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IOT Based Manhole Detection and Monitoring System

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Abstract: *Smart underground infrastructure is an important feature to be considered while implementing a smart city. Manhole system monitoring is vital to keeping the city clean and healthy. The IOT-based manhole detection and monitoring system is an innovative solution that aims to enhance public safety by monitoring the condition of manholes in real time. The proposed system consists of sensors inside the manholes and can detect various parameters. The sensor data is transmitted through IOT technology to a digital device. Hence, the system has the potential to reduce the risk of accidents and improve the efficiency of maintenance tasks by providing valuable insights into the condition of the manholes*

Keywords: IoT, Sensors, GSM module, Manhole, LM35, MQ4, Digital device, Arduino Uno, Monitoring system, Atmega328P.

I. INTRODUCTION

IoT (Internet of Things)-based manholes are a smart solution that helps monitor the condition of manholes in real time. Manholes are an essential part of urban infrastructure and play a crucial role in safely disposing of wastewater and stormwater. However, manholes are often neglected and poorly maintained, leading to several issues like clogging, flooding, and accidents.

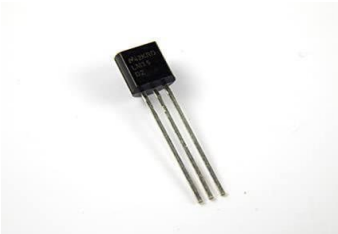
Drain obstructions hamper people's routine activities. Thus, a facility inside the city corporation should alert the officials about sewer blockages. The main areas acknowledged include alerting others to poisonous gases, determining whether the manhole cover is tilted, and rising temperatures.

With IoT-based manhole technology, sensors and devices can be installed in manholes to collect data and provide real-time insights. For example, sensors can monitor the temperature, detect manhole cover tilts, detect high water levels, or track the presence of toxic gases such as methane. The data collected by these sensors can be transmitted to an Arduino Uno. Furthermore, the GSM Module sends a notification to a digital device if it crosses the threshold value through IOT technology. Overall, IOT-based manhole covers offer many benefits, including improved safety, increased efficiency, and reduced maintenance costs. These smart technologies will likely become more widespread as cities and infrastructure connect.

II. SENSORS AND DATA COLLECTION

IOT-based manhole systems use various types of sensors to monitor different parameters that help in monitoring the condition of manholes in day-to-day life. The following sensors are used in the IOT-based manhole project.

A. Temperature Sensor -LM35



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The LM35 sensor is a type of temperature and humidity sensor that can be used in an IoT-based manhole system. This sensor is a digital sensor that can be easily interfaced with microcontrollers. The LM35 sensor can measure the temperature and humidity level inside the manhole. This information can detect abnormal conditions inside the manhole, such as high humidity or high-temperature levels, which can lead to potential hazards for workers.

B. Gas Sensor -MQ4

This is a simple-to-use, low-cost gas sensor suitable for detecting the concentration of various gases in the manhole, including methane, hydrogen sulfide, and carbon monoxide. The MQ4 gas sensor has a detection range of 300 to 1,00,000 ppm for combustible gases. The MQ4 gas sensor is based on a heating element and a semiconductor gas sensor. The heating element is used to heat the sensing element, which consists of a metal oxide semiconductor. When a combustible gas or smoke encounters the sensing element, the electrical resistance of the element changes, which is then measured by a microcontroller.

C. Tilt Sensor

A tilt sensor can be used in an IoT-based manhole system to detect changes in the orientation or tilt angle of the manhole cover. The tilt will be detected if the position of the sensor attached to the manhole cover changes.

D. Water Level Sensor

A water level sensor is a device used to measure the level or depth of water in a tank, reservoir, or any other container. It is commonly used in industrial and commercial applications, as well as in home automation systems. The sensor works by detecting the presence or absence of water, and it can be designed to provide a digital or analog output signal. They are relatively simple and inexpensive devices that provide reliable and accurate level sensing, making them popular in many industries.

III. PROBLEM STATEMENT

Manholes are essential to a city's infrastructure, providing access to underground utilities such as sewer lines, water mains, and electrical cables. However, they can also pose a safety risk if not adequately maintained. Traditional methods of monitoring manholes, such as manual inspections, can be time-consuming, costly, and sometimes hazardous for workers.

An IoT-based manhole system aims to address these challenges by providing a more efficient and safer way to monitor manholes. The system will use various sensors to collect data on the manhole's condition, including water level, temperature, and gas concentration. This data will be transmitted wirelessly to a central location for analysis and action.

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The main problem that the IoT-based manhole system will address is monitoring manholes continuously to detect potential safety hazards and maintenance needs. The system will also provide real-time updates on the manhole's status, enabling authorities to take swift action in emergencies or to address issues.

Furthermore, the system will reduce the need for manual inspections, making the process more efficient and cost-effective. It will also reduce workers' risk of accidents and injuries, as they will not need to enter the manhole for inspections physically

IV. SYSTEM DESIGN

Designing an IoT-based manhole involves integrating various sensors and technologies to monitor the manhole's condition and alert authorities in case of any issues. We built a smart IOT-based manhole monitoring system using an Arduino Uno board. The Arduino Uno is connected to a series of sensors: a temperature sensor, a gas sensor, a water level sensor, and a tilt sensor. A power supply is given to the board, which an LED will indicate.

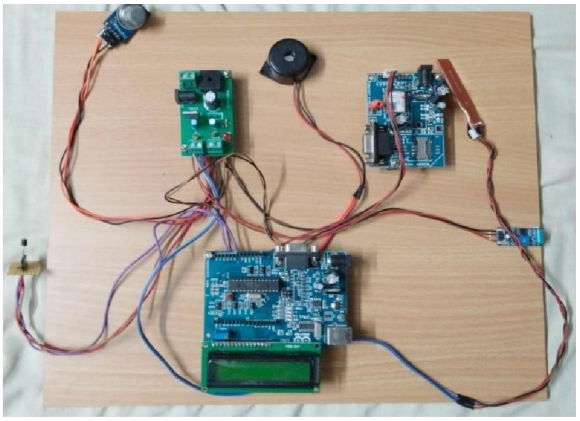

Fig.2: Schematic representation of IOT-based manhole monitoring system.

The LCD screen is attached to the board to accurately measure the parameters and alerts. Pre-determined fixed threshold values are configured in the Arduino code.When the sim is configured in the code, the GSM module is introduced and connected to the system, and it sends alerts to the digital device if it crosses the determined level or normal range obtained from the sensors.

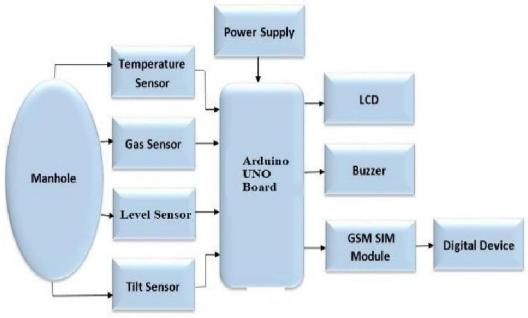

Fig.1: Experimental setup when the system is in the off position.

The experimental setup is a low-cost proposed system consisting of sensors and devices connected to the GSM module, which is transmitted to the digital device and alerts the officials with notifications to try to resolve the hazardous situations in manholes.

V. SYSTEM SPECIFICATIONS

Software Requirement:

- Arduino IDE Software
- Embedded C Language

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Hardware Requirements:

- Arduino Uno board
- Temperature Sensor (LM35)
- Water Level Sensor
- Tilt Sensor
- Gas Sensor (MQ4)
- LCD
- Power Supply
- Transformer/ Adaptor
- GSM Module (SIM)
- Digital Device

VI. WORKING PRINCIPLE

Working in an IOT-based manhole involves several components that provide real-time monitoring and analytics of critical parameters such as water level, gas concentration, and temperature level. The sensors collect data from the manhole and transmit it to an Arduino UNO, which interfaces with the sensors and collects data from them.

The Arduino Uno then transmits the collected data to a communication module such as a Wi-Fi or GSM module. It sends the data to a digital device through alert notifications if it crosses the pre-determined fixed threshold.

The collected data can be accessed and viewed in real time through a user interface such as a mobile app or a web portal. The user interface provides real-time alerts and notifications, allowing maintenance and safety teams to quickly identify and proactively address potential issues before they become major problems.

In addition, a control system can trigger actions such as pumping out water or shutting down the manhole system in an emergency. It can help improve urban infrastructure safety, efficiency, and sustainability.

STATISTICAL DATA

Table 1: Data consideration for tilt sensor

Material	Movement
Manhole Cover Tilted	Lid Open

Table 2: Data consideration for a gas sensor(PPM)

Gases	PPM	Toxicity
Methane	50,000 ppm	Explosive
Hydrogen Sulfide	500-1,000 ppm	Hazardous
Ammonia	250-300 ppm	Very Dangerous

Table 3: Data consideration for temperature sensor(°C)

Temperature (°C)	Range
0-30	Normal
30-60	Normal
60-70	Dangerous
70-above	Extremely Dangerous

Table 4: Data consideration for water level sensor

Water level	Range
0-50	Normal level
50 & above	Higher level

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VII. RESULT AND DISCUSSION

The IoT-based manhole detection and monitoring system is an innovative solution that addresses the issue of safety and maintenance of manholes in urban areas.

When the Adaptor (2 amps) is connected to the power supply unit, the power supply unit distributes the power with operating voltages 12V and 5V, as all the following sensors operate at 5V, and GSM Module operates at 12V.

Temperature sensor which is LM35 model is connected to the A0 analog pin of the Arduino and starts sensing the temperature (value will be displayed on LCD screen)

When we rise the temperature through heat (if it crosses beyond 60 degrees) indicating a dangerous level, an alert will be sent to the digital device with a buzzer sound.

Gas Sensor which is an MQ4 model (methane detector) which is connected to the A1 analog pin of the Arduino starts sensing the methane gas (value will be displayed on LCD Screen)

When we expose the methane substance toxicity to the sensor (if it crosses 50000PPM~ 50) indicating a dangerous level, an alert will be sent to the digital device with a buzzer sound.

Tilt sensor which is connected to the A2 analogpin of the Arduino detects the tilt or movement of the manhole and it automatically alerts through a notification with a buzzer sound. Level sensor which is connected to the Arduino senses the range of the water, (if it crosses the pre-determined threshold value of 50) indicating a danger zone in the manhole.

The sensor sends the notification through a GSM module to a digital device through a buzzer sound.

Based on the data received, the system can generate alerts to notify relevant authorities about potential safety hazards. It can also provide valuable insights into the condition of the manhole, allowing for timely maintenance and repairs.

The implementation of this system can significantly improve the safety of urban areas by reducing the risk of accidents related to manholes. It can also improve the efficiency of maintenance activities by providing real-time data on the condition of manholes.

In conclusion, the IoT-based manhole detection and monitoring system is a promising solution that can enhance public safety and improve the maintenance of urban infrastructure. Its implementation can lead to significant benefits in terms of safety, efficiency, and cost-effectiveness. Further research and development in this area can lead to even more advanced and effective solutions.

VIII. CONCLUSION

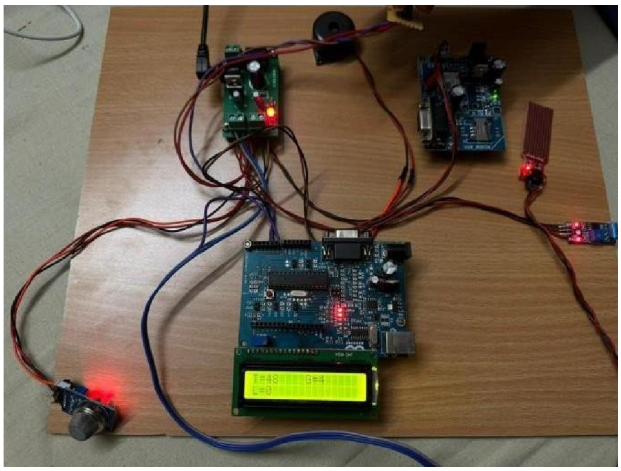

Fig 3: System sensors sensing information and displaying in the LCD.

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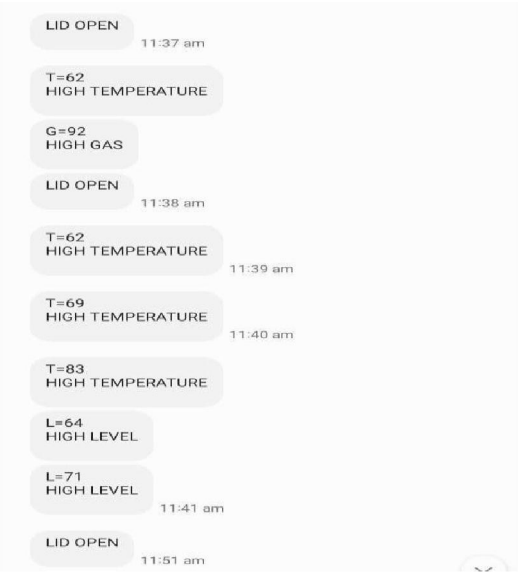

Fig 4: The system alerts the officials by sending notifications toa digital device.

IoT-based manhole systems have the potential to revolutionize the way we manage and maintain urban infrastructure. These systems can integrate various sensors, including water level sensors, to provide real-time monitoring and analytics of critical data points such as water levels, gas concentrations, and temperature variations. By collecting and analyzing this data, maintenance and safety teams can gain valuable insights into the system's functionality and take proactive measures to optimize its performance and minimize safety hazards.

These sensors can detect water levels, gas concentrations, and other critical data points and trigger alerts or actions when the levels reach a critical threshold. By integrating water level sensors into manhole systems, maintenance, and safety teams can quickly identify and proactively address potential issues before they become major problems.

Overall, IoT-based manhole systems can potentially improve urban infrastructure safety, efficiency, and sustainability. As technology advances, we can expect to see more and more applications of IoT-based systems in a wide range of industries, including infrastructure management. By leveraging the power of these technologies, we can build smarter, safer, and more sustainable cities for the future.

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