

AI BASED MANHOLE CLEANING ROBOT

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College : Biluru Gurubasava Mahaswamiji Institute of Technology, Mudhol, Bagalkot
Branch : Department of Electronics and Communication Engineering
Guide : Prof. Ravi M. Bashetti
Prof. Vinay Shettar
Student(s) : Mr. Ganesh Dindi
Ms. Srushti Tattimath
Ms. Veena Biradarpatil
Mr. Guruprasad Puranikmath

Keywords:

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Introduction:

Manual cleaning of sewer systems is one of the most dangerous and life-threatening occupations, exposing workers to toxic gases, infections, and fatal accidents. Despite legal bans, manual scavenging still exists due to lack of effective and affordable alternatives. Rapid urbanization has further increased the burden on sewer infrastructure, making safe and efficient cleaning solutions essential.

The AI-Based Manhole Cleaning Robot is designed to eliminate human involvement in hazardous sewer cleaning tasks. The system integrates Artificial Intelligence, computer vision, embedded systems, and robotics to autonomously detect and clean sludge and blockages.

It is capable of real-time monitoring, autonomous navigation, and remote operation through a dashboard. The system is designed to be cost-effective, scalable, and suitable for Indian sewer conditions. This project contributes to smart city development and ensures worker safety while improving sanitation efficiency.

Objectives:

1. Eliminate Manual Scavenging
2. Enhance Worker Safety
3. Provide Real-Time Monitoring
4. Improve Operational Efficiency

Methodology:

The system is developed using both hardware and software integration. A Raspberry Pi 4 acts as the central controller, processing sensor data and running AI algorithms. The robot uses a waterproof camera for capturing real-time images, which are analysed using computer vision techniques to detect sludge and debris.

The cleaning system consists of a submersible water pump for jetting and suction, along with a servo-controlled gripper for removing solid waste. A linear actuator provides vertical movement.

Result and Conclusion:

The AI-Based Manhole Cleaning Robot was successfully developed and tested. The system was able to detect sludge and debris effectively using AI and perform autonomous navigation inside the manhole without human intervention.

The cleaning mechanism worked efficiently by removing sludge and solid waste using suction, jetting, and gripper actions. The robot was able to operate continuously for a sufficient duration using battery power.

Overall, the project demonstrates that the proposed system can safely replace manual manhole cleaning, improve worker safety and provide an efficient and reliable sanitation solution.

References:

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- [2]. *“Cleaning Robots: Sensor Technologies and Intelligent Control Strategies—A Review,”* based on Megalingam et al., *Journal of Field Robotics*, 2025.
- [3]. *“Design of an Autonomous Mobile Cleaning Robot with Obstacle Avoidance,”* based on Joon and Kowalczyk, *Applied Sciences*, 2021.

Future Scope:

The system can be further improved by integrating advanced AI models for higher accuracy and faster detection. Cloud integration can enable remote access and data analytics for predictive maintenance. A mobile application can be developed for easier control and monitoring. Solar charging or improved battery systems can extend operational time.

The system can also be scaled for larger sewer networks and integrated into smart city infrastructure. Future research can focus on improving efficiency, reducing cost, and commercializing the product for widespread use.