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Road Damage Detection and Reporting System Using Fully Connected CNN

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Abstract: Many rural and metropolitan towns, as well as road authorities, encounter challenges in mapping surface damages resulting from numerous sources such strong rains, natural catastrophes, or other events that cause cracks and holes to emerge on the road surface. These organizations or private entities look out for solutions to implement automated methods of reporting damages on a surface of the road. The majority of the time, they lack the equipment needed to map the damage to the roadways. One of the main issues facing commuters is the numerous damaged road portions they must navigate. This causes riders to often reduce their pace, losing a great deal of time and energy and lengthening the time it takes them to reach their destinations. When driving at a faster speed and suddenly encountering a damaged section of the road, road damage can frequently be fatal. Furthermore, it is capable of identifying recurring bottlenecks, determining their cause, and suggesting remedies. The majority of the time, these traffic jams are brought on by road damage, which forces commuters to go far slower than is ideal.

Keywords: Smart road damage detection, classification, Machine Learning, Image segmentation, CNN, fully connected CNNs, RDD System (Road Damage Detection System).

I. INTRODUCTION

The health and safety of communities as well as the smooth operation of transportation networks depend on the preservation of safe and well-maintained roadways. However, there are several obstacles in the way of locating, documenting, and quickly fixing road damage. Potholes, cracks, debris, and other dangerous situations that can cause collisions, harm to cars, and general degradation of road infrastructure are common problems with road damage. Conventional approaches, which frequently depend on manual inspections or delayed responses to public concerns, have proven to be insufficient for detecting and reporting these problems.

Road surface damage detection and warning systems are essential for maintaining road safety, cutting down on maintenance expenses, and increasing the effectiveness of transportation as a whole. These systems are made to recognize different types of surface defects on roads, such as cracks, potholes, and deteriorations, and to alert drivers, road repair agencies, or self-driving cars in a timely manner. Systems for detecting and warning about degradation to the road surface are crucial for keeping road networks effective and safe. To identify damage and notify drivers and authorities in a timely manner, they use a mix of sensor technologies, machine learning, and communication systems. These systems are anticipated to become more crucial to the management of transportation infrastructure as technology advances. One sector that uses technology is road surface deterioration detection. The field of road surface damage detection uses technology—typically sensors and image processing—to track and evaluate the state of road surfaces. In order to identify and categorize road damages using photographs of the road surface, we are using the object detection technique. Convolutional Neural Networks (CNNs), the primary class of Deep Neural Networks (DNNs), may be used for this.

Research on road damage detection models based on artificial intelligence (AI) has received a lot of interest lately. Road damage may be automatically analyzed and tracked down, as manual damage identification is a tedious and time-consuming operation. A government agency is unable to maintain a reliable record of road conditions. The lack of experts who could assess the extent and condition of many impairments is another issue, as the evaluation is frequently quite subjective.

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Among the Deep Neural Networks (DNNs), Convolutional Neural Networks (CNNs) are the primary class that can be used for image recognition and classification in most applications. CNNs are deep learning models that are especially intended for image-related tasks. Convolutional layers, pooling layers, and fully linked layers make up the structure. The CNN's first layers, which include convolutional and pooling layers, extract significant characteristics from the input

pictures. These layers are in charge of identifying picture edges, forms, and patterns. The fully connected layers are located at the network's end. They take the high-level characteristics retrieved by the preceding layers and use them to produce predictions. CNN's primary advantage lies in its ability to automatically identify important elements without human oversight after training is complete. Hyperparameters, on the other hand, are configurations that need to be established before training begins and are not learnt during training. They can significantly affect the model's performance, and choosing the best settings can improve accuracy. The procedure of hyperparameter tuning has not been covered in the majority of previous research. Metaheuristic optimization techniques are preferred since the process of fine-tuning parameters by trial and error is time-consuming.

II. PROPOSED ALGORITHMS

The proposed approach describes a thorough process for creating a fully connected Convolutional Neural Network (CNN)-based system for detecting road degradation. The procedure starts with a thorough analysis of the literature and the gathering of datasets. Next, the CNN model is designed and modified especially for the purpose of detecting road damage. Advanced backpropagation techniques are used to train the model, and measures including as accuracy, precision, recall, and F1 score are used to assess its performance.

Key components of the methodology include:

A. **CNN Model Architecture:** Activation functions and pooling layers are used in the CNN model, which is specifically designed for road damage detection. Convolutional layers are used to extract features from a variety of road images. Intricate feature correlations are learned via fully connected layers, which employ regularization techniques such batch normalization and dropout to reduce overfitting and improve generalization.

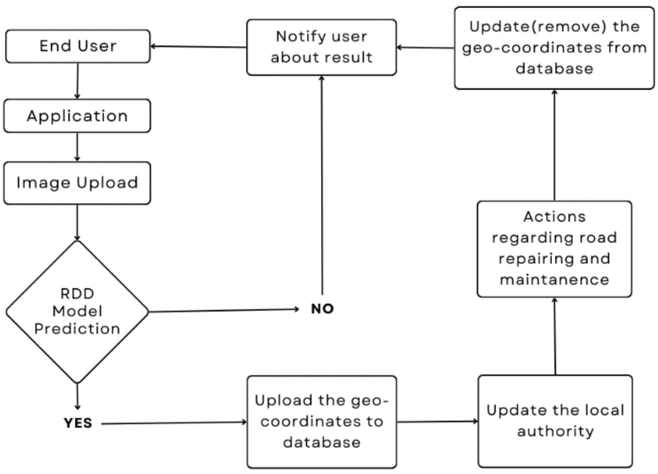
B. **Application Integration:** Real-time road damage prediction from user-submitted photographs is made possible by the integration of the trained CNN model into a Flutter application. Backend functionality is provided by Firebase, which also integrates geolocation data processing and database connectivity for data management. Firebase also makes communication between the application and the database easier.

C. **Local Government Interface:** The Flutter application that was developed has an interface that enables local government authorities to keep track of and make updates to maintenance statuses.

The methodology highlights the architecture of the CNN model for precise road damage identification, emphasizing its capacity to extract intricate patterns and features and accurately identify a range of damage kinds. The model's practical application in real-world scenarios is demonstrated by its integration into an easy-to-use system, which makes it easier for end users and local authorities to gather, analyze, and make decisions about data efficiently. This method demonstrates how cutting-edge deep learning techniques can revolutionize the management of road infrastructure and make transportation networks safer and more robust globally.

III. SOFTWARE DEVLOPMENT

The below diagram shows the system architecture:



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Actual Results of implementation:

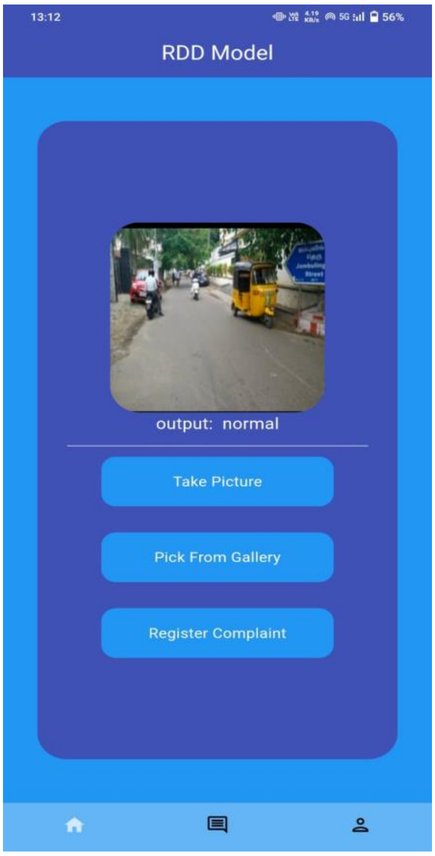


Fig. No pothole detected

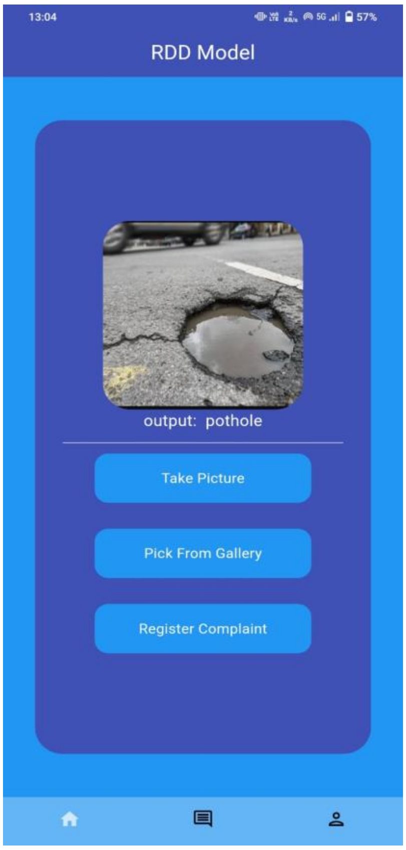


Fig. Pothole Detected

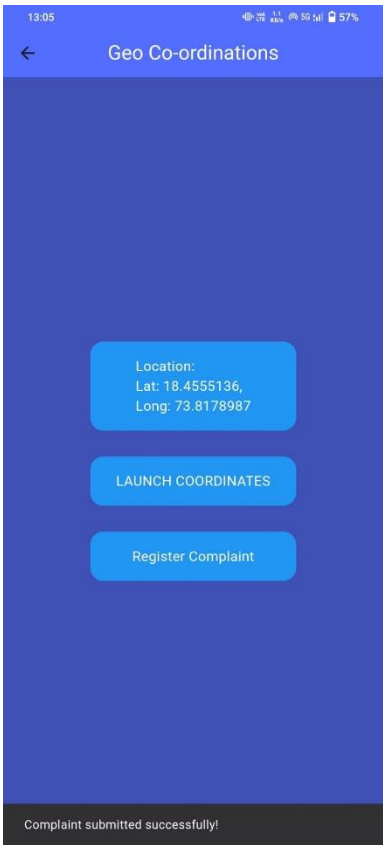
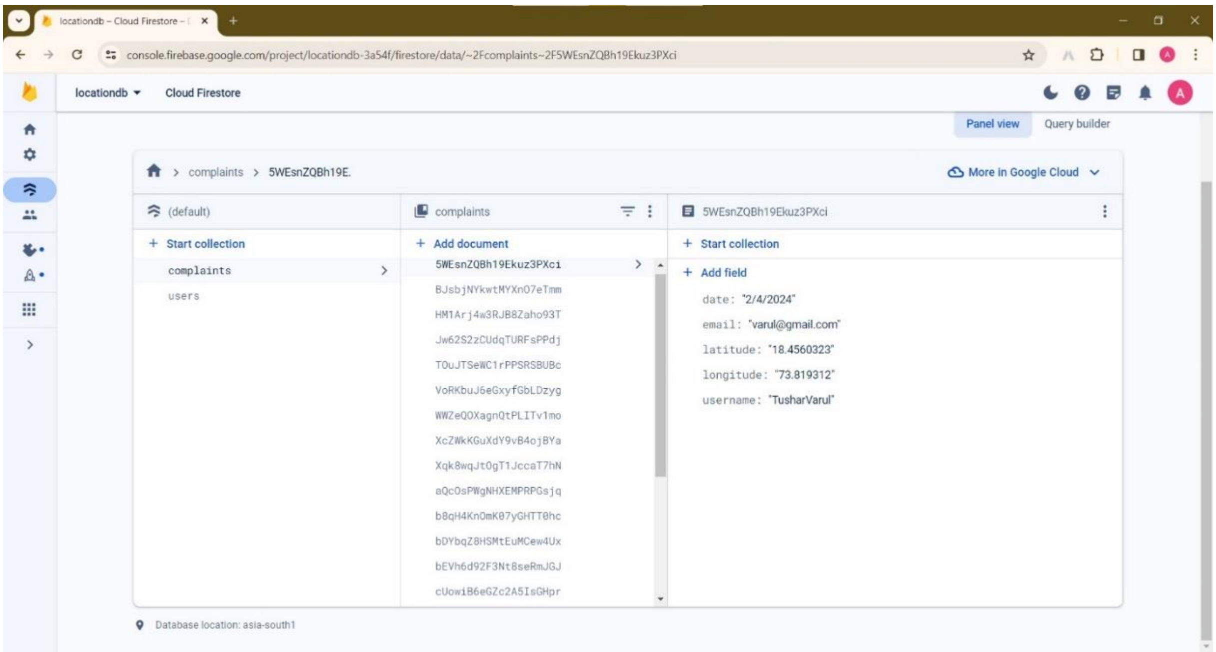


Fig. Complaint Registered

Above are the results predicted by the model in the application. For this, we have collected the different types of images having potholes not damaged road's images. If the pothole is detected then the "Register Complaint" button will be enabled to work for further screen redirection otherwise it will stay on the same image. And we get the above results successfully.



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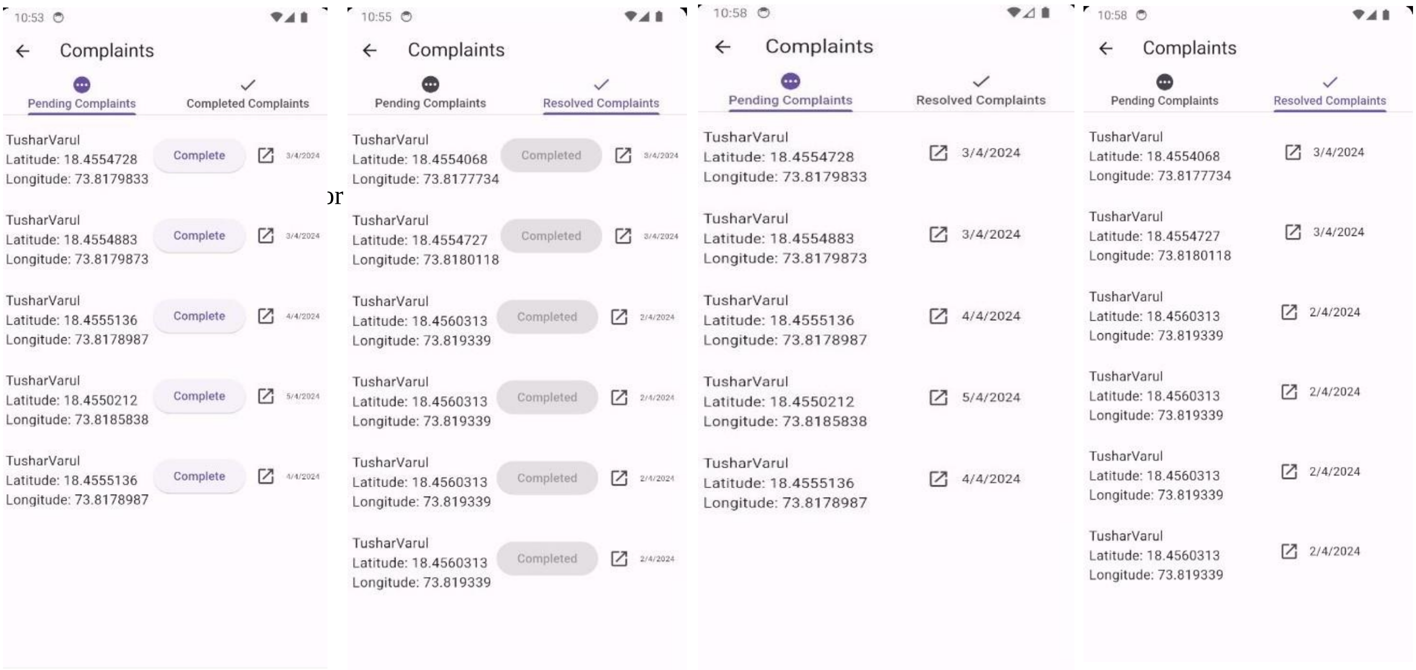

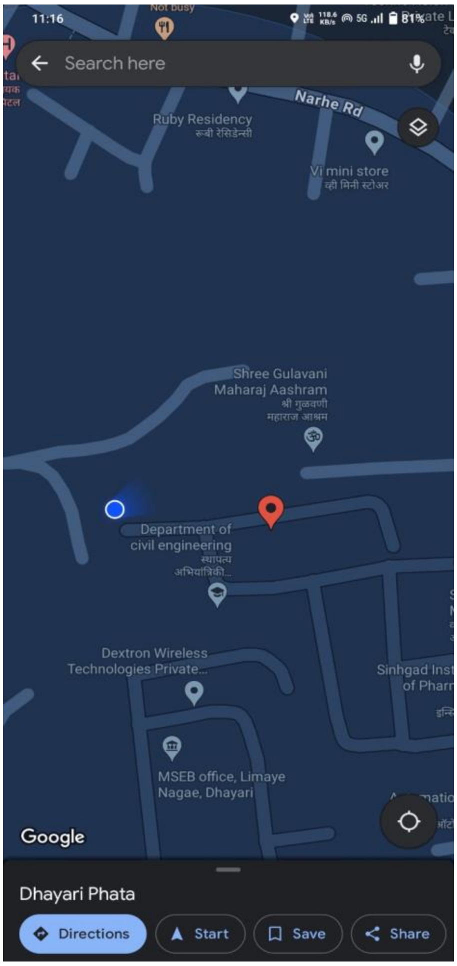

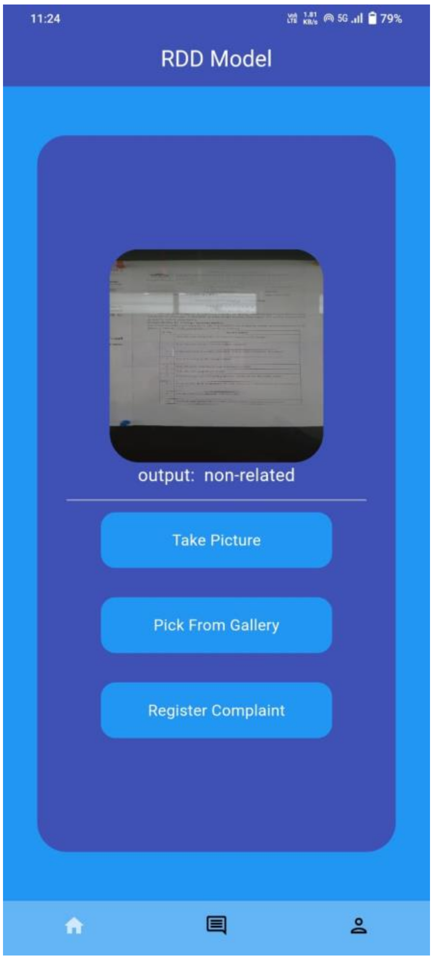

Fig. Map Launched for visualization.

Fig. Non-related Camera image detected

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Test Cases

TC ID	Description	Expected Output	Actual O/P
1	Upload the non-defective road image	Model should predict the "normal" output	Model successfully detected normal
2	Upload the road image containing potholes	Model should detect the "pothole" output	Detected pothole successfully
3	Register the complaint	Location should be fetched on the complaint screen	App gets the user precise location co-ordinates and complaint is successfully registered to the database with correct details.

IV. CONCLUSION

This paper summarizes the developments in road damage detection systems and highlights the critical role that Convolutional Neural Networks (CNNs) play in improving infrastructure management by accurately identifying and classifying road damages. The report illustrates how deep learning technologies can simplify the detection, reporting, and resolution of road damages by exploring current approaches and the comprehensive approach of the proposed system, which includes the creation of a specialized CNN model, smooth integration with user-friendly applications, and reliable database management. This model is demonstrated by the Road Damage Detection and Reporting System, which uses CNNs in conjunction with a mobile app for users and local authorities. This allows for effective coordination and communication between end users and local governments, guaranteeing timely and efficient road maintenance operations.

V. FUTURE SCOPE

With the use of sophisticated deep learning algorithms such as attention mechanisms and recurrent neural networks (RNNs), improved image processing, and sensor fusion approaches, the research and development of the road damage detection system is expected to make substantial progress in the future. The aforementioned modifications are intended to strengthen the system's predictive skills for dynamic road damage projections, boost its temporal context awareness, and improve its accuracy in detecting subtle road problems. Furthermore, strengthening the system's early detection and proactive monitoring characteristics through the integration of real-time anomaly detection and localization algorithms could enable prompt maintenance actions. Modern geospatial analytics and predictive modeling techniques may also provide insightful information on long-term trends in road deterioration, empowering stakeholders to put proactive infrastructure management and predictive maintenance plans into practice. The project aims to enhance road infrastructure maintenance and management through innovation and innovation by investigating these future research directions, which will ultimately result in transportation networks that are more robust, safer, and sustainable.

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