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Urban Eye: Manhole Surveillance with IoT

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Abstract

Every nation hopes to implement the idea of the "smart city" on its own. Many different issues must be resolved to grow the seed into a large tree. The drainage system is one of them, and it is essential. With the right drainage system, even a tiny region can make a significant contribution to society. A sewer system can be accessed through manholes. Manholes are the best approach to access the underground pipes if there are any obstructions in the drainage systems. If the obstructions are not removed, the sewage water will overflow by way of drains, which will aggravate both cars and residents. Even inclined manhole lids pose risks as they contribute to accidents. Moreover, the safety of sanitation workers entering these manholes is compromised due to a lack of awareness regarding the toxicity levels of sewage or drainage water. Although remedies for these issues exist, they rely on the initiative of authorities. The challenge lies in alerting the authorities to these problems promptly. This is precisely where our proposed system comes into play. By employing advanced sensors, we can continuously monitor the sewage water levels beneath the manhole covers. When these levels surpass a predefined threshold, an automatic alert is dispatched to the relevant authorities. The appropriate authorities receive fast updates as the condition of the manhole cover and the toxicity of the drainage water are thoroughly tracked simultaneously. To keep the general public informed about the status of these manholes, we have developed a user-friendly application. Through this app, individuals can access real-time information about the conditions of manholes near them.

Keywords: Manhole, scavengers, sewage, authorities, GSM

INTRODUCTION

Efficient drainage systems constitute a pivotal component of the smart city evolution. Manholes, serving as gateways for sanitation workers to access subterranean pipelines for blockage clearance, present several pressing challenges. Overflowing drainage water, improper manhole lid placement, and hazardous levels of toxic content in the water are critical concerns. The fusion of Internet of Things (IoT) and sensor technology can be used to resolve these problems. In numerous regions, inadequate sewage infrastructure leads to grave repercussions including accidents and extensive damages. Many manholes suffer from inadequate lid securing, a situation exacerbated by the tilting of manhole covers that results in severe accidents and physical injuries. Furthermore, the perilous toxicity levels within drainage water pose a significant threat to the lives of sanitation workers who venture into these spaces without proper knowledge.

Manual detection and ongoing monitoring of manhole-related issues is an arduous undertaking, demanding a constant human presence at each site. This project's central objective revolves around

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crafting a comprehensive solution that seamlessly oversees sewage water levels beneath manhole covers, detects cover tilting, and assesses the toxicity level of gas inside the manhole.

The employment of ultrasonic sensors is pivotal in gauging drainage water levels. Once the water surpasses defined thresholds, an immediate alert notification is dispatched to the relevant authority. This alerting mechanism is facilitated through the utilization of a Node MCU at the sensor output. By comparing the measured levels with predetermined thresholds, this module triggers a GSM alarm message to the responsible personnel, all of which is seamlessly tracked and coordinated via IoT infrastructure [1, 2].

Additionally, this device has a tilt sensor to detect whether the lid of the manhole is slanted and a gas sensor to detect the presence of gas in the manhole so that the toxicity can be monitored. If any of these exceed the defined value, an SMS is issued via the SIM800l GSM module that connects to an authority number. To make people aware of the manhole faults, all the data is uploaded to the cloud and an application is developed using MIT Inventor. The consequences of fault in the manhole system are:

- The reason even though the location is accessed, early warnings of a blockage are not obtained.
- It is challenging to pinpoint the exact position of a blockage whenever it occurs. The ramifications of delayed information include prolonged repair processes.
- Complete pipe blockages lead to highly cumbersome scenarios.
- Modern drainage systems lack advanced technological integration.
- Malfunctioning drainage lines pose substantial hardships for the populace [3].

PROBLEM STATEMENT

Manholes are an essential part of urban infrastructure that enables access to underground utilities such as water, gas, and sewage systems. However, they pose a significant safety hazard as they can cause accidents and fatalities if left unmonitored. To address this issue, a manhole monitoring system can be implemented to constantly monitor the condition of manholes and provide real-time alerts in case of any potential safety hazards. In the remainder of this declaration, we'll look at how to put in place a system for monitoring manholes that can efficiently find and notify any anomalies. Existing drainage systems lack the capacity for real-time monitoring, potentially resulting in overflow and blockage occurrences.

- Inadequate monitoring further exposes the community to dangers like the accumulation of toxic gases within manholes, posing health threats.
- Concerning manhole lids, an askew or improperly secured cover not only endangers pedestrians and vehicles but also triggers drainage system complications. This situation, once it arises, becomes exceedingly challenging to manage [4].

OBJECTIVE

- To monitor the water flow rate to avoid the overflow of drainage water.
- To keep an eye on if there is gas in the trapdoor so that the poisoning can be kept an eye on.
- To check whether the manhole lid is tilted or closed properly.
- To upload the readings of the sensors to the cloud using the ThingSpeak app and to design an app using MIT Inventor.

LITERATURE REVIEW

Design and Development of Uncapped Manhole Detection System for Waterlogged Road (Habib Shahorier Tasin) [5]

Description: The prime objective of this envisioned system is to safeguard individuals from such mishaps. It offers an intelligent mechanism capable of overseeing open manholes and promptly alerting both the user and the local municipal authority. In case of anomalies, it presents notifications on an OLED display while a buzzer emits sound signals to apprise the user. Unquestionably, this device significantly elevates public safety and stands out as an economical and easily navigable remedy.

Constructed a Suggestion for Connected Device Cesspool Detection System for Bangladesh (Saadnoor Salehin) [6]

Description: This study introduces a smart automated monitoring system for manholes. It shows the manhole's toxic vapors and dangerous substances, commonly as well as the fact that its lid is missing. In response, it triggers an alarm for nearby pedestrians, informs the relevant authorities, and thereby contributes to enhancing the local environment's overall quality. Consequently, the responsible entities can implement necessary actions for manhole maintenance. The system was deployed within an academic setting to assess its automated monitoring capabilities and the features proposed.

An Intelligent IoT-based Drainage and Fitness Detection System for Manual Scavengers (Sharma Pankaj Kumar Ramadhin) [7]

Description: Utilizing an array of sensors including ultrasonic sensors for waste level assessment, gas sensors for noxious gas detection, along with pulse and heartbeat sensors, buzzer, fan, and Arduino, this solution comes into play. Once the predefined threshold is breached, the alert buzzer activates, and data is showcased on an IoT webpage. This unique approach stands apart from conventional systems, offering a comprehensive resolution to drainage challenges. Parameters encompass waste levels, flow dynamics, and hazardous gases, all detrimental to human well-being. Anchored in IoT, the entire setup is orchestrated via Arduino, interfacing with sensors to continually update cloud-stored data. Real-time alerts through SMS, email, and IoT platforms are dispatched proactively, preempting drainage overflow. This proves beneficial not only to manual scavengers but also to residents grappling with drainage concerns in their respective localities. The seamless integration of diverse sensors, Arduino, and IoT ensures a holistic solution.

SYSTEM DESIGN

Block Diagram

In Figure 1, the block diagram represents the major components of the underground drainage monitoring system [8].

WORKING

Sensors actively oversee the manhole in the proposed framework, with data being automatically updated onto NodeMCU. When sensor values surpass the set threshold, the NodeMCU receives the corresponding signal. The NodeMCU's output interfaces with the GSM module, transmitting sensor data to ThingSpeak, where it is presented graphically and stored on the web server and cloud through ESP 8266 [9]. Notifications are dispatched to relevant authorities concerning manhole issues. Leveraging the MIT Inventor application, common people can seamlessly pinpoint problematic manholes and undertake necessary measures. This app presents real-time sensor data, aiding people in promptly identifying concerns related to water flow, gas presence, or lid positioning (Table 1).

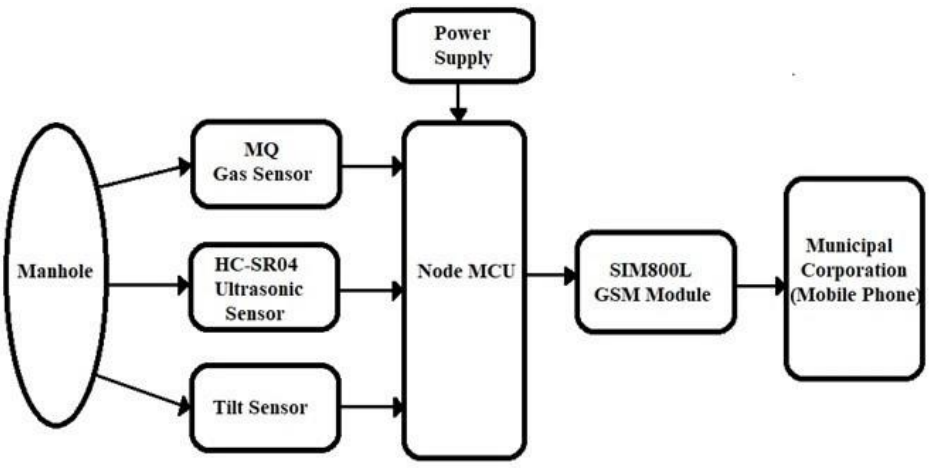

Figure 1. Block diagram of the proposed system.

Table 1. System specification.

Software	Hardware
Arduino IDE	NodeMCU
ThingSpeak App	SIM800L GSM module
MIT Inventor	XL6009 booster module
Semiconductor sensors	MQ gas sensor
Arduino module	KY-017 mercury tilt sensor module
Ultrasonic sensor	JSN SR-04T waterproof ultrasonic sensor
Batteries	18650 cell and cell holder

Node MCU

NodeMCU serves as an open-source firmware and development board, facilitating the creation of IoT devices. Built upon the ESP8266 Wi-Fi module, the NodeMCU board incorporates a built-in Lua interpreter. Sporting a robust processor, 4MB of flash memory, and integrated Wi-Fi capabilities, it also includes an embedded USB-serial converter, simplifying programming and debugging processes. With affordability and adaptability, NodeMCU stands as an excellent choice for IoT projects, supporting straightforward programming via the Arduino IDE or the Lua scripting language (Figure 2).

SIM800L GSM Module

The SIM800L module is a compact and versatile GSM solution, enabling wireless communication via GSM/GPRS networks [10]. Covering 850/900/1800/1900 MHz frequencies, it achieves data transmission speeds of up to 85.6 kbps. With support for protocols like TCP/UDP, HTTP/FTP, and MQTT, it is well-suited for diverse applications. It integrates a SIM card slot, supports voice and SMS, and its energy-efficient design suits battery-powered setups (Figure 3).

XL6009 Booster Module

The XL6009 booster module functions as a DC-DC step-up converter, elevating input voltage to a higher output. Supporting up to 32 V input and 35 V output, it incorporates a high-frequency switch, inductor, and capacitor for efficient power conversion [11]. With an adjustable output voltage potentiometer and LED power indicator, it is commonly employed in projects to power high-voltage devices from lower sources (Figure 4).

MQ4 Gas Sensor

The MQ4 gas sensor is a widely used gas detection sensor for detecting methane, natural gas, and LPG. It operates on chemo-resistance, employing a sensing material that reacts to gas presence, inducing resistance changes. This variation in resistance is quantified to ascertain gas concentration. Compact, affordable, and user-friendly, the MQ4 gas sensor is favored in gas detection due to its effectiveness (Figure 5).

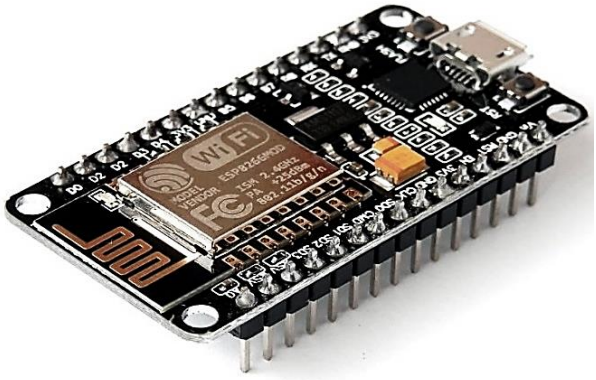

Figure 2. NodeMCU (ESP8266).

Figure 3. SIM800L GSM module.

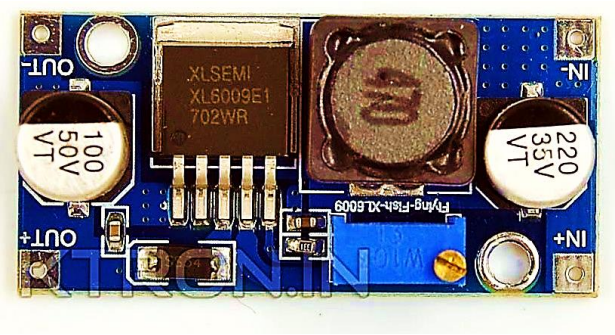

Figure 4. XL6009 booster module.

Figure 5. MQ4 gas sensor.

Figure 6. KY-017 mercury tilt switch module.

Figure 7. JSN SR-04T waterproof ultrasonic sensor.

KY-017 Mercury Tilt Switch Module

The KY-017 mercury tilt switch module is an electronic element adept at detecting object tilt or movement. Comprising a small cylindrical glass tube housing a mercury droplet and two connection pins, it functions by tilting to bring the mercury into contact with the pins, closing the circuit, and triggering a signal to the linked device [12]. Equipped with an LED indicator, it illuminates when activated. Frequently utilized in motion detection, alarm setups, and robotics projects for its efficacy (Figure 6).

JSN SR-04T Waterproof Ultrasonic Sensor

The JSN SR-04T waterproof ultrasonic sensor is a distance measurement device employing ultrasonic waves. Housed in a waterproof casing, it is apt for wet settings. With a 4.5-meter detection span and 0.5 cm precision, it features a compact layout. Operating on 3 V to 5.5 V voltage and consuming less than 15 mA, it boasts efficiency. Communication with microcontrollers occurs through a standard TTL UART interface (Figure 7).

18650 Cell and Cell Holder

A lithium-ion battery with the form of a cylinder and dimensions of 18 mm by 65 mm is called an 18650 cell. Comprising a cathode, anode, separator, electrolyte, and casing, it permits lithium-ion movement for charge and discharge. In contrast, a cell holder is a structure, often plastic or metal, securing the 18650 cell. It typically features multiple metal contacts for positive and negative terminal connections. Additionally, the holder may include tabs, leads, or wires for simplified integration into electronic circuits (Figure 8).

Figure 8. 18650 cell and cell holder.

METHODOLOGY

The subterranean drainage monitoring system anticipates and prevents drainage water overflow within manholes through data analysis. It aids authorities in addressing tilted manhole covers and assessing gas levels. Employing ultrasonic, tilt, and gas sensors interfaced with Node MCU, the system gains intelligence.

Upon sensor readings hitting threshold levels, GSM dispatches alert messages to relevant authorities. Continual cloud data uploads facilitate round-the-clock manhole status updates for officials. A mobile application allows general public awareness regarding manhole issues (Figure 9).

RESULTS AND DISCUSSION

The benefits of the Urban Eye system in revolutionizing manhole surveillance through IoT technology and its potential to enhance urban infrastructure management and public safety.

The circuit is configured on the breadboard, initiating data acquisition by sensors upon the power supply. These inputs are relayed to Node MCU, which connects to Wi-Fi for continuous data updates in the ThingSpeak app. The data exhibited in ThingSpeak concurrently reflects in the mobile app. If any value surpasses the predetermined threshold, a GSM-powered alert is dispatched to relevant authorities, ensuring swift response (Figures 10 to 12).

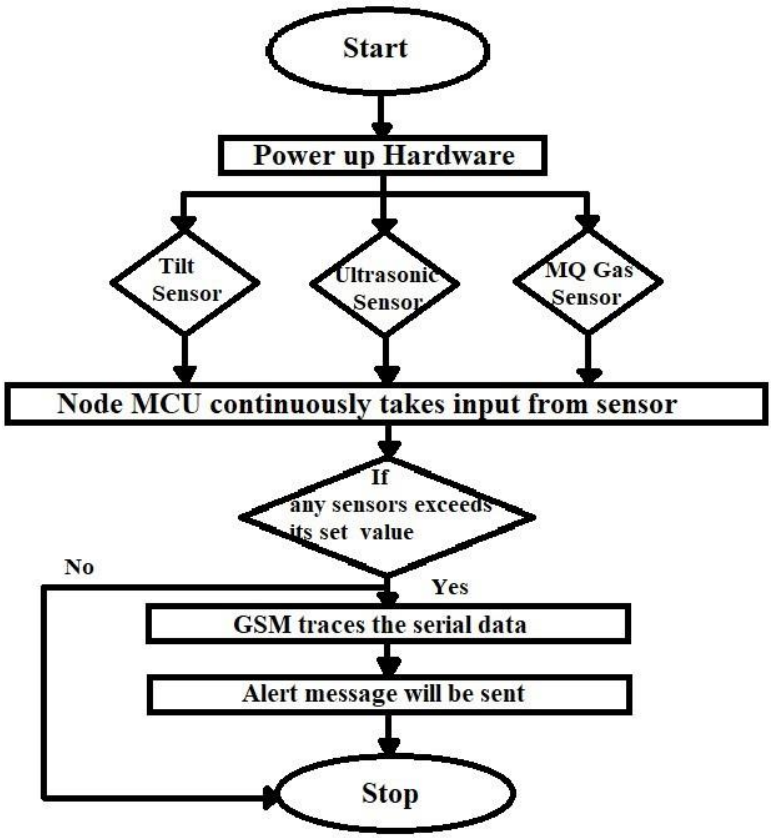

Figure 9. Flowchart of the proposed module.

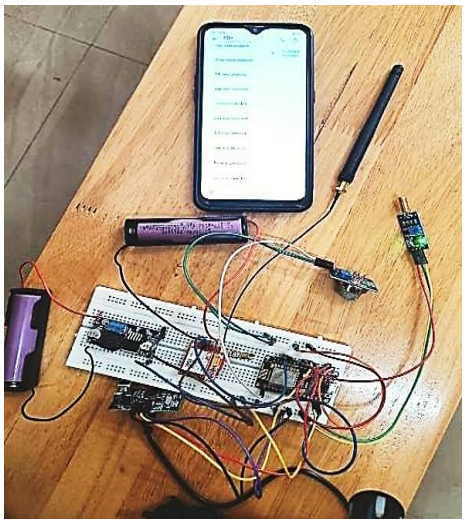

Figure 10. Message alert for gas level, water level, and tilt in the manhole cover.

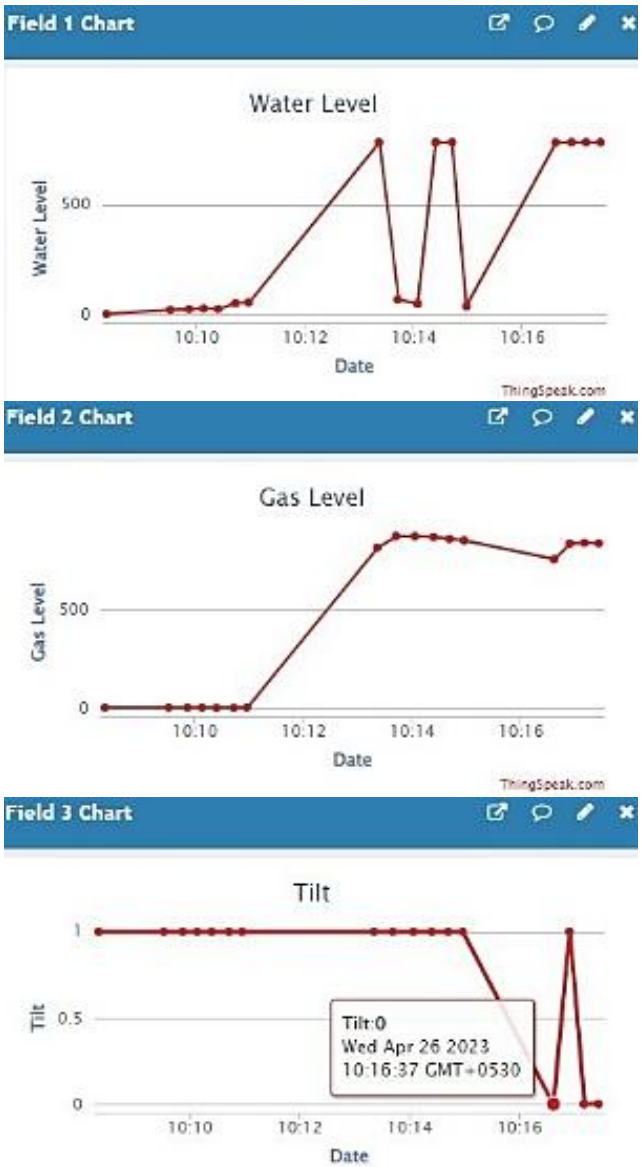

Figure 11. Data updated on the ThingSpeak App.

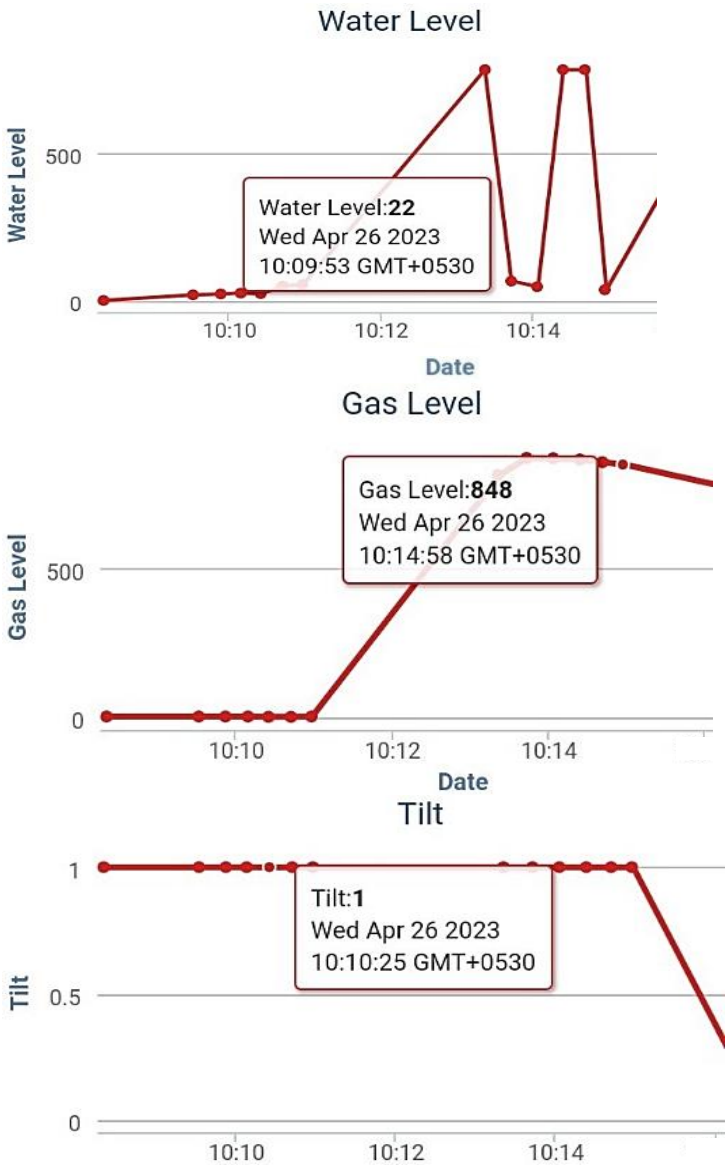

Figure 12. Data in the mobile application.

CONCLUSION

The application outlines various real-time uses such as instant identification of underground drainage and manhole issues. Parameters like tilted manhole covers, toxic gases, sewage water levels, and flow are continuously tracked and transmitted via ThingSpeak. This empowers authorities to promptly address concerns. By reducing unnecessary visits to manholes and enabling timely interventions, regular drainage checks are streamlined, averting risks. The unique aspect lies in conveying faults not only to authorities but also to the public via the MIT Inventor app, fostering awareness and distinguishing our project.

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