International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
Volume 37, Issue 01 and Publication Date: 4th January, 2025
An Indexed, Referred and Peer Reviewed Journal ISSN (Online): 2347-601X
www.ijemhs.com

Monitoring and Detection of Manhole Using IOT

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Abstract: In today's metropolitan smart cities, manholes and their maintenance have become a significant concern. A drainage monitoring system plays a crucial role in ensuring that cities remain clean and hygienic. One of the key challenges is assessing the current condition of manholes situated on roads. It has been observed that many manhole covers are either displaced or damaged. These faulty manholes pose a serious threat to road safety, increasing the likelihood of accidents. Moreover, improper sewage maintenance can lead to groundwater contamination, which may cause the spread of infectious diseases. During the monsoon season, blocked drains can severely disrupt public life. Therefore, there is a need for a system that can notify authorities about sewer blockages, their exact locations, potential gas leaks, rising water levels, and temperature variations.

The aim of this project is to develop an efficient system to prevent accidents caused by open or damaged manholes in densely populated cities. The system will incorporate various sensors to continuously monitor the status of manhole covers, thereby helping to prevent accidents. This solution minimizes manual labor while enhancing operational safety and efficiency. The implementation of this system will support timely responses and ensure the smooth functioning of municipal services.

Keywords: Arduino Integrated Development Environment, Alert messages, Sensor nodes, Adafruit, Wi-Fi & Internet of Things.

I.INTRODUCTION

A manhole, also referred to as a utility hole, maintenance hole, or sewage hole, is an entry point to confined spaces such as shafts, utility vaults, or large underground chambers. These are primarily used to access subsurface public utilities for inspection, maintenance, and upgrades. Common underground services connected through manholes include water supply, sewerage systems, telephone lines, electricity, stormwater drainage, district heating, and gas pipelines.

Currently, municipal authorities are facing increasing difficulties in managing these manholes due to unpredictable environmental conditions. For instance, sudden rainfall can cause a rapid rise in drainage levels, which may lead to overflow, blockages, or even accidents. In such scenarios, a manhole detection and monitoring system using IoT can prove to be highly beneficial.

This system enables real-time monitoring and assessment of manhole conditions without requiring physical human intervention, thereby enhancing worker safety. By utilizing various IoT-based sensors—such as water flow sensors, gas sensors, temperature sensors, and humidity sensors—the system continuously evaluates environmental and structural parameters within the drainage network.

The system addresses key limitations of traditional methods. For example, a water flow rate sensor is installed at node intersections to detect any irregularities in flow caused by blockages. When the measured flow exceeds a set threshold, the system triggers an alert at the control station, allowing quick action by the authorities. This automated detection system significantly reduces manual effort, speeds up response time, and protects the health and safety of municipal workers.

II.LITERATURE REVIEW

Internet of Things for Smart Environment Applications. Authors: Sunidhi Vashisth, Sunil Kumar Chawla, Bharti Mahjan, and Himani Chugh et al Description: The Internet of Things (IoT) is becoming an emerging technology due to the rapid use of the internet. IoT is a kind of “universal global network” that combines different things such as mobile, laptop, notepad, etc. IoT is a smartly integrated system that interacts with other machines, environments, objects, and infrastructure that comprises intelligent machines including radio frequency identification (RFID) and sensor network technologies [1]. In every company, people send emails and access websites, or other online means, and in most countries, the internet is available to transmit data across mobile devices and the Internet through easier, faster, and less costly systems. The main purpose of this object is to provide a detailed study of IoT along with its applications in different fields such as health, urban city, industry, transportation, and smart building.

A Smart IoT-based security system for residents aim is to develop an IoT-based security system for resident, which include biometric authentication, plate recognition, and a movement detection system. In this proposed method, the programming platforms such as Python, and Arduino, were used to develop to demonstrate the proposed system. The performance of the developed proposed system is evaluated by testing the system with several sample tests and from there, the performance was examined [2].

Towards the Implementation of IoT for Environmental Condition Monitoring in Homes an effective implementation of the Internet of Things used for monitoring regular domestic conditions by means of a low- cost ubiquitous sensing system. The description of the integrated network architecture and the interconnecting mechanisms for reliable measurement of parameters by smart sensors and transmission of data via the internet is being presented. The longitudinal learning system was able to provide a self-control mechanism for better operations of the devices in the monitoring stage. The framework of the monitoring system is based on the combination of pervasive distributed sensing units, an information system for data aggregation, reasoning, and context awareness. Results are encouraging as the reliability of sensing information transmission through the proposed integrated network architecture is 97%. The prototype was tested to generate real-time graphical information rather than a test bed scenario [3].

: The Smart city's development goal is to monitor the quality of resources in the city to improve good management and faster development of the city required necessity is to upgrade healthy and safe cities that deliver Realtime services and the latest facilities to implement the concept of the smart city use IoT concept by which easy wireless communication is possible. The system consists of sensors that collect different types of data from sensors and transfer them to the Raspberry Pi3 controller. The acquired output from the controller is sent to the control room through E-mail and also display on the personal computer [4].

The design space of wireless sensor networks, Wireless Communications Authors: Romer, K. Mattern Description: In the recent past, wireless sensor networks have found their way into a wide variety of applications and systems with vastly varying requirements and characteristics. As a consequence, it is becoming increasingly difficult to discuss typical requirements regarding hardware issues and software support. This is particularly

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problematic in a multidisciplinary research area such as wireless sensor networks, where close collaboration between users, application domain experts, hardware designers, and software developers is needed to implement efficient systems. In this paper, we discuss the consequences of this fact with regard to the design space of wireless sensor networks by considering its various dimensions. We justify our view by demonstrating that specific existing applications occupy different points in the design space [5].

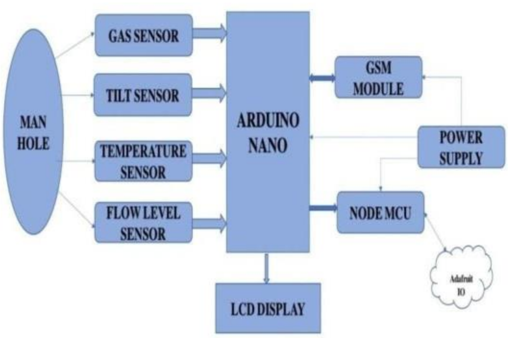
III.SYSTEM DESING

1.Working Principle

The underground drainage monitoring system is designed to enhance the health and safety of urban environments while also minimizing the workload of municipal staff. The system uses a network of smart sensors—including flow, tilt, temperature, and gas sensors—which are interfaced with an Arduino Uno microcontroller to form an intelligent, automated monitoring solution.

Each sensor is configured with a predefined threshold limit. When the environmental condition (e.g., gas level, water flow, temperature, or tilt due to a displaced manhole cover) exceeds the respective threshold, the sensor immediately transmits this data to the Arduino Uno. The microcontroller processes the information and identifies which parameter has breached its safe limit.

Once abnormal conditions are detected, the Arduino Uno triggers an alert signal and transmits the data—including the location of the affected manhole—to the municipal authorities or central monitoring system. This allows for quick response and maintenance, effectively preventing accidents, blockages, or health hazards caused by unattended manholes.



Additionally, an Arduino Nano is utilized to continuously monitor and update the live sensor readings from each manhole within a specific area using IoT connectivity. These real-time updates ensure constant surveillance without the need for manual inspections.

To provide on-site visibility, the system also features an LCD display that shows relevant messages and sensor status updates. This can help maintenance personnel during physical checks or when troubleshooting on the ground.

2.Description

a)Arduino IDE
The Arduino Integrated Development Environment (IDE) is the primary software used for writing and uploading code to Arduino boards. It features a text editor for coding, a message area for error notifications, a console, and a toolbar with shortcuts for common functions. Code is uploaded to the microcontroller via a USB cable, allowing seamless communication between the computer and Arduino hardware.

b) Adafruit IO
Adafruit IO is a cloud-based platform that enables IoT devices such as Arduino to store, display, and manage sensor data. It allows real-time data visualization and historical tracking. Besides monitoring, it also supports automation and control of devices remotely through dashboards.

2.4 Hardware Description

The system integrates several hardware components to enable smart monitoring of manholes. Key components include:

a) Arduino Nano
The Arduino Nano is a compact microcontroller board based on the ATmega328P chip.

- Digital I/O Pins: 14 (6 support PWM)
- Analog Input Pins: 8

- Operating Voltage: 5V (supports 5V–12V range)
- Clock Speed: 16 MHz
- Current per I/O Pin: 40 mA
  It is ideal for space-constrained embedded systems like this project.

2.5 Component Features and Specifications

b) Float Sensor
A float sensor detects high or low levels of liquid in a container. It is primarily a contact-type sensor that converts the liquid level into an electrical signal. It is commonly used in water-level monitoring systems and is reliable for continuous fluid measurement.

c) DHT11 Sensor
The DHT11 is a low-cost digital sensor for measuring temperature and humidity.

- Uses a thermistor and a capacitive humidity sensor.
- Outputs digital signals (no need for analog input).
- Data updates available every 2 seconds, making it suitable for applications not requiring high-speed updates.

d) MQ135 Gas Sensor
This sensor is used to detect harmful gases such as ammonia, benzene, carbon dioxide, smoke, and sulfur compounds.

- Requires a 5V power supply, consuming about 150mA.
- Needs a 20-second preheat time for accurate readings.
- Part of the widely used MQ gas sensor series for air quality monitoring.

e) Tilt Sensor
A tilt sensor detects changes in orientation or angle.

- Operates using a metallic ball that switches between ON and OFF states as it tilts.
- Works as an eco-friendly alternative to mercury switches.
- Often referred to as an inclinometer when combined with a readout display.

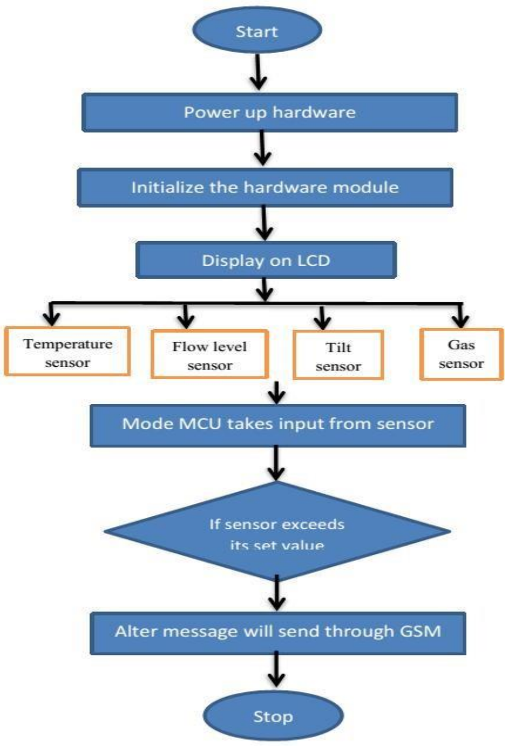
f) LCD (Liquid Crystal Display)
An LCD module is used to visually display output data such as sensor readings or warning messages.

- Advantages over LEDs include support for alphanumeric characters and graphics.
- Widely adopted due to affordable cost and versatility.

g) GSM Module (SIM800L)
The SIM800L GSM module enables wireless communication via mobile networks.

- Operates in the 800 MHz band, which is compatible with most Indian carriers.
- Users in other countries must check compatibility (e.g., US uses 850/1900 MHz, Canada 1900 MHz).
- Sends alerts and manhole status updates via SMS to authorities.

IV.METHODOLOGY



In our project, we have addressed the limitations of conventional Internet-dependent systems by implementing an edge network architecture. Instead of relying on continuous Internet access, we have designed a localized manhole monitoring system using an array of sensors and ESP8266 (NodeMCU) configured as a standalone access point.

The system includes various sensors such as tilt, gas, float, and temperature sensors, which are interfaced with an Arduino Nano acting as the central microcontroller. The Arduino reads real-time data from these sensors and transmits the information to the NodeMCU (ESP8266). The ESP8266 is programmed to create its own local wireless network, eliminating the need for external internet connectivity.

When a user is within the range of this network, the system automatically pushes sensor data and alerts to their device via a local web interface or mobile notifications. Additionally, the system logs all data with timestamps for future reference in the IoT module.

V.RESULS AND DISCUSSION

The developed manhole monitoring system was successfully tested in a controlled environment, and all components performed as expected. The tilt sensor accurately detected when the manhole cover was misaligned or removed, triggering an alert via a buzzer and sending an SMS to the authorized personnel. The float sensor effectively sensed rising water levels inside the manhole, simulating conditions such as flooding or drainage blockages. Upon reaching the threshold, the system generated appropriate alerts and logged the water level data for future analysis.

The DHT11 sensor provided real-time temperature and humidity readings, which were displayed on the LCD and updated live on the local web interface without requiring an internet connection. The MQ135 gas sensor reliably detected the presence of harmful gases such as carbon dioxide and ammonia. Once gas concentration exceeded safe levels, the system immediately activated the buzzer and sent SMS alerts to the designated mobile number.

The ESP8266 (NodeMCU) was configured in access point (AP) mode, creating a local wireless network that allowed any nearby device to access the sensor data through a web browser. This approach eliminated the need for internet connectivity and proved especially beneficial in remote or low-network areas. Furthermore, the GSM module successfully sent SMS alerts when critical thresholds were breached, with an average response time of less than five seconds.

VI.CONCLUSION

Underground monitoring presents a significant challenge, especially in urban environments. This project introduces a smart solution for effectively monitoring and managing underground drainage systems. It incorporates real-time applications such as identifying manhole conditions and tracking drainage performance. Key environmental parameters-including temperature, presence of toxic gases, water flow, and water levels-are continuously monitored and updated through the Internet of Things (IoT). This real-time data transmission enables municipal authorities to take timely and informed action, thereby eliminating unnecessary visits to manholes and ensuring inspections are carried out only when needed. Moreover, consistent online updates help maintain regular monitoring routines, ultimately minimizing health hazards and improving the overall efficiency of urban drainage management.

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