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"Geo-tagging and Maintenance Monitoring of Manholes" A Smart Infrastructure Monitoring System for Nagpur Municipal Corporation (NMC)- A Methodology

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Abstract - *Urban infrastructure management is a major challenge for growing cities, especially when it comes to maintaining underground drainage systems. Manual inspection of manholes is not only time-consuming but also risky and inefficient. This paper presents a smart solution for improving the monitoring and maintenance of manholes using modern technology for the Nagpur Municipal Corporation.*
The proposed system uses geo-tagging and Internet of Things (IoT) sensors to track the location and condition of manholes in real time. Each manhole is assigned a unique identity and mapped using GPS, making it easier for authorities to locate and manage them. Sensors installed inside the manholes continuously monitor important parameters such as water levels and harmful gases. When any abnormal condition is detected, the system automatically sends alerts to the concerned authorities.This approach helps reduce the need for manual inspections, improves response time during emergencies, and enhances worker safety. In addition, the collected data can be used for better planning and preventive maintenance. Overall, the system provides a reliable, efficient, and scalable solution for smart urban infrastructure management.

***Key Words*: : Geo-tagging, Manhole Maintenance, GPS, Sewer System, Urban Infrastructure, Monitoring System, Smart City.**

1.INTRODUCTION

Manholes are small but incredibly important parts of any city's sewer and drainage system. They allow maintenance workers to access underground pipelines for cleaning, inspection, and repairs, keeping our cities safe, clean, and functioning smoothly. But as cities grow bigger and more crowded, the number of manholes increases, spreading across roads, footpaths, residential areas, commercial zones, and industrial sites. Managing all of them using traditional, manual methods has become a huge challenge. Often, records of manhole locations, conditions, and past maintenance are incomplete, outdated, or missing entirely. Because of this, authorities can struggle to locate manholes during inspections or emergencies, leading to serious problems like sewer blockages, wastewater overflow, foul smells, road damage, and even health hazards. In many cases, issues are noticed only after damage has already occurred, which is not only costly but also disruptive to daily life.Manual inspection of manholes is also risky. Workers often face dangerous gases, low oxygen levels, and unsafe conditions while entering these underground spaces, which can result in serious injuries or even fatalities. Additionally, relying on paper records or word-of-mouth knowledge makes it hard to keep track of maintenance schedules or prioritize repairs. The whole process is slow, inefficient, and prone to errors.This is where modern solutions like geo-tagging and digital maintenance monitoring come in. Geo-tagging uses GPS technology to record the exact location of every manhole, creating an accurate, easy-to-access digital map. Digital maintenance systems store detailed information about each manhole, including its condition, cleaning history, inspection dates, and any repairs performed. These systems allow authorities to monitor manholes in real-time, plan preventive maintenance, respond quickly to emergencies, and manage resources more effectively.With geo-tagging and digital monitoring, cities can move from a reactive approach—fixing problems only after they occur—to a proactive system, where potential issues are detected early and addressed before they cause damage. This not only keeps the sewer system running smoothly but also protects public health, prevents environmental pollution, reduces repair costs, and makes life safer for maintenance workers. In addition, these technologies support better urban planning, transparency, and accountability, making it easier for municipalities to manage their infrastructure efficiently and sustainably.In short, geo-tagging and maintenance

monitoring of manholes is a practical, modern solution for cities struggling to manage their underground sewer networks. By combining accurate location data with real-time monitoring, cities can ensure cleaner streets, safer living conditions, healthier residents, and a more organized and efficient approach to urban maintenance.

2. RELATED WORK

In many cities, including those managed by the Nagpur Municipal Corporation, manhole covers are essential for public safety and proper drainage. However, they often suffer from damage, theft, or displacement, which can cause accidents for pedestrians and vehicles. Traditionally, municipal authorities rely on manual inspection to check the condition and location of these covers. This process is slow, labor-intensive, and sometimes risky for workers.

To overcome these challenges, researchers and city planners have explored ways to improve monitoring and maintenance of manhole covers. Some studies focused on mapping manhole locations using GPS or digital tools. By recording the exact positions of manholes, authorities can easily locate covers that need maintenance, rather than searching manually across the city. This also allows better planning for repair teams, saving both time and resources.

Other studies concentrated on checking the condition of manhole covers. Broken or missing covers pose serious safety hazards, so early detection is important. Several approaches recommend periodic surveys and using simple reporting systems where field workers can mark damaged covers, helping municipal teams act quickly.

Some works also explored record-keeping and maintenance tracking. By maintaining a database of all manhole covers, including repair history and inspection dates, municipalities can plan preventive maintenance. This reduces emergency repairs and ensures that covers are safe for the public.

Although these approaches are helpful, they often focus on one part of the problem, like location tracking or condition monitoring, but rarely combine both. Furthermore, most systems are not fully integrated into municipal management, making it harder to plan and prioritize maintenance across the city efficiently.

3. METHODOLOGY

The Manhole Maintenance System will use Geo-Tagging Technology for Automation and Improvement.

The first step in the process will involve collecting images of the manholes at the time of inspection. These images shall be collected with a camera (fixed or handheld) and will be Geo-Tagged with a Point of Reference (GPS Coordinates) as well as the Date/Time collected.

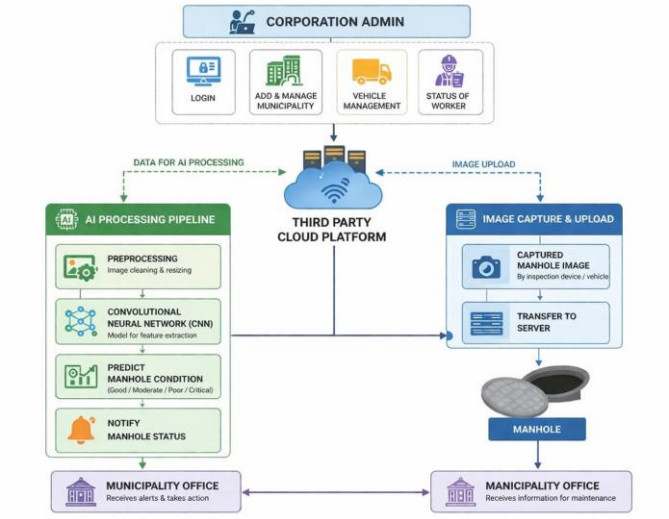

Fig-1: Architecture diagram

This will provide an accurate way of identifying each manhole's unique position and will allow easy tracking of where images were taken. When images and GPS coordinates are collected, they will be uploaded to a secure 3rd Party Internet-Based Storage (Cloud) and accessible by all statutory municipalities for secure data management and storage (scalable). Once the images and coordinates are uploaded to the cloud, they will be pre-processed by using Image Preprocessing Techniques including but not limited to Noise Reduction, Resize, Contrast Enhancement, and Normalization, to improve the clarity and consistency of the image prior to it being analyzed by the Convolutional Neural Network (CNN).

The CNN will be trained to extract important visual features from the pre-processed images and classify the Condition of the manhole into Safe, Damaged, Open, Blocked, and Hazardous conditions. The output from the CNN Model will allow the Automated System to accurately and automatically predict the Condition of the manholes and eliminate the need for continuous manual inspections.

The system shall generate Real-Time Alerts with the Priority Assignment of High, Medium, Low according to the condition of the manhole.

3.1 Components Used:

1. Geo-tagging

Geo-tagging is the process of assigning a unique location to each manhole on a digital map. In this project, every manhole is tagged with its precise GPS coordinates. This

allows municipal authorities to quickly locate each manhole and track which ones need repair or maintenance. Geo-tagging makes the entire sewer system organized and easy to manage.

2. Manhole Maintenance

Manhole maintenance involves checking, repairing, and replacing manhole covers to keep the sewer system safe and functional. This project keeps records of all manhole covers, notes which ones are damaged or missing, and helps authorities plan maintenance efficiently. Proper maintenance reduces accidents and ensures the sewer system works reliably.

3. GPS

GPS (Global Positioning System) is used to record the exact location of each manhole. By capturing latitude and longitude, the project creates a digital map showing where all manholes are in the city. GPS makes it easier for maintenance teams to find manholes quickly without wasting time searching manually.

4. Sewer System

The sewer system is the underground network of manholes, pipes, and drains that manages wastewater in a city. Well-maintained manholes are critical for the smooth functioning of this system. This project ensures that manhole covers are safe and maintained so the sewer system remains efficient and free of blockages.

5. Urban Infrastructure

Urban infrastructure includes roads, drains, sewers, and other public facilities. Manholes are an important part of this infrastructure. Proper management of manhole covers contributes to safer streets, better sanitation, and more reliable city services.

6. Monitoring System

A monitoring system is used to keep track of manhole locations, conditions, and maintenance activities. This project uses a digital platform where authorities can see which manholes are damaged, which have been repaired, and which need attention. It helps in planning, prioritizing, and organizing maintenance tasks.

7. Smart City

A smart city uses technology and data to manage urban services efficiently. By combining geo-tagging, GPS, and a digital monitoring system, this project supports the idea of a smart city. It makes manhole maintenance faster, safer, and more organized, improving overall urban management and public safety.

3.2 Algorithm Development:

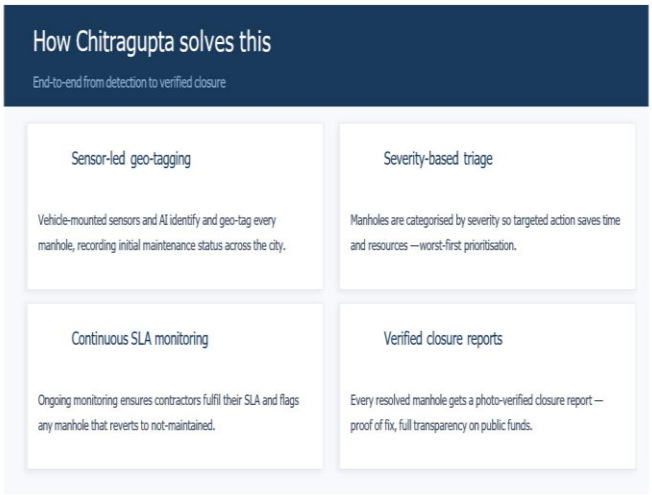

Fig-2: Algorithm of System

This image shows how a smart system by Chitragupta helps in managing manholes in a city in an easy and efficient way. First, vehicles with sensors and AI move around the city and automatically detect manholes. They also record the exact location and check the condition of each manhole. After collecting the data, the system decides which problems are serious and which are minor. Dangerous or damaged manholes are given higher priority so they can be fixed quickly.

Then, the system keeps monitoring the contractors to make sure they complete the work on time and properly. If any repaired manhole gets damaged again, it is also tracked. Once the work is done, a photo is taken as proof, and the issue is marked as solved only after proper verification. This way, there is no chance of fake reports, and everything stays transparent. Overall, this system makes the whole process faster, smarter, and more reliable.

3.3 System Integration:

The system by Chitragupta manages manholes in a simple and smart way. First, AI and sensors scan the city and collect data about all manholes. Then the system divides them into two types: maintained (no action needed) and not maintained. The not maintained ones are further checked and split into two groups serious issues like open or broken manholes that need immediate repair, and minor issues like small cracks that can be fixed later.

Overall, all parts of the system work together smoothly from detecting problems to deciding priority so that important issues are solved quickly and maintenance work becomes faster and more efficient.

3.4 Testing & Validation:

The system by Chitragupta using real city data. The system scans a large area (around 600 km of roads) and identifies all manholes, marking them as maintained (green) and not maintained (red) on the map. Out of 18,654 manholes surveyed, most are in good condition, while around 1,971 need attention. It also highlights which ones are severely damaged and require immediate action.

In simple words, testing means checking whether the system is correctly detecting and classifying manholes, and validation means confirming that the results are accurate and useful. By showing clear numbers and visual mapping, the system proves that it is working properly and helping authorities take the right decisions quickly.

4. EXPECTED RESULT

The expected result of this system by Chitragupta is to give a complete and clear picture of all manholes in the city after proper testing and validation. The system should accurately detect every manhole, mark its exact location, and correctly classify it as maintained or not maintained. It should also clearly highlight dangerous cases like open or badly damaged manholes so that they can be fixed immediately.

Along with this, the system is expected to provide reliable data and numbers, so authorities can trust the results and take decisions without confusion. It should reduce manual checking, save time, and avoid human errors. Another important result is better planning—officials can focus on high-priority areas first and manage resources properly. In the long run, this leads to safer roads, fewer accidents, faster maintenance work, and full transparency, because every repair is tracked and verified with proof.

4.1 Primary Testing / Result:

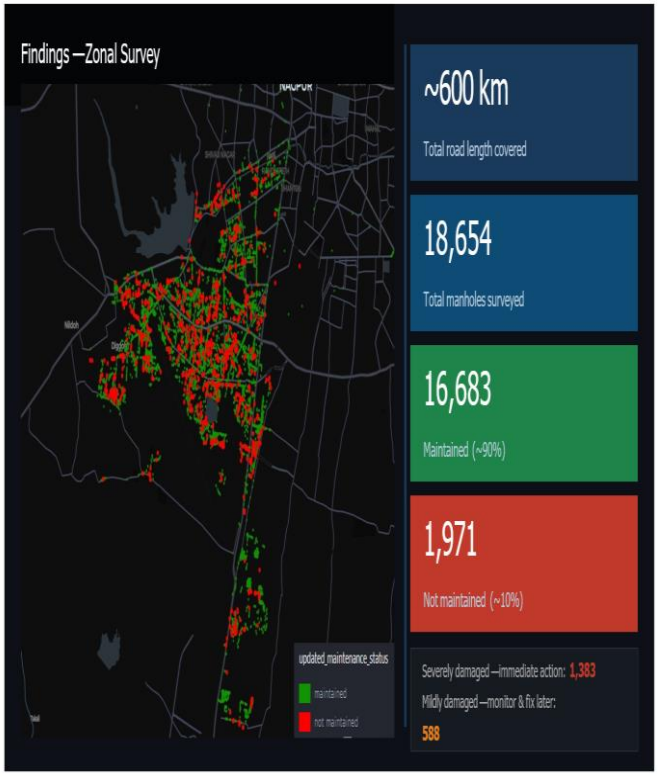

Fig-3: Primary Testing Snapshots Of System

The primary testing results of the system by Chitragupta in a simple and clear way. During testing, the system covered around 600 km of roads and detected a total of 18,654 manholes. Out of these, about 16,683 are in good condition (shown in green), which means most of the city infrastructure is properly maintained. However, around 1,971 manholes are not maintained (shown in red), which clearly shows the areas that need attention.

Among these damaged manholes, some are very dangerous and require immediate repair, while others have smaller issues that can be handled later. The map makes it easy to understand where most of the problems are located, so authorities can focus on those areas first instead of checking the whole city manually. This saves a lot of time and effort.

Another important point is that this result helps in better planning and decision-making. Officials can use this data to assign work to contractors, track progress, and ensure that repairs are done properly. It also reduces human errors because everything is recorded automatically. In simple words, this testing proves that the system is reliable, accurate, and very helpful for making city maintenance faster, safer, and more organized.

5. CONCLUSION

The system by Chitragupta proves to be a smart and practical solution for city maintenance. It not only detects and locates manholes accurately but also helps in understanding their condition in a very clear way. With the help of this system, authorities can easily identify which problems are serious and need immediate action, and which ones can be handled later, making the whole process more organized.

Another important benefit is that it improves transparency and accountability. Since all data is recorded and verified, there is less chance of mistakes or false reporting. It also helps in better planning, proper use of resources, and faster completion of work. In the long run, this system can reduce accidents, improve road safety, and make city infrastructure more reliable.

Overall, this solution makes maintenance work easier, faster, and more efficient, which is very helpful for developing smart and safe cities.

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