. The robot was able to move efficiently inside the drainage pipeline using DC gear motors controlled by the ESP32 microcontroller. The DHT11 sensor continuously monitored temperature and humidity, while the MQ-2 gas sensor detected harmful gases such as methane and smoke present inside the drainage system.

The camera module successfully provided live video streaming, allowing remote visual inspection of the pipeline conditions. Real-time sensor readings and live video feeds were transmitted to the web interface through Wi-Fi, enabling operators to monitor the drainage system remotely. Whenever harmful gas levels exceeded the preset threshold, the system generated alerts through LEDs and web notifications.

The high-torque drill mechanism effectively removed small blockages such as sludge and debris. The overflow monitoring feature also detected abnormal water levels and provided warning alerts to prevent drainage overflow. Overall, the system reduced the need for manual inspection and improved safety, monitoring efficiency, and maintenance operations.



DISCUSSION

The project demonstrates the effective integration of IoT, robotics, and real-time monitoring technologies for smart drainage management. The ESP32 microcontroller provided stable communication between sensors, motors, and the web interface. The environmental monitoring system improved safety by continuously detecting hazardous conditions inside drainage pipelines.

The live camera feed helped operators identify blockages and inspect pipeline conditions remotely without entering hazardous environments. The blockage removal mechanism reduced manual labor and minimized worker exposure to toxic gases and confined spaces. The web interface made monitoring and control easier by displaying live sensor data, alerts, and robot navigation controls in real time.

However, some limitations were observed during testing. Wi-Fi signals may become weak in deep underground pipelines, affecting communication and video transmission. Battery life may also limit longduration operation. In addition, the drill mechanism is more effective for small and medium blockages and may require improvements for handling larger obstructions.

Despite these limitations, the system provides a reliable, safe, and cost-effective solution for drainage inspection and maintenance. Future improvements such as AI-based blockage detection, autonomous navigation, cloud integration, and advanced communication technologies can further enhance the efficiency and scalability of the system for smart-city applications.

V.FUTURE SCOPE

1. Integration of ai-based image processing for automatic blockage detection.
2. Addition of autonomous navigation algorithms for complete pipeline traversal without manual control.
3. Implementation of solar-powered battery systems for extended operation in remote areas.
4. Incorporation of advanced gas sensors to detect a wider range of hazardous gases.
5. Real-time predictive maintenance using iot data analytics.
6. Use of multi-robot systems for simultaneous inspection of larger drainage networks.
7. Wireless mesh networking for communication in long or underground pipelines.
8. Miniaturization for smaller diameter pipelines and tighter spaces.
9. Integration with cloud platforms for centralized monitoring of city-wide drainage systems.

VI. CONCLUSION

The iot-based autonomous drainage inspection and blockage removal robot provides a safe, efficient, and reliable solution for monitoring and maintaining urban drainage systems. By integrating sensors, camera modules, and high-torque motors with the esp32 microcontroller, the system enables real-time environmental monitoring, remote control, and automated blockage removal. This project reduces human exposure to hazardous conditions, enhances operational efficiency, and ensures timely response to emergencies such as gas leaks or overflows. The web interface allows continuous remote monitoring, data logging, and alert management, making the system highly suitable for smart city infrastructure and industrial pipeline applications. With further enhancements like ai-based blockage detection, autonomous navigation, and cloud integration, the system can evolve into a fully intelligent drainage management solution, ensuring safer and more sustainable urban and industrial environments..



REFERENCES

1. Muthugala, m. A. V. J., & chia, l. T. (2021). Raptor: a design of a drain inspection robot. *Sensors*, 21(17), 5742. <https://doi.org/10.3390/s21175742>
2. Jain, d. R. K., & das, s. (2021). Development of iot based inspection robotic system and anti-clogging robot. *Proceedings of the iee international conference on robotics and automation (icra)*. <https://dl.acm.org/doi/10.1145/3478586.3478598>
3. Nguyen, t. L., & ryu, h. (2022). Autonomous control for miniaturized mobile robots in sewer pipe networks. *Frontiers in robotics and ai*.
<https://www.frontiersin.org/articles/10.3389/frobt.2022.997415/full>
4. Yang, m., blight, a., bhardwaj, h., shaukat, n., han, l., richardson, r., pickering, a., jackson-mills, g., & barber, a. (2025). Tinyml-based in-pipe feature detection for miniature robots. *Sensors*, 25(6), 1782. <https://doi.org/10.3390/s25061782>
5. Xiong, b., & zhang, h. (2025). A visually assisted cleaning robot for sewers. *Applied sciences*, 15(7), 3426. <https://doi.org/10.3390/app15073426>
6. Yang, m., blight, a., bhardwaj, h., shaukat, n., han, l., richardson, r., pickering, a., jackson-mills, g., & barber, a. (2025). Tinyml-based in-pipe feature detection for miniature robots. *Sensors*, 25(6), 1782. <https://doi.org/10.3390/s25061782>

