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Safe Streets Initiative by Open Manhole Detection

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***Abstract*—The primary objective of our project is to mitigate the escalating occurrence of traffic accidents that progressively arise year after year. These accidents are predominantly caused by uncovered manholes, especially during the nighttime hours. In order to achieve this goal, the project aims to implement an innovative system for detecting open manholes. This system will serve to bolster both road safety and urban infrastructure. The system's functioning depends on an accelerometer sensor that is placed underneath the manhole, which constantly monitors the manhole's position and inclination. As soon as the manhole is opened, LED strips surrounding it will promptly turn red, thereby serving as a prominent warning signal. Additionally, a pole equipped with lights will be strategically placed to promptly alert approaching riders. In situations where heavy rainfall obstructs visibility, the LED strips will be elevated to ensure optimal noticeability, taking into consideration the water level on the streets. The system integrates several crucial components, including the Accelerometer Sensor, Power supply, Servo motor, Micro controller, rain and level sensors, LED strips, and LED indication board.**

***Index Terms*— Manholes, Road Safety, Accelerometer Sensor, Servo Motor, Arduino Microcontroller, Manhole cover or Utility cover.**

I. INTRODUCTION

Cities in India face a considerable variation in the issue of street safety, particularly with respect to manholes. While some urban areas have taken proactive steps to enhance their infrastructure and address safety concerns, others still face formidable challenges. It is crucial to exercise caution and prudence, especially in areas where maintenance and upkeep may be lacking.It is incumbent upon individuals to remain cognizant of their immediate environment and surroundings so as to obviate the potential perils that can arise from uncovered manholes. The misalignment or tilting of manhole covers or lids can precipitate grave accidents that can cause severe harm to individuals, leading to injuries of varying degrees. The consequences of inadvertently descending into an open sewage system are multifarious and can range from life-threatening situations, such as asphyxiation, to the ultimate consequence of death itself. The primary factors that contribute to road accidents during nighttime hours can be attributed to a couple of key elements. Firstly, the presence of poor road conditions plays a significant role in these unfortunate occurrences. Numerous roads are plagued by the presence of potholes and a lack of proper maintenance, which in turn poses significant risks not only to drivers, but also to pedestrians. Secondly, inadequate street lighting is another contributing factor to the heightened risk of accidents, particularly during the night. When streets are poorly illuminated, it becomes increasingly challenging for motorists to navigate their way safely, consequently increasing the likelihood of collisions and other related incidents.

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Inadequate maintenance practices have resulted in the emergence of open manholes and potholes, thereby presenting significant hazards to both pedestrians and drivers. Recognizing the gravity of this situation, we have leveraged cutting-edge technology to mitigate this issue to a certain extent. Specifically, we have developed a system that is capable of detecting open manholes present on the streets, thereby providing valuable assistance to pedestrians and bike riders by effectively alerting them to the presence of such hazards. Moreover, this innovative system has been designed with cost-efficient sensors such as the accelerometer sensor and level sensor, along with a straightforward software language. These sensors are seamlessly connected to an Arduino microcontroller, which in turn interfaces with a light indicator board. Notably, a servomotor has been strategically positioned beneath the manhole cover, which plays a pivotal role in facilitating the elevation of LED strips that surround the manhole. Understanding the fundamental concepts of traffic lights and road safety systems allows us to gain a deeper appreciation of this technological solution and its potential to reduce the hazards posed by open manholes and potholes.

Open manhole detection initiatives are of utmost importance for a variety of reasons. To begin with, they contribute to the enhancement of public safety by reducing the occurrence of accidents and injuries resulting from open manholes, particularly in densely populated urban areas where pedestrian traffic is significantly high. Secondly, these projects effectively prevent damage to vehicles and infrastructure by promptly notifying authorities about unsecured manholes. Moreover, they play a crucial role in improving the efficiency of city maintenance operations, as they enable swift responses to incidents, minimize downtime, and reduce maintenance expenses. Ultimately, open manhole detection initiatives are indispensable in fostering urban spaces that are both safer and more environmentally sustainable.

II. Literature Survey

The advancement of technology has brought about a significant shift in urban safety measures, particularly in the realm of manhole detection and accident prevention. In this literature review, we delve into a collection of studies focused on automated detection systems and preventive strategies targeting manhole-related accidents.

- The study "Automated Detection of Manhole Status and Prevention of Accidents Using Passive Infrared Sensors,[1]" conducted by S. PRIYADHARSINI and T. VARSHA, aims to develop an automated system that uses Passive Infrared (PIR) sensors to detect manhole status and prevent accidents by identifying potential hazards through the detection of humans or animals in close proximity to manholes. The system employs machine learning algorithms to evaluate data from PIR sensors and determine the manhole's status.
- The system proposed by H. S. Tasin, M. S. Sarkar, M. A. Rahman, S. H. Shara, and M. S. R. Zishan called “Design and Development of
- Uncapped Manhole Detection System for Waterlogged Roads [2]" is designed to detect uncapped manholes on waterlogged roads using image processing techniques. This real-time system alerts authorities of its findings and can be integrated with existing traffic management systems.
- On the other hand, the "Design and Implementation of Intelligent Manhole Cover Monitoring System Based on NB-IoT [3]" by X. Guo, B. Liu, and L. Wang employs Narrowband Internet of Things (NB-IoT) technology to monitor manhole cover status in real-time. The system uses sensors to gather data and send it to the cloud for analysis, and it can also be integrated with existing smart city infrastructure.
- The proposal for the redesign of the manhole cover warning device by J. Dai, X. Jiang, and Yi Wang in their work, "Redesign of Manhole Cover Warning Device Based on Road Safety" [4], aims to improve road safety by using a combination of sensors and cameras to detect the presence of humans or animals near manholes and alert the authorities in real-time in case of potential danger.
- Similarly, J. Zhang and X. Zeng's design for an intelligent manhole cover monitoring system, "Design of Intelligent Manhole Cover Monitoring System Based on Narrow Band Internet of Things" [5], proposes the use of NB-IoT technology to monitor manhole cover status in real-time and alert the authorities if any potential danger is detected. Both systems can be integrated with existing traffic management and smart city infrastructure.
- Manhole Detection Using Image Processing on Google Street View Imagery [7], V. Vishnani, A. Adhya, C. Bajpai, P. Chimurkar, and K. Khandagle present a system that employs image processing on Google Street View imagery to detect manholes. Their system utilizes machine learning algorithms to identify manholes in the imagery and extract their coordinates for manhole mapping and monitoring purposes. The study suggests that the system can be used to identify manholes that are not visible on traditional maps, offering valuable information for urban planning and infrastructure management

- The present review emphasizes the essential function of automated detection systems and preventive measures in bolstering urban safety, especially in the context of manhole related incidents. Studies have shown that advanced sensor technologies such as PIR sensors and NB-IoT, as well as innovative techniques like image processing on Google Street View images, are being employed to tackle the challenges presented by open manholes. Despite the diverse methodologies and technologies utilized in the studies, a shared goal of enhancing public safety and infrastructure management is evident in each contribution. Moving forward, continued research and innovation in this field offer the potential for further advancements in automated manhole detection and accident prevention, ultimately resulting in safer and more resilient urban environments.

III. PROPOSED SYSTEM

In this project paper, we introduce a groundbreaking proposed system that has the potential to redefine the landscape of public safety in a profound manner. Our approach is characterized by its innovative nature, as it seamlessly integrates cutting-edge technologies and strategic methods to provide a comprehensive and all-encompassing solution for overcoming the myriad challenges that plague road safety. Moreover, our system is designed to make a significant contribution to the ongoing development and improvement of secure streets, thereby making it an indispensable asset in the pursuit of public safety. The block diagram of the proposed system is depicted in Fig.1. The incorporation of all the necessary components onto an Arduino Uno Board serves a dual purpose, as it not only ensures cost-effectiveness but also facilitates a seamless and cohesive interaction between the various elements of the system. This integration is made possible through the utilization of the Arduino IDE, which serves as the programming platform for the Arduino Board. By leveraging the capabilities of this powerful and versatile platform, we are able to harness the full potential of the Arduino Board and optimize its performance in the context of our proposed system. This strategic decision not only enhances the overall functionality of the system but also contributes to its cost-effectiveness, making it an attractive solution for the implementation of road safety measures. The Arduino IDE provides a user-friendly interface that enables the efficient programming of the Arduino Board, allowing for the seamless execution of the system's operations. Overall, the incorporation of the Arduino Uno Board and the utilization of the Arduino IDE represent crucial elements in the successful implementation of our proposed system.

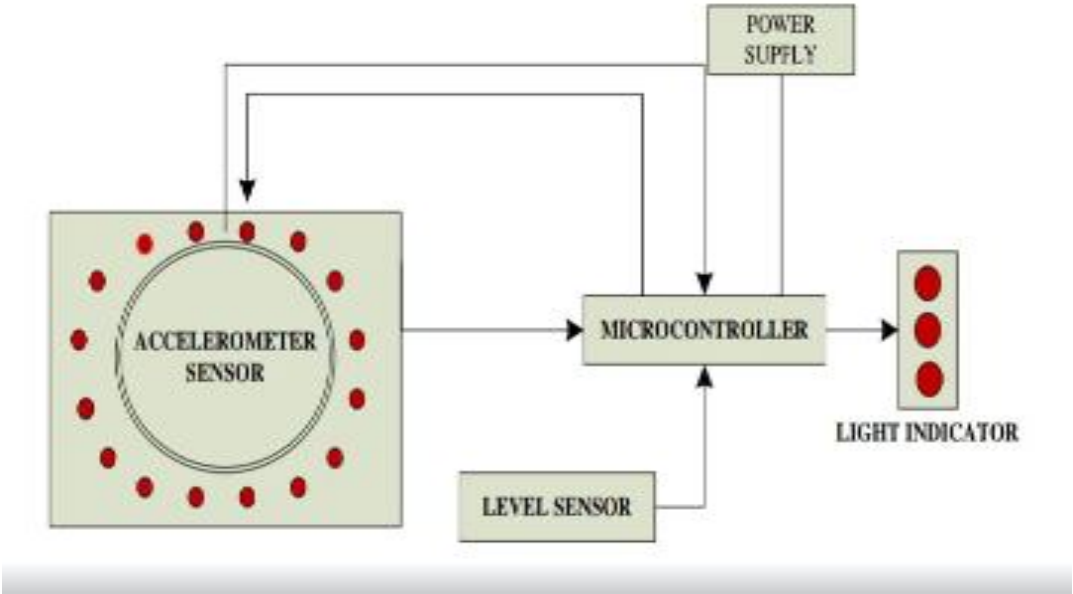

Fig. 1. Block Diagram

A. Hardware

The **Arduino Uno board**, which served as the project's central component and allowed it to function, was attached to a variety of sensors and indicators. The Arduino Uno, as seen in Figure 2, is the perfect example of how readily available hardware and processing power come together. Driven by the ATmega328P microprocessor, its applications range from sophisticated prototype projects to instructional environments. Well-

known for its smooth interaction with a wide range of sensors and actuators, the Uno is a great starting point for multidisciplinary research in the fields of electronics and programming. is compatible with the Arduino IDE, an integrated development environment that makes writing, assembling, and uploading code to the board easier.

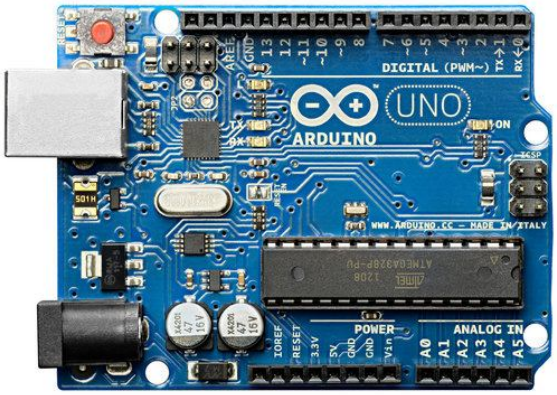

Fig.2. Arduino Uno

Our prototype utilizes the **ADXL345 Accelerometer Sensor**,(in Fig. 3) which operates on the principle of microelectromechanical systems (MEMS) technology. This sensor is commonly used in electronic devices for tasks like tilt sensing, motion detection, and gesture recognition. It is integrated into products like smartphones, tablets, gaming controllers, and wearable devices. The ADXL345 accelerometer sensor boasts low energy consumption, making it an excellent choice for battery-powered devices. In our application, the sensor is attached to the manhole cover to detect inclinations and changes in motion or position. When the sensor experiences acceleration, the microstructures deform due to inertial forces, causing the capacitance between them to change. This change in capacitance is measured and used to determine the direction and magnitude of the applied acceleration.

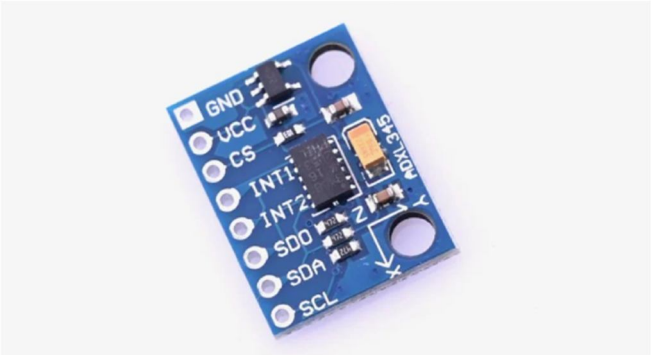

Fig. 3. ADXL345 Accelerometer Sensor

The ADXL345 measures variations in capacitance by capacitive sensing. With its several detecting components oriented along distinct axes (x, y, and z), the sensor is able to detect acceleration in a particular direction due to the unique microstructures of each element. These capacitance variations are translated into continuous voltage impulses corresponding to each axis' acceleration. After that, the analog signals are transformed by the ADC into binary values that a microcontroller or other processing device can read. A communication interface such as I2C or SPI is used to output the digital acceleration data, making it simple to integrate with microcontrollers or other digital devices.

The **Ultrasonic Level Sensor** works by projecting high-frequency sound waves, often known as ultrasonic waves, in the direction of the target surface. When these waves enter the outside of the substance or liquid being measured, they pass through the air and are reflected back towards the sensor. Following the measurement of the wave's round-trip duration, the sensor determines the distance between itself and the material's surface by utilizing the sound speed in air.

In this particular application, the ultrasonic level sensor is installed on the side of the road and connected to an Arduino microcontroller. Its primary function is to measure the depth of stagnant water in the streets after

rainfall and send a signal to the Arduino microcontroller. The Arduino, in turn, activates a servo motor, which raises the LED strips surrounding the manhole cover to the same height as the road. One of the key advantages of the ultrasonic level sensor is its ease of installation and cost-effectiveness compared to other level sensors. The sensor is installed on the side of the road and connected to an Arduino microcontroller, which activates a servo motor to raise the LED strips surrounding the manhole cover to the same height as the road. The ultrasonic level sensor is an affordable and easy-to-install option compared to other level sensors.
In our project, the mechanism that elevates the LED strips during flooding is controlled by a **Servo Motor**. The LED strips may be raised by using a servo motor that is attached to a gear system or a lever mechanism. This guarantees enhanced visibility and notifications for safety, especially in inclement weather. The LED strips and an Arduino microcontroller are linked to the servo motor. The Arduino board provides the input, and the LED strips show the output. In Figure 4, the servo motor is seen. Figure 5 shows the assembled hardware system.

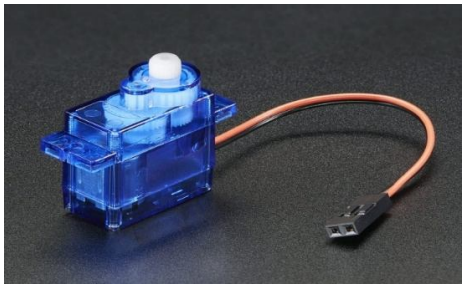

Fig. 4. Servo Motor

Fig. 5. Assembled Hardware Setup

B. Software

Writing code for an Arduino often involves using a condensed form of C++ enhanced by extra libraries and features provided by the Arduino framework. The Arduino Integrated Development Environment (IDE) is used to program the Arduino microcontroller, which is the brains of the system. To complete a project, we use the Arduino programming environment to create the required C++ software, which we then upload to the Arduino microcontroller. This software is in charge of controlling a servo motor, communicating with sensors, and supervising LED indicators that are directly linked to the system

IV. RESULTS

In the proposed system depicted in Fig. 6, the project takes shape during the initial phase of testing.

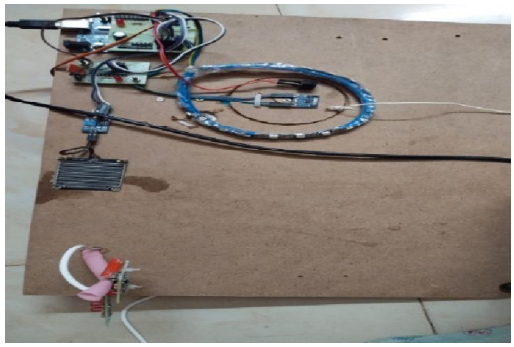

Fig. 6. Prototype of Manhole Detection

As illustrated in Fig. 6 and Fig. 7, the prototype receives a supply of power, and the manhole cover or utility cover is in a closed condition. Upon the manhole cover being opened, the ADXL Accelerometer sensor comes into action, transmitting information to the Arduino microcontroller.

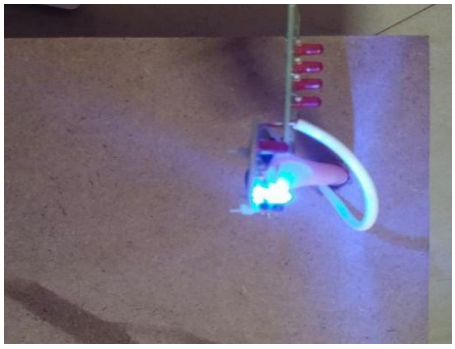

Fig. 7. Light Pole Indicator (off condition)

Subsequently, the Arduino processes this data and triggers the illumination of LED strips surrounding the manhole cover, concurrently activating a light indication board adjacent to the road, as in Fig. 8.

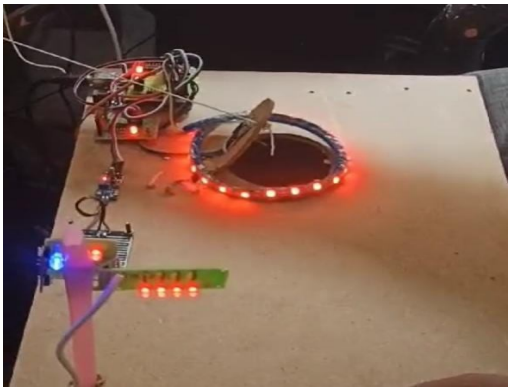

Fig. 8. System when Manhole is Open

As the Rain Sensor detects an increase in moisture content parallely the Level Sensor gauges the street level during rainfall, a compelling feature comes into play. The LED strips encircling the manhole dynamically ascend with the assistance of a servomotor, as illustrated in Fig. 9.

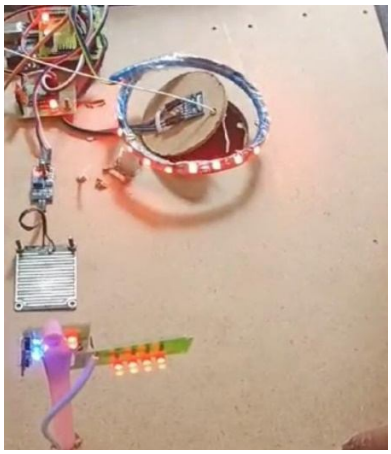

Fig. 9. Rise of the LED Strips

This creative device acts as a preventative precaution against possible threats in addition to improving visibility and awareness in bad weather. The prototype has been created with efficiency as its top concern, using a lot less

power than traditional open manhole detection projects. This is an essential point to make. This has been accomplished while upholding very high standards of precision and dependability. An energy-efficient and dependable solution for manhole safety is made possible by the combination of intelligent control via an Arduino microcontroller, accurate actuation mechanisms, and smart sensors

V. Future Work

The recognition of the achievements and advancements delineated in this study inspires an examination of persuasive directions for further research in the field of public safety and the safe streets program. Going further with the integration of energy collecting solutions—like using solar panels or kinetic energy harvesters—is one especially interesting path. By utilizing renewable energy sources, the thoughtful integration of these technologies seeks to increase the project's sustainability and maybe increase its operational lifespan without solely depending on outside funding. This strategy not only responds to the pressing requirement for the system to continue operating in a variety of environments, but it also complies with current environmental concerns.
Simultaneously, a crucial area for future work lies in the development of a user-friendly interface or a dedicated mobile application specifically designed for monitoring and configuring the system. Providing users with seamless access to real-time information about road conditions and system status is of utmost importance. Implementing a user-centric interface not only enhances the accessibility of the system but also promotes community engagement, allowing individuals to actively participate in ensuring road safety. This innovative step towards enhanced user interaction represents a significant advancement in making the safe streets initiative more inclusive, adaptive, and responsive to the needs of the community it serves.
Investing in research on emerging technologies aimed at creating safer streets for the public will significantly contribute to the expansion and improvement of our current methods and practices. Developing such technologies will not only improve the efficiency but also enhance the overall safety of the community. The application of these technologies will also promote community engagement, fostering a sense of ownership and responsibility among individuals towards the initiative. This will ultimately lead to a safer and more sustainable future for everyone.

VI. Conclusion

In conclusion, our project addresses the critical issue of road safety by focusing on the identification and prevention of accidents caused by exposed manholes. By incorporating state-of-the-art technologies like, ADXL 345 Accelerometer sensor, ultrasonic level sensor, and servo motor, our system effectively alerts pedestrians and cyclists to the presence of open manholes, particularly during nighttime and in unfavorable weather conditions. The Arduino Uno board functions as the brain, facilitating seamless interaction among the various components, thereby ensuring cost-effectiveness and optimal functionality.
The hardware and software components of the proposed system, combined with the promising outcomes achieved during the initial testing phase, demonstrate its potential to transform road safety. The careful use of power, along with the integration of intelligent sensors and an Arduino microcontroller, results in an energy-efficient and reliable solution for manhole safety.
Moving forward, future efforts will involve exploring energy harvesting solutions to promote sustainability and developing a user-friendly interface or mobile application for real-time monitoring. By staying on the cutting edge of emerging technologies, our goals are to continually enhance and expand our methods to create safer streets and improve public safety.

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