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A GPS and Machine Learning Driven Approch to Pothole Detection and Reporting System

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ABSTRACT: The number of vehicles that are on the road today, whether it is highways or single carriageways, is increasing all the time. Potholes are often viewed as static objects from the perspective of an autonomous vehicle, posing a risk to road users, especially at high speeds. They typically appear during rainy seasons or when big vehicles such as trucks use the roads on a regular basis. Manual detection methods are time-consuming and expensive. Computer vision and machine learning can help automate pothole identification. Accurate and timely hole identification is crucial for effective ITS (Intelligent Transportation service) and route management. In addition to preventing accidents due to potholes, landslides, and uneven roads, a road structure safety monitoring system is crucial to ensuring long-term vehicle safety. Identifying potholes is therefore crucial to facilitating their continuous maintenance and repair.

Pothole detection has become possible as image processing and deep learning technologies have advanced over time To overcome this problem, in this paper, focuses on the development a pothole detection and reporting system. It allows users to sign up and log in to report potholes they encounter. Users can take photos of potholes and specify where they spotted them on a map, or our system will automatically detect them using a special computer software. A customizable website allows users to keep track of the potholes they have reported. Authorities, such as city officials, require a separate login. They can view reported potholes and update their statuses, such as identifying them as fixed. We've also made it simple for authorities to view all reported potholes on a map, allowing them to prioritize where to fix first.

Currently, most pothole detection systems combine machine learning with accelerometer data, but there are few models that rely only on machine learning. This new technology aims to change that by utilizing machine learning to precisely and quickly detect potholes. By focusing solely on machine learning, this strategy promises to improve road repair, avoid vehicle damage, and make driving safer. Machine learning can analyze large amounts of data to precisely identify and classify potholes, allowing roads to be repaired more quickly. Using these systems can reduce costs, improve roads, and make driving safer. Essentially, applying machine learning is an excellent approach to detect and repair potholes, making roads more pleasant and safer for everyone.

I. INTRODUCTION

After the US, automobile usage is the second largest form of transportation globally in India. The Indian government contributes millions of rupees annually to the construction and maintaining of roads, which is an important cost in the national budget. A nation's infrastructure advancements determine its level of economic success and growth. Infrastructure development has a number of obstacles, yet a well-functioning network is important for business, social mobility, industry, and national communication.

The highway infrastructure should be maintained, and the damages may be the reason for the growing number of accidents. However, roads inside towns are constructed to be smaller and made up of one or two lanes. Roads are vital in people's daily life, so periodic maintenance shall be made to keep them functional and safe. The vast majority of the nation's roadways have congestion, have poor surfaces, and have unsatisfied maintenance demands.

Roads have many undesired potholes that are extremely unsafe for commuters due to inadequate road network design and development as well as natural calamities like severe rains. On a daily basis, commuters have to struggle with problems because of awful road conditions. Because of the discomfort, stress, and frustration that traffic congestion affects for everyone, it is crucial to increase awareness of these dangerous driving circumstances. Potholes additionally result in an enormous amount of injury to automobiles. Typical problems involve damage to the suspension, steering, tires and rims, and even the body of the automobile. Some of the pothole image as shown in fig1:

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Fig 1: sample image of pothole

Additionally, potholes may cause vehicles to become out of alignment, which may lead to uneven tire wear and an earlier need for replacement. This imposes a significant financial strain on the country's residents. According to the Ministry of Road Transport and Highways, approximately 11300 people died and 29600 were injured in road accidents caused by potholes in 2021, 2022, and 2023. According to UNESCAP, road traffic accidents cost India over 3% of its GDP each year, or approximately USD 58,000 million in absolute terms (as of 2022).
In order to effectively maintain roadways, maintenance departments must assess their state on a regular basis. This is frequently achieved through yearly inspections or in response to public concerns. Staff travel down the streets inspecting and documenting the conditions, which are subsequently recorded into a database. In any situation, the monitoring is more valuable. To address the aforementioned issues, a cost-effective solution is required. Fundamentally, there is a schism between the people, elected officials, and civic bodies.

II. LITERATURE REVIEW

[1]Shubhra Rao Kuthyar,Roopashree S,Rasika V,Sahana Manjesh,Priyadarshini has introduced An Intelligent Pothole Detection and Alerting System using Mobile Sensors and Deep Learning developed 2021 IEEE 18th India Council International .The mobile applications are created with Flutter, a cross-platform framework for Android and iOS. Commuters utilize the public app to report potholes in various modes such as trip mode and capture image mode. These modes make use of smartphone accelerometers as well as deep learning techniques like YOLOv3 models. They also have specific features such as alert mode, which alerts the user of nearby potholes while commuting, and geotagging of all potholes spotted by all users. The customized mobile application for Elected Representatives, PWD, and the assigned contractor is designed to track the reporting and progress of pothole repair and to assign the next task in the process

[2]Ganesh Babu R,Chellaswamy C,Surya Bhupal Rao M,Saravanan M,Department of Electronics and Communication Engineering;"Deep Learning Based Pothole Detection and Reporting System (IEEE 2020) aimed to an accelerometer and ultrasonic sensor were set up in the bottom of a car while moving at a speed of 25 km/h and a GPS was used to determine the location. The microcontroller, which also detects the pothole, informs the control room of its location. The microprocessor (ATmega328) initializes the GPS and also provides the coordinates. The methodology used was a comparison of CNN, KNN (k-Nearest Neighbors), and Kirchhoff's Theory Method.

[3] Ping Ping ; Xiaohui Yang; Zeyu Gao;"A Deep Learning Approach for Street pothole Detection";2020 IEEE Sixth International Conference on Big Data Computing Service and Applications (BigDataService). proposed a intended to construct an accurate and efficient pothole detecting system by utilizing machine learning and artificial intelligence technologies. Yolo V3(You Only Look Once) Algorithm, SSD(Single Shot Detector) Algorithm, HOG(Histogram of Oriented Gradients) with Support Vector Machine, and Faster R-CNN are four current deep learning models that are trained to see which model or ensemble of models delivers the best results.

[4]Shebin Silvister,Dheeraj Komandur,Shubham Kokate,Aditya Khochare,Dr. Vishwanath Karad MIT World Peace University Pune, India;" Deep Learning Approach to Detect Potholes in Real-Time using Smartphone";2019 Introduces a system to detect potholes in real time, a system that uses deep learning algorithms and is integrated with cellphones is used. The customer the system's interface is a smartphone app that maps all potholes along the route the user is

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taking. At the same time, deep learning object detection algorithm: The Single Shot Multi-Box Detector (SSD) searches for potholes in the background using a mobile camera. As soon as an unregistered pothole is spotted by SSD, the coordinates of the pothole are updated in real-time in the database. To detect unregistered potholes, accelerometer and gyroscope signals are continuously collected and analyzed by a Deep Feed Forward Neural Network model. This dual detection system comprising camera-based and accelerometer-gyroscope-based detection not only cross checks detections but also gives steady findings even when one mechanism fails. The pothole coordinates are displayed on the map user interface, which is accessible within the same application.

[5]Pothole Detection Using Deep Learning: A Real-Time and AI-on-the-Edge Perspective: For a real-time pothole detection, Muhammad Haroon Asad proposed Annotation for each image is performed explicitly after the collection of the dataset. Annotated data are split into training and testing data before passing it to deep learning models such as the YOLO family and SSD for custom model training. weights obtained after training contribute to model performance evaluation on testing data. Custom weights are then converted into the OpenVino IR format to perform real-time detection on OAK-D and Raspberry pi as host computer.

[6]Dr.M. Seetha ,Professor and Dr. K. Prasanna,Associate Professor, has India;"Intelligent Deep Learning Based Pothole Detection and Alerting System";International Journal of Computational Intelligence Research Volume 19.provides a deep learning-based technology that can detect potholes early using photographs and videos, lowering the risk of an accident. Faster Region-based Convolutional Neural Network (F-RCNN) and You Only Look Once Version 3 (YOLO V3) are the foundations of this model. It also discusses the difficulties of detecting potholes, such as changing lighting conditions and data noise.

[7]Anas Al-Shaghouri, Rami Alkhatib, Samir Berjaoui Chouf 2010, Lebanon;"Real-Time Pothole Detection Using Deep Learning" deployed and tested many deep learning architectures for detecting potholes. First, a cellphone mounted on the automobile windshield captures many photographs of potholes. Then, by downloading pothole photographs from the internet, we expanded the quantity and variety of our database (1087 images with over 2000 potholes). Second, several object detection methods are used to detect potholes in road photos. To compare pothole detection performance, real-time Deep Learning algorithms with various configurations such as SSDTensorFlow, YOLOv3-Darknet53, and YOLOv4-CSPDarknet53 are employed.

[8]Yeoh Keng Yik, Nurul Ezaila Alias, Yusmeeraz Yusof and Suhaila Isaak in 2010 IEEE sixth eition proposed a Apart from accelerometer detection, image processing, or machine learning-based detection, which are easier to design and deliver more accurate results. When a pothole is identified by a real-time webcam, the position is recorded and visualized using Google Maps API. A total of 330 data sets were sampled for the pothole detecting training model's implementation. As a consequence, the model produced 65.05 mAP, 0.9% precision, and 0.41 recall. The detection limitation of the YOLOv3 method can be improved further by employing GPU with better specified performances that can sample 1000 to 10,000 datasets.

[9]Prof.Arunadevi Khaple(Professor), Shubham Barangule(Student), Nandakishor More(Student),Omkar Mote(Student), Abhishek Doke:”POTHOLE DETECTION AND COMPLAINT MANAGEMENT SYSTEM USING DEEP LEARNING" 2023.In this paper , proposed system utilizes deep learning techniques to automatically detect potholes in real-time, using a camera mounted on a vehicle. The system employs convolutional neural networks (CNNs) to classify images and identify potholes. It also includes a complaint management module that enables citizens to report potholes using a mobile application, which then sends the location and image of the pothole to the system. The system's backend processes the data received from the camera and the mobile application, and generates reports and alerts for concerned authorities. The system aims to streamline the process of pothole detection and management, enabling prompt repair and maintenance of roads, and improving road safety.

[10] Aparna , Yukti Bhatia, Rachna Rai , Varun Gupta 2023 In this paper, Convolutional neural networks based potholes detection using thermal imaging analyses the feasibility and accuracy of thermal imaging in the field of pothole detection. upon collecting a sufficient amount of data containing images of potholes under various conditions and weather, and implementing augmentation techniques on the data, a convolutional neural networks approach of deep learning, which is a new approach in this problem domain using thermal imaging, was adopted.

[11] Kunal Chawla,Vanshika Kaul,Cse-AI &ML, Chandigarh University,Mathura, India.Parth Thakkar,Shiv Sahil Soni 2023 adapts a StreetSafe: AI-Based Android Application for Pothole Detection This research paper proposes an android application StreetSafe which is an end-to-end pothole detection application, which can be downloaded on any Android

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based device and which can help to combine all these processes and even save lives of innocent drivers and pedestrians. The methods proposed in this paper are proven to be 97% accurate in detecting these anomalies and alerting the user about these anomalies on the road.

[12]Harun Joe,Joseph Blessingh, Joel proposed An Intelligent Pothole Detection System using Deep Learning"; 2020.The research focuses on gathering and evaluating pothole datasets in order to train a convolutional neural network. The tiny YOLOv3 object detection technology is used to detect potholes. A system architecture is identified that can be used to create a mobile application for detecting and displaying a visualized image of potholes and the information can be used by the Municipal Authority to repair the potholes.

[13] Prof.Arunadevi Khaple, Shubham Barangule, Nandakishor More,Omkar Mote, Abhishek Doke 2023 survey on pothole detection and complaint management system using deep learning:This survey paper provides an overview of the recent advancements in the pothole detection system using CNNs. The paper discusses the state-of-the-art techniques and their limitations, as well as the challenges and future directions in this field. The survey paper reviews several state-of-the-art techniques in pothole detection using CNNs, including YOLOv4, Faster R-CNN, and Mask R-CNN. The paper also highlights the challenges in this field, including the limited availability of datasets and the need for real-time processing algorithms that can run on low-power devices.

[14]Mr K. Krishna Reddy,Tuniki Bhavana,Bandyala Tejaswini, P. Mallesh,Adepu sharath, 2023 A Deep Learning Approach For Pothole Detection".employs standard techniques such as "use of FRCNN" and "inception v2 model," which are detailed further below. The key benefit of this strategy is the short training duration, easy training process, and improved accuracy. The following procedures must be taken in order to obtain a trained and operational Faster R-CNN architecture. -RPN training entails first training the RPN architecture with the dataset so that it can propose the expected region.Fast R-CNN Training - Faster R-CNN, as we know, is a hybrid of RPN and Fast R-CNN. So, in order to create a Faster R-CNN, we must train a Fast R-CNN utilizing the suggestions obtained by RPN (after training). Convolutional layers are being fixed, and unique layers are being fine-tuned to RPN.

[15]Shylee Veronica, Poojashree C, Himangshu Das, Mangesh Thakur 2022 proposed a Pothole Detection System" a system for detecting road potholes using computer vision and deep learning. To identify and locate potholes in the provided data set, we employ the YOLO v5 technique. It is a revolutionary convolutional neural network (CNN) that detects objects with high accuracy in real timeIn the sense that it provides predictions after only one forward propagation run through the neural network, the approach "only looks once" at the image.After non-max suppression (which assures that the object detection algorithm only recognizes each object), it then provides discovered items.

[16] Rupsha Debnath, Sayandeep Dutta, Dr. Sangita Roy, Arpita Santra 2023 adapts Real Time Pothole Detection with Deep Learning and Arduino dataset consists of two image sets: normal roads and potholes. The dataset's photos have all been labeled. We took a dataset from Kaggle and trained it with Python Machine learning. The dataset includes 352 photos of typical roads and 329 photographs of potholes.

REVIEW FINDINGS

- The studies focus on the various uses and implementations of pothole detecting systems, emphasizing their usefulness in road maintenance and safety.
- Deep learning techniques, notably CNNs and models such as YOLO v3 and SSD, are effective in reliably identifying potholes in photos and videos, providing real-time detection capabilities.
- Studies show that integrating sensors and GPS technology in automobiles allows for automatic detection and precise geotagging of potholes while driving.
- Advanced approaches, including as thermal imaging, are being investigated to improve the accuracy and feasibility of pothole identification under changing environmental circumstances.

III. PROPOSED SYSTEM

Our method is intended to make the process of reporting potholes on roadways more convenient for everyone involved. To begin, individuals must create an account, which grants them access to the reporting platform. Once logged in, people can easily upload photographs of potholes they see. They can also specify the exact position of the pothole on a map or allow the system do it automatically. Following the upload, users may keep track of the status of their pothole reports on a dedicated page, ensuring transparency and visibility throughout the process. Authorities in charge of road

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maintenance can access the system using their own login credentials. They may view all reported potholes and take immediate action to address them.

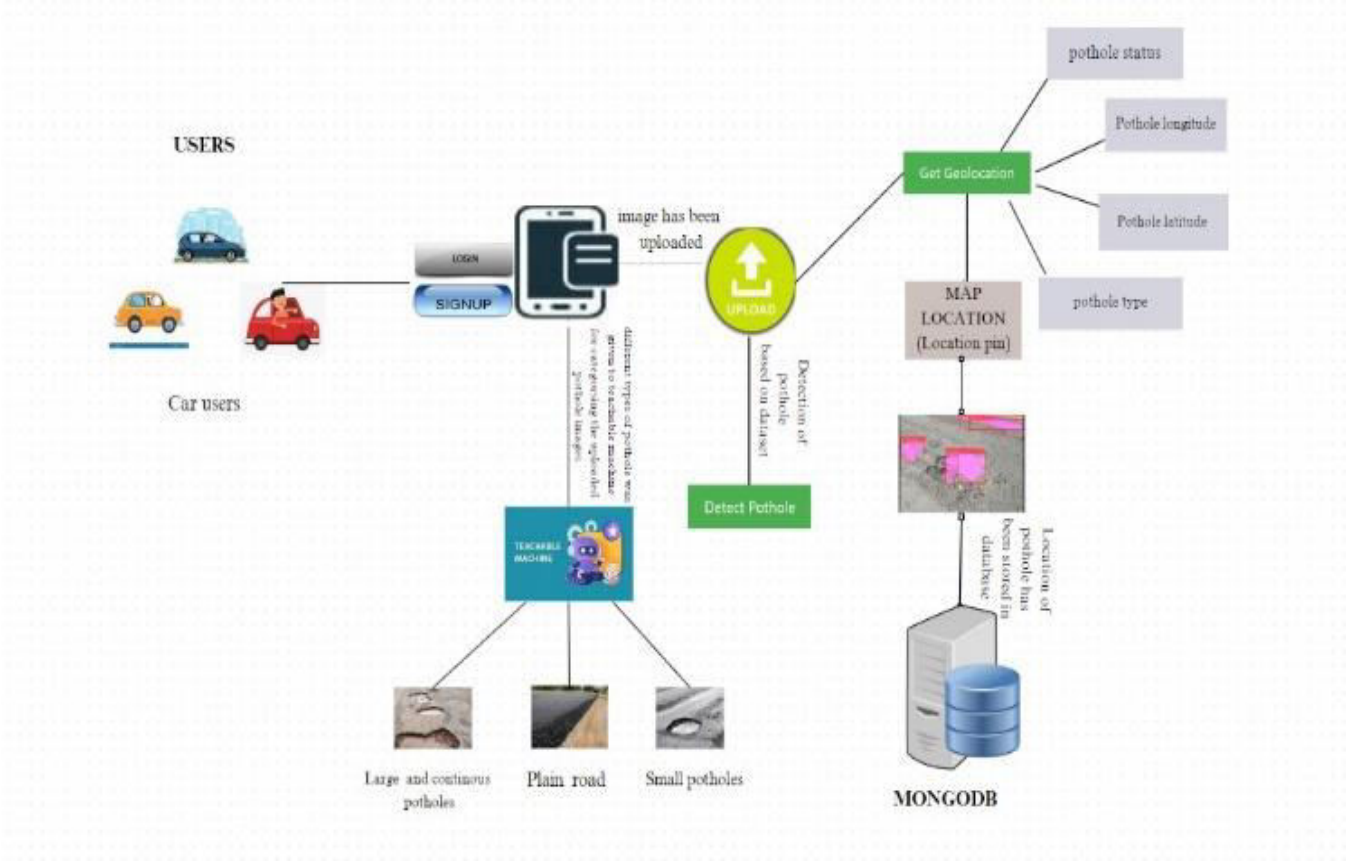

Fig 2: System Architecture

As shown in Fig. 2,to detect the pothole we collected a dataset which contains classes of some common type of potholes .The dataset includes 200 real-time images including training, testing and validation subsets. Here, they can view all reported potholes and take necessary action to address them promptly. By having access to this information, authorities can efficiently prioritize and allocate resources for pothole repairs, ultimately contributing to safer roads for everyone All data, including user accounts, pothole reports, and their statuses, is safely kept in MongoDB, a dependable database system. This ensures that information is organized and readily available when needed. By centralizing this data, the system allows for more effective coordination between users and authorities, ensuring that reported potholes are filled in a timely way.

Overall, our solution intends to simplify the pothole reporting and repair procedure, hence improving road safety and infrastructure maintenance efforts. An identification is made using CNN model to detect skin pothole in images. By evaluating the trained model with custom dataset, it results in detecting identification of pothole and reporting the pothole and the updating the status of the pothole.

IV. RESULTS

When the user login to account and uploaded the image of the pothole and by clicking the get geo location button and detect pothole button it will displays the as shown below fig 3 by containing pothole latitude and longitude, pothole status and type of pothole means small (or) large (or) medium pothole.

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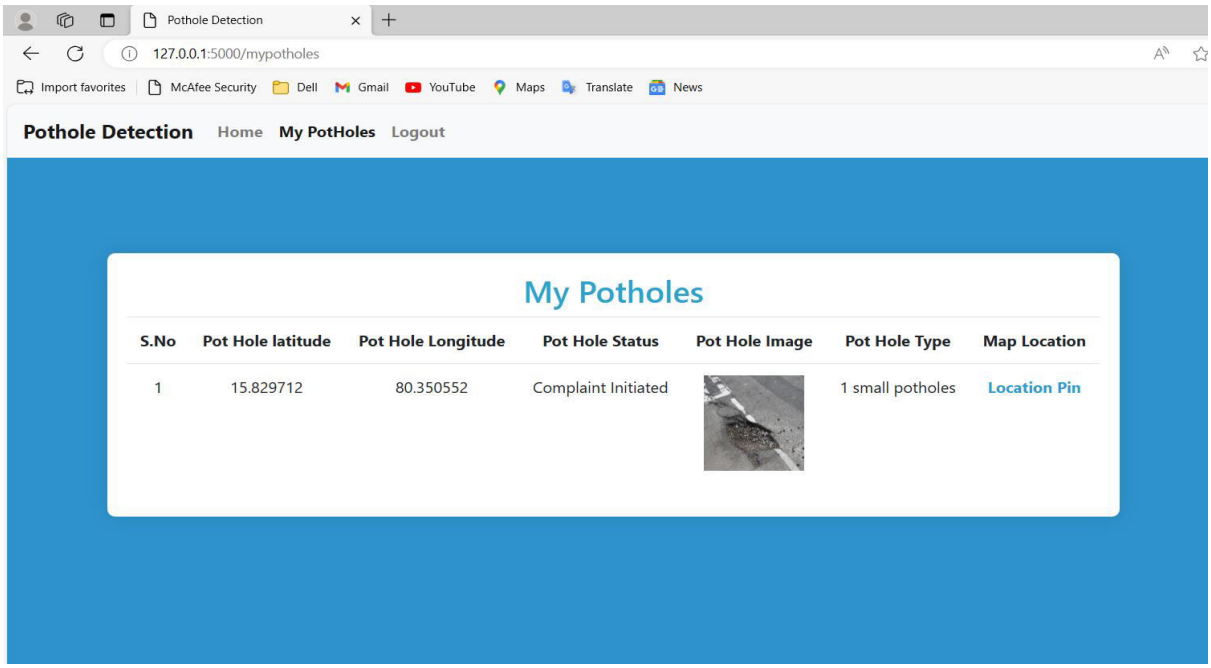

Fig 3: My potholes:Report status and location overview.

When the user clicks on the locate pin then it shows the following fig 4 by pinning the location in the map through this we can detect easily the location and avoid the rededency. This information is then send to a central server or platform where it is processed and analyzed.

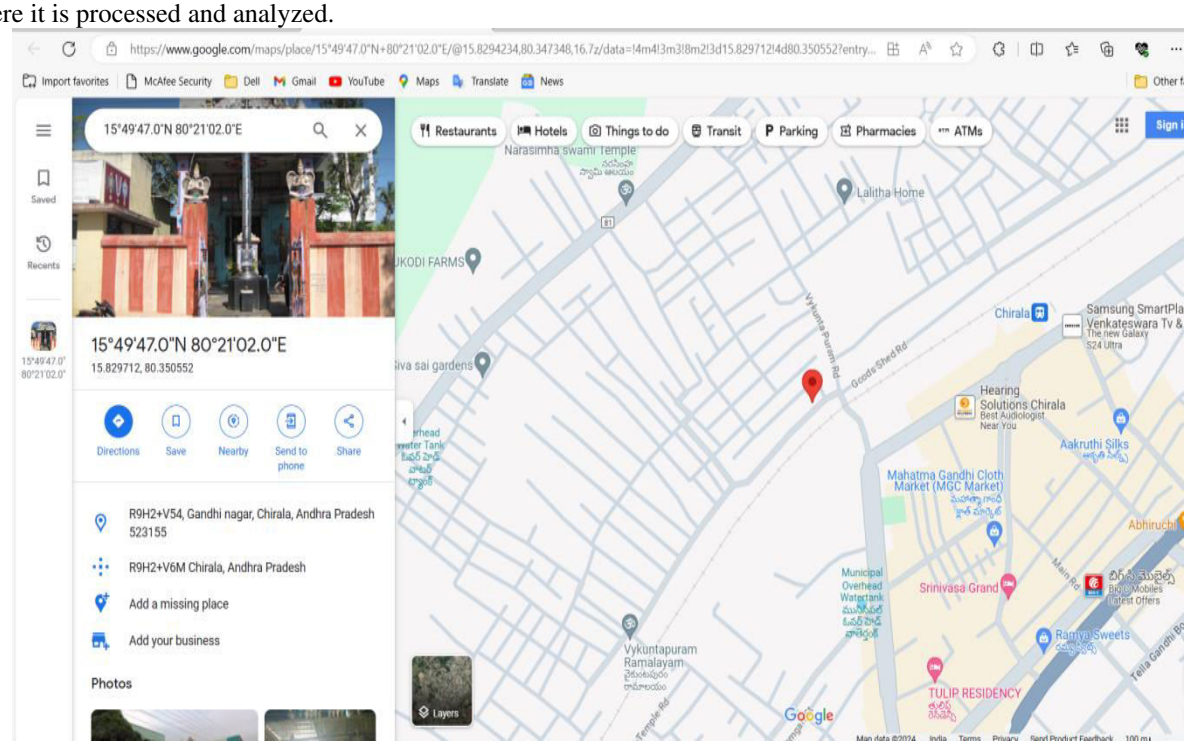

fig 5: pothole location on map.

When the authority login the page and then updating the status of the pothole as shown in the below fig 6 . this update is very useful for which pothole is alive and which is recovered
This update will done by the authorites only because of reducing frods

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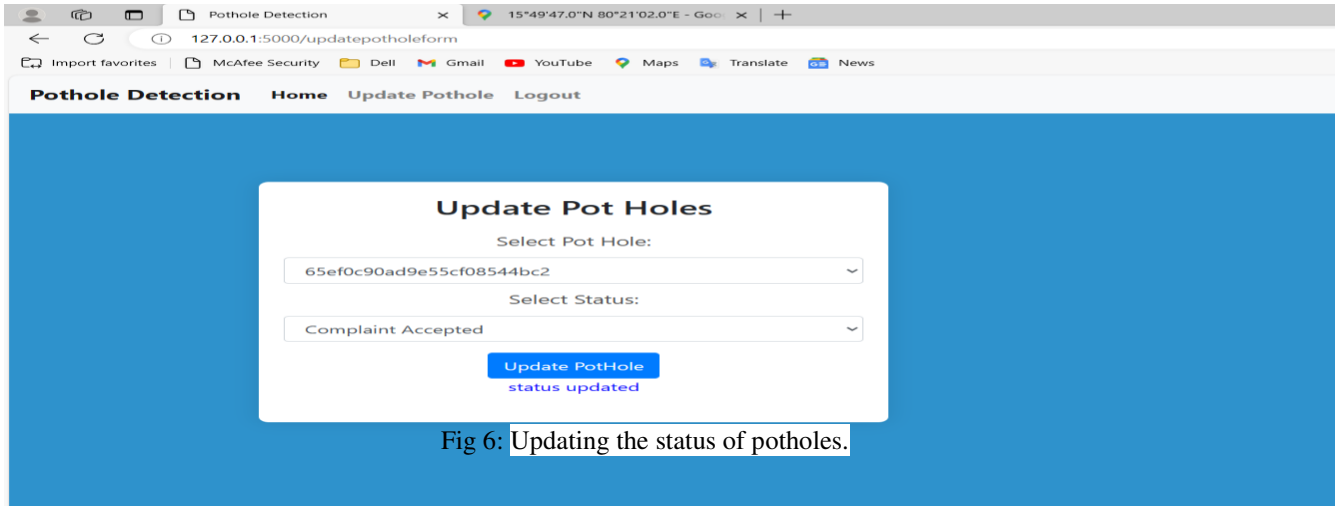

Fig 6: Updating the status of potholes.

The user can check the pothole which is uploaded has been complaint accepted or not which was updated by the authority

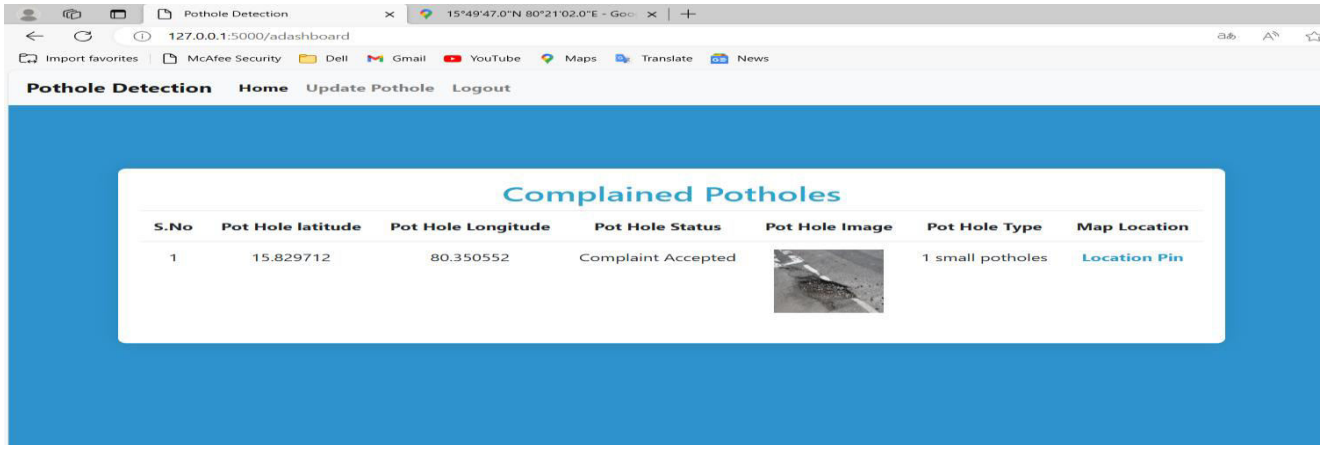

Fig 7: Complaint Accepted by Authorities

V. CONCLUSION AND FUTURE WORK

Primary identification of potholes is critical for road safety and maintenance. Our methodology effectively categorizes and locates potholes, allowing for timely repairs and preventing accidents. The use of modern object detection models such as SSD and Faster CNN ensures great accuracy in pothole detection. Our approach meets the demands of all road users by offering a quick option for reporting and repairing potholes without relying solely on authorities. Looking ahead, we intend to enhance our technology to detect a broader range of road problems and add capabilities such as online reporting and repair progress tracking, thereby improving overall road infrastructure management.

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