Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 14, Issue 06, ACSCON - 2026

IoT based Manhole Monitoring System

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Abstract- *A Drainage Monitoring System plays an important role in keeping towns and cities healthy and clean. Many manholes are left open without supervision, which can lead to accidents. In India, several cities have adopted underground emptying systems because they are essential. However, not all manholes are secure. Many are in poor condition, increasing the risk of accidents on the roads. Therefore, the status of emptying will be checked daily. Irregular inspections can cause overflow, clog emptying systems, and lead to complaints. Manual monitoring has proved ineffective, making it difficult to handle issues quickly when emptying. After researching these problems, we developed an IoT-based manhole system that monitors temperature, gas levels, and water levels. These damaged manholes pose a threat to public safety. This research aims to prevent accidents and protect lives.*

1.INTRODUCTION

Drainage lines run under plenty of Indian cities. Running the sewage setup falls to the Municipal Corporation, aiming for cleaner air and safer surroundings. When upkeep slips, rainwater sneaks into pipes where it should not be. Trouble spikes when rains arrive each year. Manholes give way as rising fluids press from below. Wrong to trust biodegradable cleanup. Infections slip into wells, bringing sickness. Seasonal clogs stir trouble. Manhole cover mishaps rise when drains fail. Gases may escape - fire follows, then lives lost. A split anywhere on the cover may lead to its collapse. Keeping track of access points matters a great deal. Right now sewage removal isn't moving forward. Poisonous fumes such as methane along with carbon monoxide pose real danger. Health risks turn severe without warning. Workers handling waste regularly confront these dangers - sometimes fatally. While clearing blockages individuals could breathe in toxic air. Heat might trigger sudden explosions, sometimes deadly. Security for people walking by depends partly on the manhole's top piece staying in place. When that cover is gone, officials usually notice what has happened. A shift in how the lid sits could lead to dangerous incidents too. Building a way to watch over and care for these openings is the goal here. A light flickers when gas builds up inside the chamber. This setup watches lid position, heat shifts, and gas development closely. Immediate data flows to responders so delays shrink. Hidden sensors spot cover movement without warning signs. Urban zones lean on connected tools that check conditions nonstop. One study points out how often manhole lids go unchecked. When covers fail, risks climb for everyone nearby. Unseen leaks drain resources while streets stay busy overhead. Monitoring cuts down on surprise failures across neighborhoods. A warning setup sends updates on how things are running so the company knows what is happening. That way officials can move quickly if fixes are needed. Gas levels get spotted by a sensor built into the trash network to stop blasts before they happen. Keeping an eye on wastewater paths becomes possible through one small tool doing constant checks. Rising liquid inside pipes or someone lifting the exit cover triggers the alert process It starts when sensors spot vehicles approaching. Information moves through a network once found. From there, data travels by Wi-Fi to officials at the city office. What happens next shows up online - overflow levels and gas readings appear together. Sensors do the watching without help. Cloud storage holds what is gathered for later look. Streaming information nonstop into the cloud setup. Drivers then get updates about potholes thanks to this flow of details. Research work numbered seven brings IoT into play for smarter water runoff control. Detection happens through sensing units that trigger warning signals sent by GSM tech to city officials.

II RELATED WORK

Smart cities could include things such as adaptive traffic lights, various sensors, and communication networks. When smart gadgets become part of urban setups - thanks to well-placed IoT tech - they tend to simplify daily living, according to study [9]. Environmental tracking tools, shaped through IoT, offer practical solutions in poorer regions. Sensors come in many forms: ones that spot flooding, measure heat and moisture, sense ultrasonic waves, check air quality, or detect shifts in

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ISSN: 2278-0181
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angle, as shown in research [4]. Flood levels - low, medium, or high - get confirmed by the overflow sensor, aiding faster warnings. This setup appears in study [2], where several tiers exist side by side. One such tier handles sensing duties. That part uses a Raspberry Pi microcontroller at its core. Layers stack beyond it: network, application, perception, among others Despite gathering signals from underground access points, data moves through IoT networks for transfer between systems. Paper [11] shows the method scales well while keeping quality and safety standards high. Power demand stays remarkably low throughout operation cycles. Still, sending information takes far longer than expected due to sluggish speeds. Most earlier studies focused on locating the lid plus checking harmful gas levels inside manholes. Instead, this work looked at the manhole cover along with heat and moisture readings. Overflow alerts were included too - sending warnings when measurements climbed past limits. Officials got instant notification through alert tones. [13]

III. SYSTEM DESCRIPTION

It is designed up with ultrasonic sensor, tilt sensor, gas sensor, temperature and humidity sensor and water level sensor. It is used as measure the temperature and humidity, inside drainage depth, gases, lid of manhole in a certain distant field. In the project [10], have used IoT based technology for better performance, simple way of communication, for low cost based and drainage water management system. The proposed system will provide the real time data updating to IoT device in addition to accurate sensor data information. The paper [6] represented monitor the inside manhole drainage temperature and humidity,

excess release of dangerous gases, level of drainage water and position of manhole cover. In these research paper [1], To understand the working of raspberry pi and connectivity between sensor, helps to solve the problem by a smart device using IoT. The research paper [3] represents the implementation and develop function of Manhole Detection System by using the sensors which Raspberry Pi read the data from the sensor units and send the alert message to the user through GSM module and system data is monitored in the App.

The block diagram shown in Fig. 1 determines the Manhole Detection and monitoring system. Whether any changes in both the temperature and humidity, releases of harmful gases, presence of manhole cover or not, level of wastewater is detected by the respective sensor. This system consists of:

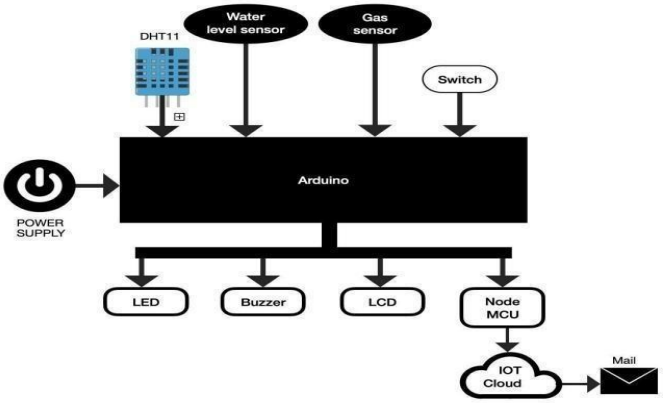

Fig. 1. Block Diagram

A. Ultrasonic sensor- HC-SR04

In proposed design the specific type of HC–SR04 (Ultrasonic sensor) is used. it can convert the sound signals into electrical signals. In Fig. 2 sensor emits the ultrasonic waves whether these waves hits near the object and reflect the waves back to the sensor and convert into the electrical signals. Hence, it can sense there is an object present In front of the sensor. This sensor will detect noncontact range between 2 cm to 400 cm with an accuracy of 3mm. When there is manhole cover between 2cm to 400 cm in the range the system will not sense the alertness. In any case, if the manhole covers above 400 cm the system will generate alertness and followed precautions will be taken by the corporation. In research work the role of sensor is to check whether the lid of manhole is present or not to the basement of drainage. This ultrasonic sensor used as many industrial applications as possible to track the In front object present or not.

Fig. 2. Ultrasonic sensor- HC-SR04

B. Tilt sensor

The mercury type of tilt sensor shown in Fig. 3 is used to check whether any changes in the angle of tendency of manhole cover to the cellar other than the zero degree. It can also measure angle of inclination of manhole cover take place to the basement and live data has been updated in the App.

Fig. 3. Tilt sensor

C. Water level sensor

The magnetic reed liquid level type of overflow sensor is used to detect the level of drainage water present inside the drainage system. In cities due to heavy rainfall there is maximum chance of increase and overflow of drainage water outside the road. Due to this overflow of drainage water in the road accidents will take place. While these people are moving

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in the road can't see whether in particular location manhole cover is present or not. In sensor Fig. 4, the float switch will use the magnetic reed switch is to open or close the circuit. The float switch, magnetic reed switches hermetically sealed within the stem, most often made with the plastic, under any condition raise and fall of drainage water level takes place automatically the float switch moves up and down the length of the stem. Hence, it will check any changes took place in level of drainage water inside the manhole cover under any desirable condition.

Fig. 4. water level sensor

D. Temperature and Humidity sensor - DTH11

In working system temperature and humidity sensor Fig. 5 is DTH11 model have been used for measuring the values of temperature and humidity inside the drainage system. It is simple, low–cost, digital and can sense both the temperature and humidity at a simultaneously. In drainage system under the manhole cover there is drastic changes takes place based on temperature and humidity. While there is any chance of increases in temperature and humidity inside the drainage depth. The alert message will be generated and send to the municipal corporation.

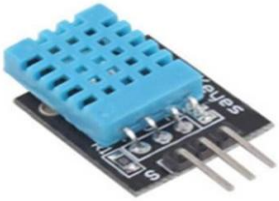

Fig. 5. Temperature humidity sensor - DTH11

E. MQ2 Gas sensor

The gas sensor is used in the proposed design is MQ2 Gas sensor. It can also be represented as chemiresistor. It consists of sensing material as resistance. whereas various types of gases in contact with the resistance present inside the sensor, if there are any changes in the value of resistance will sense the which type of gas is released inside the manhole. Fig. 6 the various type of gases concentration will measure by the voltage divider. It will provide the voltage values which is used to measure the concentration of gases. when the voltage divider network has the voltage values are high as well as concentration of gases is high. It will identify various types of gases are fumes, CO gas, CH4 gas, Liquid petroleum gas, alcohol and H2 gas. It can observe the concentration of gases from the range 200 to 1000 ppm. This type of gas sensor used for the research work as to detect the harmful gases releases inside the manhole of drainage system. If there is excess release of toxic gases inside the drainage depth. The microprocessor sends the alert message to the municipal corporation through GSM module. The amount of concentration of gas releases and output data display in the App.

Fig. 6. MQ-2 Gas sensor

F. SIM900 GSM Module

In the research work as used the mode of communication to send the information of all sensor values to the municipal corporation with the help of SIM900 GSM Module. These GSM Module operated with bandwidth 900MHz and in India the mobile networks are providing the same 900MHz band across all over areas. To operate the Module, insert the SIM card in the given slot. It can support all mobile networks except jio network and access in the 4G network speed. To run the module Raspberry Pi board should be connected where it will read and generate data from the sensor units. Fig. 7 the GSM Module it can send the alert message to the municipal corporation.

Fig. 7. SIM900 GSM Module

G. Adaptor

Mainly, 12-Volt and 5-volt Adapter Power Supply have been used in the research work. These Adapters are widely used for the power supply to the system. The 12-volt adapter has used in the GSM Module and another 5-volt adapter is used in Raspberry Pi board for the working of the manhole detection and monitoring system.

H. Raspberry Pi 3 Model B+

In this proposed design, mainly microprocessor has used to process and run the all the units in the system. The model has introduced in the research work is Raspberry Pi 3 model B+. Fig. 8 present model has used in the system as the better features than previous model. The microprocessor consists of 1GB RAM, in-built dual–band WIFI and have the Bluetooth version 4.2. By the help of personal hotspot can connect to the WIFI in Raspberry Pi to access the internet. In paper [8], the function of microprocessor is which fetch the information from the sensor and transmit signal to the GSM Module. Furthermore, the data is updated in the App by using IoT technology.

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Fig. 8. Raspberry Pi 3 Model B+

A Manhole Detection and monitoring system help in maintaining human safety, clean city and reduce the effort of municipal corporation. The different kind of sensors - (water level, Ultrasonic(HC-SR04), Temperature and humidity(DTH11), Tilt and MQ2 Gas sensors) are interfacing with microprocessor Raspberry Pi in order to run the system efficiently and accurately. When these sensors sense the data whether the live data reach the threshold level, and these sensors immediately send the respective value of data to the microprocessor. Furthermore, Raspberry Pi sends the information and condition of the drainage system to the municipal corporation. Based on the information the high authority of municipal corporation officials will take action and follow the certain precaution. Also, microprocessor update the live data and output data of the system will be display and at a time update in the App by using IoT. An alert text message will be sent to the municipal corporation through GSM.
Fig. 9 consists of detail flow chart.

Algorithm

- Start
- Power supply is given to hardware system.
- Initialize and run the hardware Module.
- Raspberry Pi board sense the value of data from the Sensors.
- Tilt sensor check the lid of manhole having the zero degree of angle of inclination to the basement. If the angle of inclination is more than zero degree.
- DHT11 (Temperature humidity) sensor sense temperature and humidity levels in the underdrainage system.
- MQ2 Gas sensor check the harmful gases level concentration under respective condition.
- Water level sensor sense the level of drainage water under manhole cover at that time.
- Ultrasonic sensor detects whether the manhole cover is present or not.
- If any sensor exceeds more than threshold or set value. Then alert message sent to the municipal corporation through GSM Module. By using IoT technology the output data updated in the App.
- The information of the data will be display and monitor in the App.
- Stop.

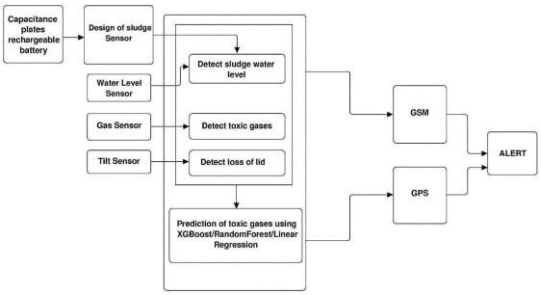

Fig. 9. Execution Flow chart

In the research work have used the various type of sensors and the values of the sensors are lay hold of into consideration. To maintain the Manhole detection and monitoring at all times. When the Raspberry Pi collects the all the data from the sensor's units. These sensors receive all the values and following steps to be followed.

1) First Ultrasonic sensor senses whether manhole cover present or not to the basement if it present or else, it goes to the second step.

2) Second step to be followed tilt sensor check whether the angle of tendency of manhole cover to the cellar is 0 or more than zero degree if it present zero or else it goes to the third step.

3) Third step to be followed temperature and humidity sensor sense the values of data inside the drainage system. whether these values reach the threshold value or else it goes to the fourth step.

4) Fourth step to be followed gas sensor detect the various types of gases release inside the drainage system. If there is excess release of toxic gases or not it goes to the final step.

5) Finally, water level sensor detects the level of drainage water present under the manhole cover. If there is any chance of increase of drainage water or else, it sends the alert signal message to the municipal corporation through GSM. A live data update in the App through IoT network.

II. SOFTWARE IMPLEMENTATION

For coming to the software implementation of proposed design. It can proceed into three steps process.

1. Operating System
2. Programming Code

A. Operating System

To start software implementation, the operating system Raspbian - Linux Environment is required. To run the

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ISSN: 2278-0181
Vol. 14, Issue 06, ACSCON - 2026

software aspects of Manhole detection and Monitoring system Raspbian OS plays crucial role. To operate the Raspberry Pi board Linux environment, install in the system. Also, to read and write the programmed code Raspbian OS is important.

B. Programming Code

To operate and run the system software code is required. By using the Arduino IDE can develop suitable programmed code. After completing the programmed code write up and to run the code in the Raspberry Pi board. Finally, the desired result will be displayed. [14]

Arduino IDE

Inside the Manhole Monitoring System, programs reach the Arduino chip through a tool called Arduino IDE. This workspace makes coding easier by offering clear tools and an approachable layout. Instead of complex steps, it uses a version of C/C++ that feels familiar to many coders. Code runs here before moving onto the hardware. One task involves setting up the Arduino Uno to gather readings from different detectors - like those catching gas levels or shifts in angle. When signals come in, they get sorted and reviewed right inside the environment. If numbers go beyond what's considered safe, the system takes note without delay.

After writing the code in the Arduino IDE, compilation happens before sending it to the Uno via USB. Running nonstop, the microcontroller keeps an eye on what's happening inside the manhole as things unfold. If something unusual shows up - like rising water, dangerous gases, or the cover being moved - the board reacts by activating warnings, relayed to a phone app or shown on a display panel. Built-in features such as the Serial Monitor let users check live data from sensors while troubleshooting test runs.

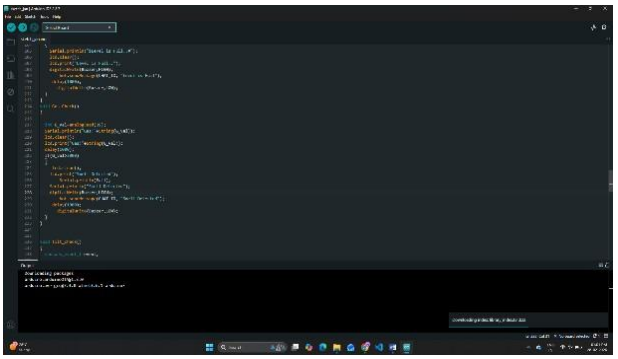

Fig. 10. Arduin IDLE file

III RESULTS AND DISCUSSION

The system gets started by taking power supply externally all the sensor will start working. Sensor unit senses all the physical parameters like Gas concentration, drainage water level, with the help of sensors temperature, humidity and gas leakage can be identified. The system also informs whether the manhole lid is open or closed by using the ultrasonic sensor. All the sensors are checked in such a way that their values are below and above the threshold value. In any case, above parameter are changes spontaneously the Raspberry Pi send signals to the GSM module and it can send alert message to the Telegram application. The municipal corporation can handle that telegram application.

Inside the manhole, several kinds of sensors keep track of changing conditions. Water height gets watched by a dedicated sensor, spotting when levels climb too high. Instead of relying on sight, an ultrasonic device calculates inner depths to catch clogs or fast-rising floods. Dangerous fumes like methane show up thanks to a gas-detecting unit built into the setup. Heat changes do not go unnoticed either - temperature tools watch for spikes without warning signs. While one part checks liquid volume, another stays alert for invisible threats below ground. Each piece works apart yet fits within a larger network sensing trouble before it spreads. Measurements update continuously so risks reveal themselves early. No single element acts alone; they form layers of awareness under city streets. Hidden but active, these devices trace shifts few would otherwise notice.

A single microcontroller links several sensors, connecting them through a communication chip. This arrangement watches manhole environments closely, spotting risks as they appear. When trouble shows up, warnings go out fast - helping keep workers safe and systems running. Built this way, it responds quickly, using feedback from each sensor to act before problems grown. The hardware setup is shown in below Fig. 12.

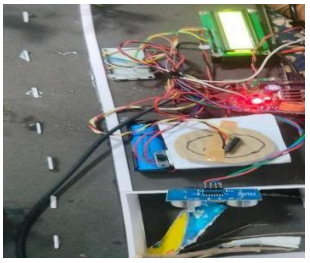

Fig. 12. Hardware Setup

The desired results are shown in the IoT based manhole monitoring in app Fig. 13 by using IoT technology.

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ISSN: 2278-0181
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Fig. 13. The results are display in Telegram app

III. CONCLUSIONS

Manhole cover localisation is a challenging problem. We have proposed a multi-view scheme, which combines 2D and 3D analysis. Following a principle of spending little time on the bulk of the data, and reserving a more refined analysis for the promising parts of the images, the proposed system combines efficiency with good performance. The main contribution of the paper is that for the first time a system based on vision and GPS is used successfully for the task of manhole mapping. Our system benefits from using multiple views and thereby goes beyond detection and recognition, obtaining pixel-level accuracy and centimetre level accuracy in the 3D localisation of manholes. In the future, we plan to investigate the role of scene context and how the proposed pipeline can be used for other class specific tasks in mobile mapping. Acknowledgements. This work has been partly supported by the European Commission FP7-231888-EUROPA project. We thank Geo Automation for providing the images and for their support. The sensor unit is automatically sensing the all parameters like toxic gas, flow rate of water and also sense the humidity and temperature in manhole This project system is reducing the work of man power and increasing the safety of work and speed of work. It is easy to get all above mentioned information in one click solution.

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