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IoT-based Manhole Management System for Open Manhole Covers

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Abstract: ***The IoT based manhole management system for open covers is a system aimed to improve the management of manhole covers in urban infrastructure. The system uses IoT technology to monitor the status of manhole covers in real-time and sends alerts to the authorities if a manhole cover is open or missing or stolen. The system also includes an Android Application to notify the people if they are near an open manhole cover and to ensure their safety. The system was developed using NodeMCU as an instance of Arduino, and for the web application the programming languages used were HTML, CSS, JavaScript, PHP and API. The system provides an efficient and effective solution for the management of manhole covers, reducing the overall cost of maintenance and ensuring public safety.***

Keywords: IoT, Manhole Management, NodeMCU, Alert System, Android Application.

1. INTRODUCTION

Manhole covers are essential components of urban infrastructure because they provide access to sewage and utility networks that are buried beneath the earth. On the other hand, when manhole covers are either missing or incorrectly secured when they are open, cars and pedestrians are put in a precarious situation that poses a significant risk to their safety. An Internet of Things (IoT)-based manhole management system that incorporates an alarm system for open manhole covers is presented in this article as a potential solution to a problem that has been identified. The system utilises Internet of Things (IoT) technology to conduct out real-time monitoring of the state of manhole covers and notifies the proper authorities if any of the covers are found to be missing or open. The system also includes an Android application, the objective of which is to preserve the safety of members of the

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general public by warning them if they are in the neighbourhood of a manhole cover that is missing or open if they are using an Android device.

Literature Review

IoT-based systems have been used in various fields for their ability to monitor and control devices remotely. In the field of urban infrastructure management, IoT-based systems have been used to monitor traffic, air quality, water supply, waste management, and many more. Manhole management is a critical aspect of urban infrastructure management, and IoT-based systems can provide an efficient and effective solution.

Several studies have been conducted on the use of IoT technology in manhole management. In [2], the author contends that a smart light pole-based system can enhance the safety monitoring of urban manhole covers. The manhole cover's movement, tilt, flooding, and positioning data are processed and controlled by the system using the microcontroller STM32F103C8T6, and the data is then transmitted to the LoRa gateway using the LoRa communication protocol. The smart light pole's wide screen display shows the abnormal condition, and the cloud platform transmits the data to management users who have subscribed for processing. Urban manhole covers are effectively and precisely monitored using the suggested system's multi-modal, all-around safety linkage monitoring.

In [4], the author discussed about an intelligent manhole monitoring system based on IoT technology, which uses various sensors like gas and temperature sensors to sense damages in the manholes. The system notifies the municipality's office through messages if there is any abrupt change in any of the sensor parameters, enabling timely maintenance. The paper aims to solve the problem of irregular monitoring of manhole conditions in smart cities and improve the accuracy of maintenance. The proposed system is expected to be highly beneficial for maintaining manholes and creating a safe and harmonious smart city environment.

In [1], the author proposes a rapid detection method using mobile LiDAR, computer vision, and deep learning techniques. The method extracts road surface data, forms 2D geographic reference feature images, and applies object detection to locate manholes. The proposed method outperforms previous methods with high precision and F1-feature rates, even in complex road situations. Keywords include road manhole cover, road management, mobile laser scanning, and deep learning.

In [3], the author represents a design for an intelligent manhole cover monitoring system based on narrow band Internet of things (NB-IoT) technology to solve the problems of stolen and poorly managed gas well covers in cities. The system includes a perception layer, network layer, and application layer. The system is based on the embedded ARM microprocessor and combines sensor technology to collect data, and takes NB-IoT technology as the core for communication. The paper demonstrates that the system works stably and can help achieve intelligent management of smart cities for a harmonious and safe environment.

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In [5], the author proposes a system for the supervision and management of ownerless manhole covers (OLMCs) using sensors and 3G transmission technology. The system uses fixed RFID base stations and dormant RF cards to monitor the condition of manhole covers and transmit the data to the supervision center in a timely manner via GPRS wireless network. The proposed system offers an active and intelligent way of managing OLMCs and can contribute to the safe and efficient operation of the city.

In This paper an Internet of Things-based manhole management solution for exposed manhole covers. The device employs Internet of Things technology to keep tabs on manhole covers in real time and notify the proper authorities if one is open or missing. To further safeguard the public's safety, the system also includes an Android app that may alert users when they are in the vicinity of a manhole cover that has been left open.

2. METHODOLOGY

The IoT-based manhole management system was developed using a combination of hardware and software components. The hardware components consisted of NodeMCU, which was installed on the manhole covers, and sensors that detected the status of the cover, i.e., open or closed. The data collected from the sensors were sent to a central server using the Wi-Fi network. A dashboard was developed using HTML, CSS, and JavaScript to display the data collected from the sensors, including the location of each manhole cover obtained from Google Maps API.

An Android application was also developed to notify the public if they were near an open manhole cover. The application used GPS to obtain the user's real-time location, and if the user was near an open manhole cover, the application sent a notification to ensure their safety. The data collected from the sensors were stored in a database, and API was used to retrieve and display the location of each manhole cover.

A. System Design

The system is composed of two main components: a NodeMCU microcontroller and an alert system. The NodeMCU microcontroller is placed inside the manhole and detects when the cover is open. The microcontroller is connected to a magnetic sensor that detects the presence of the cover. When the cover is removed, the sensor sends a signal to the microcontroller, which then sends an alert to the alert system. The alert system is designed to receive alerts from multiple NodeMCU microcontrollers and send notifications to the relevant authorities.

B. Alert System

The alert system is responsible for receiving alerts from the NodeMCU microcontrollers and notifying the relevant authorities. The alert system uses a web-based application that receives alerts from the microcontrollers via an API. The API is designed to ensure secure communication between the NodeMCU and the alert system. Once an alert is received, the application sends a notification to the relevant authorities via email, SMS or phone call.

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C. Web Application

JavaScript, HTML, and CSS were used to create the user interface for the online application. The web application offers a website where users and administrators may access information on the state of manhole covers and alarms sent out by the system. Each manhole cover's position and state, including whether it is open or closed, are shown on a map on the website. Each manhole cover's status is listed for both the user and the administrator to see. The online program also provides a Dashboard for the administrator to change settings, add new manholes, remove existing manholes, or modify manhole metadata, among other system options.

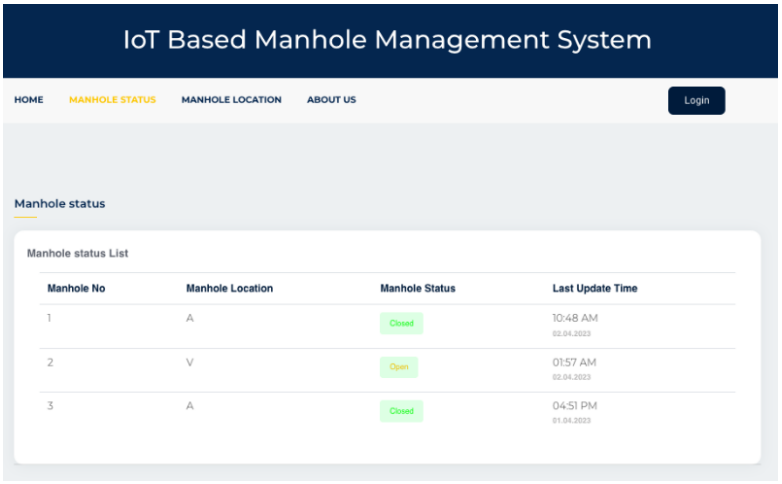

Fig.1 Manhole List Table in Web Application.

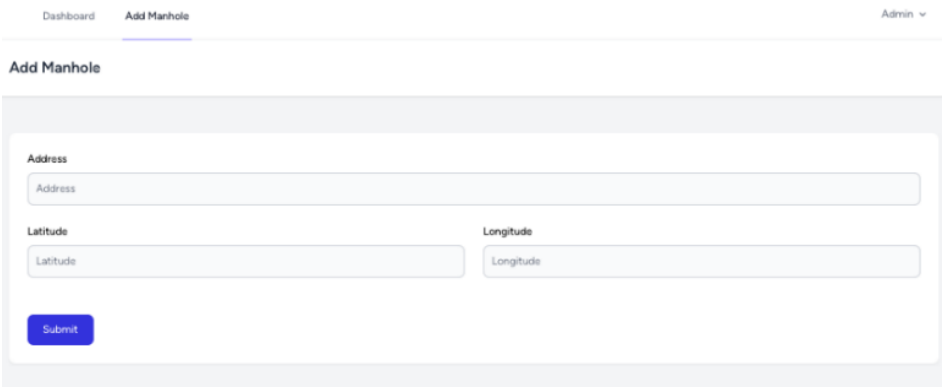

Fig.2 New Manhole Addition Form in Web Application.

D. Android Application

An Android application is also included in the system to notify the public of nearby open manhole covers. The application uses GPS to determine the user's location and alerts them if they are within a certain distance from an open manhole cover. The distance is calculate using the 'Haversine' formula. The application also provides users with the location of nearby manholes and the status of manhole covers. The working diagram for Android Application.

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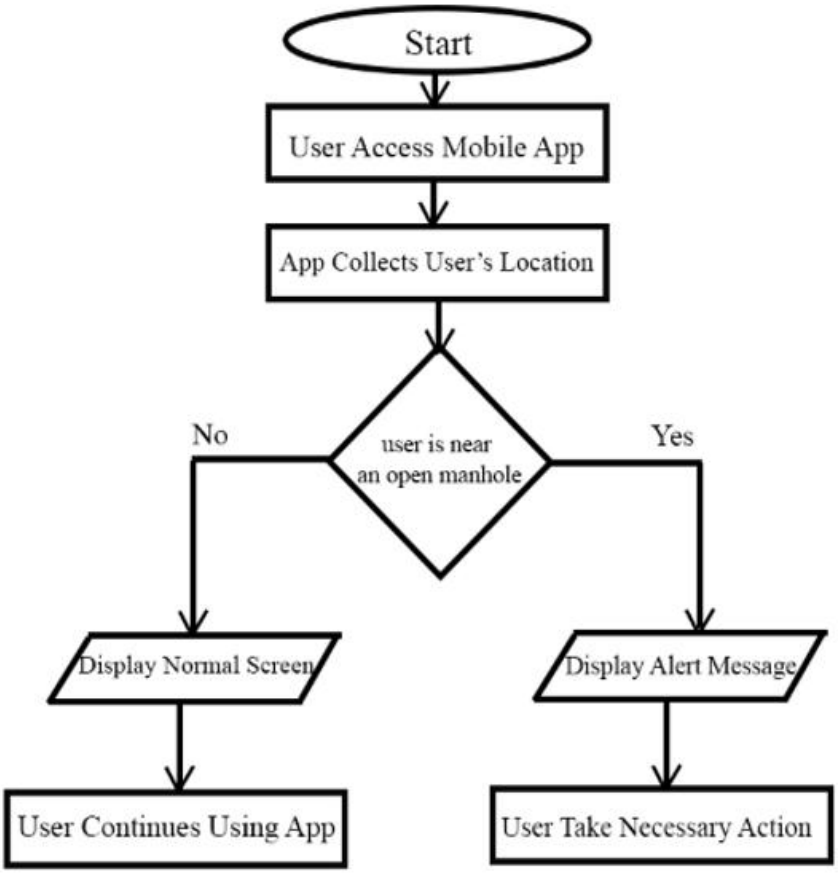

Fig.3 Flow Diagram of Android Application.

Android Application User Interface:

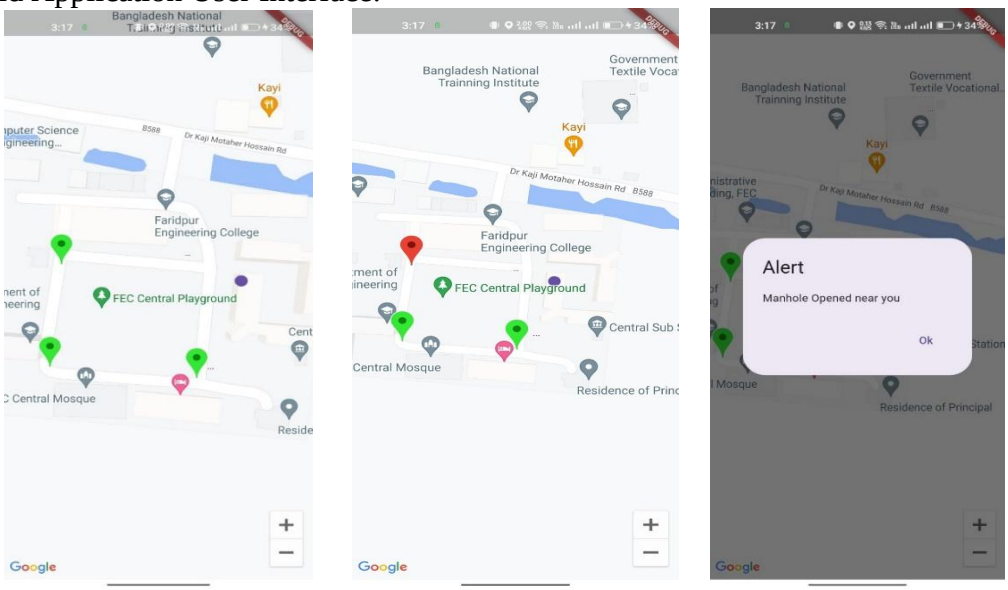

Fig.4 User Interface of Android Application

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The green and red points in Fig. 4 depict the condition of manhole covers. When the manhole cover is closed, it appears as green, and when it is open or stolen, it appears as red.

Calculations

To calculate the distance between the manholes and public we use 'Haversine' formula. Using the 'haversine' formula, this determines the greatest-circle distance between two places, or the shortest distance over the surface of the globe, and provides an 'as-the-crow-flies' distance between the points (ignoring any hills they fly over, of course!).

Haversine formula is:

$a = \sin^2(\Delta\varphi/2) + \cos \varphi 1 \cdot \cos \varphi 2 \cdot \sin^2(\Delta\lambda/2)$

$c = 2 \cdot \text{atan2}(\sqrt{a}, \sqrt{(1-a)})$

$d = R \cdot c$

where φ is latitude, λ is longitude, R is earth's radius (mean radius = 6,371km);

3. RESULT AND DISCUSSION

This paper suggests entirely unique methods for monitoring and maintaining the condition of manhole covers. Real-time explanations of manhole cover identification are provided. With the assistance of NodeMCU, it keeps track of the condition of the manhole lid utilising red switch technology. Using the Internet of Things, it forwarded the information to the relevant authorities. Through NodeMCU, these statuses are continuously tracked and updated. Government officials can take the appropriate action by receiving warnings from the microcontroller, and the general public can be informed as well by utilising the android application. In this approach, superfluous excursions to check on the condition of manhole covers can be avoided and only necessary ones made.

Future Scope

In the future, supplementary devices were installed in order to acquire the information on manhole covers in a shorter amount of notification time. Using GPS technology, it is also possible to track down the location of the manhole cover with increased precision. These days, the absence of manhole covers is the cause of a significant number of accidents. Crack sensors are used to locate and diagnose any defects in the manhole cover.

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