

**IOT BASED MANHOLE DETECTION AND MONITORING SYSTEM**

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Abstract:

Urban areas frequently face safety risks due to open manholes and increasing environmental pollution. This project proposes an IoT-based Manhole Detection and Monitoring System to enhance urban safety and environmental management. The system uses a raspberry pi camera module integrated with a Raspberry Pi 4 model B to detect manholes through a deep learning model based on YOLO (You Only Look Once). The trained CNN model identifies open and damaged manholes in real time and ensures immediate detection. In addition, pollution levels in specific areas are monitored using environmental sensors. If excessive pollution is detected, the CNN model analyzes the data, predicts the severity level, and automatically generates a report. When abnormal conditions such as open manholes or high pollution levels are identified, the system sends instant text message alerts to the authorities through Email. This enables quick action, reduces accident risks, and helps control environmental hazards. The proposed system provides a smart, automated, and cost-effective solution for urban area monitoring and smart city development

Keyword: Manhole Detection, Pollution Monitoring, Artificial Intelligence (AI), YOLO Algorithm

1. INTRODUCTION

With the rapid expansion of urban areas and increasing population, the demand on municipal infrastructure has grown significantly, particularly in developing nations. Among these



infrastructures, underground drainage and sewage systems are crucial for ensuring proper sanitation, public health, and environmental protection. Manholes act as important access points for inspection, cleaning, and maintenance of these systems. However, due to inadequate monitoring and delayed maintenance, manholes often pose serious safety and environmental risks.

Uncovered, damaged, or misaligned manhole covers can result in dangerous accidents for pedestrians, vehicles, and maintenance workers. These risks become even more severe during nighttime or adverse weather conditions such as heavy rainfall, where visibility is limited. Moreover, issues like blockage in drainage systems can lead to overflowing manholes, causing water stagnation, spread of harmful diseases, and increased pollution levels. Conventional manual inspection methods are not only labor-intensive but also inefficient and unreliable, making it necessary to adopt smarter and automated solutions.

The emergence of Internet of Things (IoT) technology offers a powerful approach to overcome these challenges. IoT facilitates the connection of sensors, communication networks, and data processing systems to enable real-time monitoring and intelligent decision-making. In the context of manhole monitoring, IoT-based systems can utilize sensors such as ultrasonic sensors to measure water levels, gas sensors to detect hazardous gases like methane, tilt sensors to identify displacement of manhole covers, and temperature sensors for environmental monitoring.

The collected data is transmitted through communication technologies visualized through dashboards or mobile applications. This enables authorities to receive instant alerts and take prompt action when abnormal conditions are detected. Thus, an IoT-based manhole detection and monitoring system provides a reliable, efficient, and proactive solution for improving urban safety and infrastructure management

2. LITERATURE SURVEY

Harish Ragavendra M. (2026) [1] proposed an IoT-based smart manhole monitoring system for detecting hazardous gases and temperature inside underground drainage systems. The system utilized methane (CH_4), hydrogen sulfide (H_2S), and carbon monoxide (CO) gas sensors along with a temperature sensor to continuously monitor manhole conditions. The collected data was transmitted through an IoT platform, enabling real-time monitoring and timely alerts to improve worker safety and prevent accidents.

Praveenkumar, Praveen Takhar, Sathvik N. G., Thokchom Mobisana, and Mrs. Thrisha V. S. (2025) [2] developed an IoT-based manhole detection and monitoring system for urban safety using Arduino Uno/ESP32, MQ-series gas sensors, ultrasonic sensors, DHT sensors, and wireless communication technologies such as GSM, Wi-Fi, and LoRa. The system also integrated Firebase and ThingSpeak dashboards to provide continuous monitoring, detect gas leakage, sewage overflow, and manhole cover displacement, and send instant alerts to the concerned authorities.



Rasel Hossen, Diptajoy Mistry, Mushiur Rahman, Waki as Sami Atikur Rahman Hridoy, Sajib Saha, and Muhammad Ibrahim (2025) [3] introduced a deep learning approach for road damage and manhole detection using the YOLOv9 object detection algorithm. Their work employed polygonal image annotation, Roboflow, Ultralytics, Python, and computer vision techniques to accurately identify damaged roads and open manholes. The proposed AI-based model improved detection accuracy and supported smart city applications by enabling automatic hazard identification.

S. Manikanta Swamy and E. Hari Chandana (2024) [4] proposed a smart manhole surveillance system using IoT technology. The system incorporated a camera module and LoRa-based communication to monitor manhole conditions continuously. It enabled remote surveillance, early fault detection, and long-distance communication, thereby improving maintenance efficiency and enhancing public safety.

Guru Prasath V.A. and Sowmya H.D. (2022) [5] presented an IoT-enabled manhole detection and monitoring system using NodeMCU (ESP8266), MQ-2 gas sensor, ultrasonic sensor, infrared sensor, GPS, GSM module, and ThingSpeak cloud platform. The system continuously monitored toxic gases, sewage level, and manhole cover status while providing real-time notifications through cloud services and SMS alerts to municipal authorities.

Abhishek Natu, Chaitanya Deshpande, Prof. Gajanan Chavhan, and Prof. Ketki Kshirsagar (2024) [6] designed an IoT-based manhole monitoring system using ESP8266 NodeMCU, SIM800L GSM module, waterproof ultrasonic sensor, KY-017 tilt sensor, MQ-2 gas sensor, GPS module, and the Blynk IoT platform. Their system monitored manhole cover displacement, gas leakage, water level, and geographical location while providing live monitoring through a mobile application.

M. S. Monishree and B. Maneshwaran (2023) [7] developed an IoT-based manhole monitoring system that utilized pH and gas sensors to monitor underground sewer conditions. The proposed system focused on detecting hazardous gases and measuring wastewater quality, enabling authorities to receive early warnings regarding abnormal sewer conditions and improving maintenance planning.

P. Kumar and S. Singh (2022) [8] proposed a solar-powered IoT-based smart manhole monitoring system that addressed the power requirements of conventional monitoring systems. By integrating solar panels with IoT sensor nodes, the system achieved continuous monitoring using renewable energy while reducing operational costs and improving energy efficiency.

Ruheena M. A., Rukhayia Sheereen, Sheeba Kulsum, and T. Komala (2021) [9] developed a manhole detection and monitoring system using Arduino Uno, DHT11 temperature sensor, MQ-2 gas sensor, water level sensor, GSM module, GPS, LCD, relay module, and IoT technology. The system continuously monitored environmental parameters inside the manhole and transmitted



warning messages whenever dangerous conditions such as toxic gas leakage or water overflow were detected.

Wesam Moneer Rasheed, Raed Abdulla, and Low Yee San (2021) [10] proposed a computer vision-based manhole cover monitoring system over IoT. Their system combined MATLAB, HOG feature extraction, Naïve Bayes classification, Arduino Mega, SIM808 GSM/GPRS module, GPS, and the Blynk IoT platform to detect missing or displaced manhole covers automatically. The proposed approach demonstrated that integrating computer vision with IoT significantly improves the accuracy and efficiency of manhole monitoring systems.

3. PROPOSED METHODOLOGY

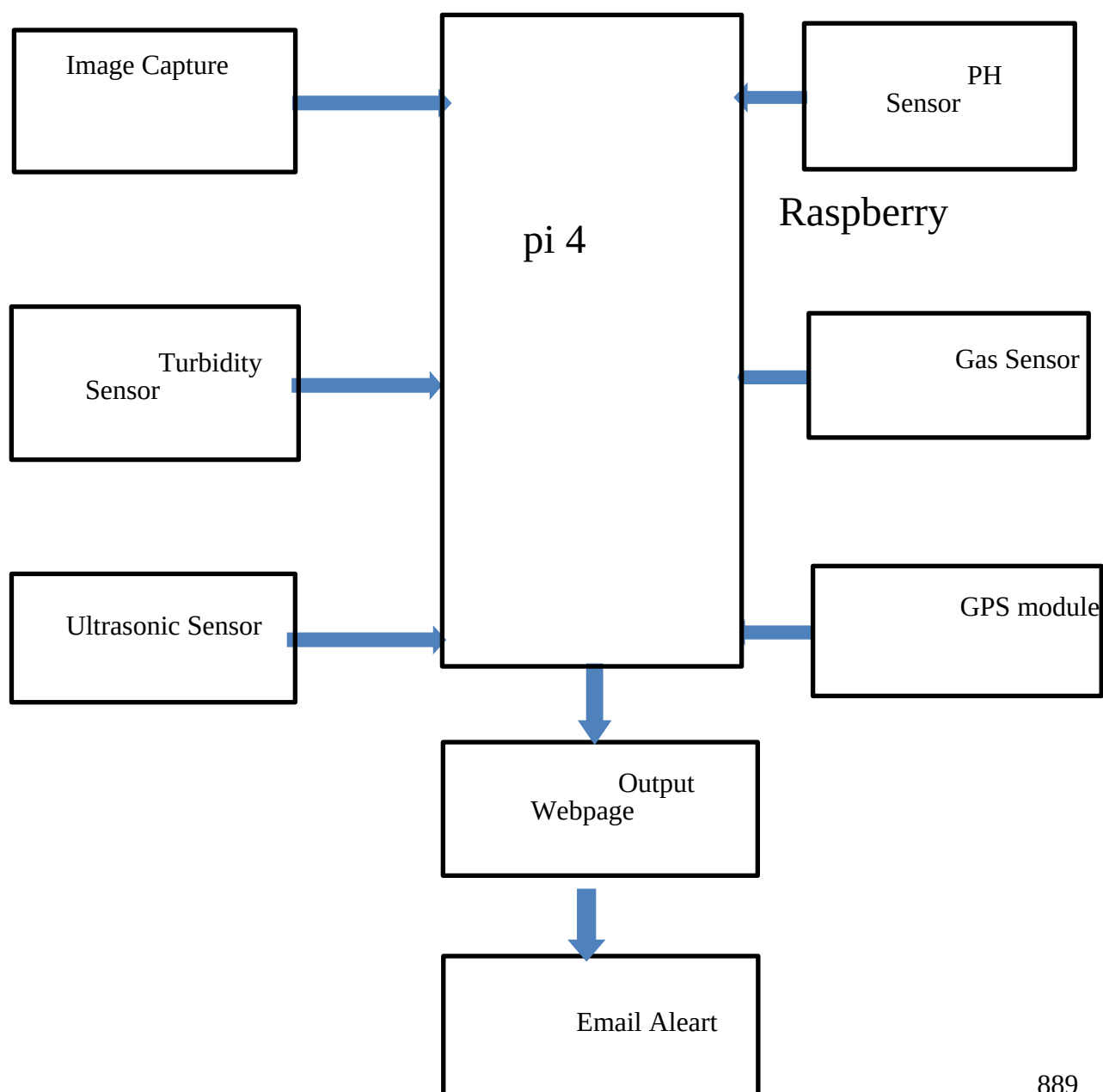




Figure.1 Block Diagram of Manhole Detection

The proposed IoT-Based Manhole Detection and Monitoring System is developed to enable smart monitoring of urban drainage infrastructure by integrating Internet of Things (IoT) technology, Artificial Intelligence (AI), computer vision, and cloud computing. The system operates through a sequence of processes that include image capture, manhole detection, condition classification, real-time decision-making, cloud data management, and automated alert generation.

The process begins with continuous image acquisition using cameras strategically installed at different manhole locations. These cameras continuously record live video streams in standard formats such as MJPEG and transmit the footage to a processing unit. Individual frames are extracted from the video stream for further analysis, allowing uninterrupted monitoring of manholes without requiring manual inspection.

After acquiring the video frames, the system applies computer vision techniques to detect the presence of manholes. A trained AI model analyzes each frame to identify and locate manholes by determining their exact position within the image. Once detected, the manhole region is separated from the surrounding background so that only the relevant area is processed. This approach reduces unnecessary computations and improves the overall detection accuracy.

The extracted manhole image is then passed to the classification stage, where its physical condition is evaluated. Using deep learning and image-processing algorithms, the system examines visual characteristics such as lid alignment, surface cracks, displacement, deformation, and open spaces. Based on these features, the AI model categorizes the manhole into predefined classes, such as Safe/Closed or Open/Damaged, while also generating a confidence score that indicates the reliability of the prediction.

Following classification, the system performs real-time analysis to determine the severity of the detected condition. If the manhole is identified as closed and undamaged, the status is recorded as normal. Conversely, if the model detects an open or damaged manhole, the system immediately marks it as a critical hazard. This rapid evaluation enables timely identification of dangerous situations, helping authorities respond before accidents occur.

All detection results, including captured images, classification outcomes, timestamps, location information, and confidence scores, are then transmitted to a cloud platform. The cloud server functions as the central data management and processing unit, providing secure storage, remote accessibility, and scalable infrastructure for long-term monitoring. It also supports centralized analysis and maintains historical records that can be used for maintenance planning and performance evaluation.

To improve the reliability of the monitoring system, IoT sensors installed inside or around the manhole continuously measure environmental conditions. These sensors monitor parameters related to the manhole's operational status and provide additional confirmation of its condition. By combining sensor data with AI-based image analysis, the system achieves more accurate and



dependable monitoring, reducing false detections and enabling efficient infrastructure management.

4. CONCLUSION

The proposed IoT-Based Manhole Detection and Monitoring System provides an intelligent and efficient approach for improving the monitoring and maintenance of urban drainage infrastructure. By combining Internet of Things (IoT) technology, environmental sensors, computer vision, and deep learning techniques, the system facilitates continuous, automated, and real-time monitoring of manhole conditions. It is capable of identifying critical situations such as open or damaged manholes, detecting hazardous gas leakage, monitoring abnormal water levels, and assessing environmental pollution.

The integration of a Raspberry Pi with a camera module and a YOLO-based object detection model enables accurate and rapid identification of manholes under different environmental conditions. Additionally, the deployed sensors continuously collect environmental data, improving the reliability of the monitoring process and providing comprehensive information about the manhole's operational status.

The system is designed to generate immediate notifications whenever hazardous conditions are detected, allowing municipal authorities to take prompt corrective action. This significantly reduces the possibility of accidents, enhances public safety, minimizes environmental risks, and improves the overall efficiency of maintenance operations.

In comparison with conventional manual inspection methods, the proposed solution offers higher accuracy, faster response time, reduced operational costs, and lower dependence on human intervention. Furthermore, the system aligns with the objectives of smart city development by enabling automated infrastructure monitoring, supporting data-driven decision-making, and promoting efficient management of urban drainage networks. Overall, the proposed system contributes to creating safer, more sustainable, and technologically advanced urban environments.

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