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Enhancing Real Time Pothole Detection Using Vehicles on Machine Learning

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Abstract: Machine learning (ML) is a branch of computer science and AI, that helps machine learning from data and perform some tasks that humans can do it train machines to perform task like analyze data categorizing images, etc.
In the existing system, they have used YOLOv2 algorithm to detect and identify potholes. They proposed a automated system that determines the state of the road. They trained the system by using images captured from mobile cameras will be tested on several road images. Even though the existing work is effective, there are some issues such as it does not provide accuracy with detecting small objects in images and also the box precision can be less accurate. It requires high resources for Real-time applications with-High Resolution images. To address the issues, We proposed a YOLOv8 advanced algorithm. Which offer better accuracy and precision in object detection. YOLOv8 enhances speed and efficiency in Real time detection technique and also it is faster in detecting the High Resolution images. So our proposed work will overcome these challenges by providing better Efficiency and Accuracy
Keywords: You only look once(YOLO),Open Computer Vision Library(Open CV),Real time Pothole Detection, Machine Learning, Global Positioning System, Bounding boxe

I. INTRODUCTION

Potholes are a widespread and hazardous problem on roads, contributing to a significant number of accidents and vehicle damage, particularly in regions with heavy rainfall and inconsistent road maintenance like India. The presence of potholes not only endangers drivers but also increases the overall wear and tear on vehicles, leading to higher maintenance costs and potential safety risks. Traditional methods of detecting and addressing potholes, such as manual inspections and the use of vibration-based sensors, have proven to be limited in their effectiveness.

Manual inspections are labor- intensive, time-consuming, and often delay the detection of hazards, while sensor-based approaches can be costly and may not provide comprehensive coverage or accuracy. The main objective of this project is to automate pothole detection, eliminating the need for manual labor and complex sensor systems. This will streamline the road maintenance process, allowing authorities to quickly locate and repair potholes, reducing the risks of accidents and minimizing vehicle damage. In addition, this system offers a scalable solution that could be easily deployed across various regions and road networks, enabling consistent and continuous monitoring of road conditions. By providing real-time alerts and reports on pothole locations, it also allows authorities to prioritize repairs, ensuring that the most dangerous or damaging potholes are addressed first.

This project seeks to overcome these challenges by developing an automated, real- time pothole detection system that utilizes the YOLO (You Only Look Once) algorithm in conjunction with OpenCV. OpenCV (Open Source Computer Vision Library) is a powerful, open-source software library that provides a wide range of tools and algorithms for computer vision tasks. It is widely used in fields such as robotics, machine learning, augmented reality, and medical imaging due to its versatility and ease of use.

OpenCV is designed to enable real-time image and video processing, making it highly valuable for applications like object detection, face recognition, motion tracking, and autonomous vehicles. Initially developed by Intel in 1999, OpenCV has since evolved into one of the most popular libraries for computer vision, with contributions from developers worldwide.

It supports a variety of programming languages, including Python, C++, and Java, and is compatible with a wide range of platforms such as Windows, Linux, macOS, and AndroidYOLO is a powerful object detection algorithm known for its speed and accuracy, making it ideal for real-time .By analyzing road images captured at 720×720 pixel resolution, the system can quickly and accurately identify potholes, highlighting them in real-time and providing immediate notifications.

Furthermore, the system could play a crucial role in the context of smart city initiatives, where infrastructure management is increasingly being driven by data. By integrating pothole detection with broader city maintenance systems, this project could support the creation of comprehensive road condition databases, helping urban planners and road authorities make more informed decisions regarding infrastructure upgrades and resource allocation.

With the potential for future advancements, such as incorporating GPS for location tagging and developing severity assessment algorithms, this project sets the stage for more sophisticated, proactive, and data- driven approaches to road safety.

This approach not only enhances road safety by reducing the time between pothole formation and detection but also offers a scalable and cost-effective solution that can be implemented across various regions and road conditions.

Ultimately, this project aims to revolutionize how potholes are detected and managed, contributing to safer roads, lower vehicle maintenance costs, and better-informed decision-making for road infrastructure management. By providing a faster, more reliable, and cost-effective solution, the system will play a key role in improving road safety and driving the future of smart, technology-driven infrastructure management.

II. RELATED WORKS

Panop Khumsap et al . introduced Road surface inspection for cracks, distortion, and disintegration-together with appropriate surface treatments-are mandatory in maintaining the ride quality and safety of the highways. Due to especially high occurrences of `reflection', `alligator cracks' and `potholes' in Thailand, and the fact that they require markedly different treatment methods, a classifier that can distinguish among those two types of bad surface is most desirable.This paper proposed two novel feature extractions based on regional profiling and Cartesian profiling of orthogonal axes features which worked well with this particular problem, with added benefit of decoupling feature extraction from the classifiers themselves.The experimental results showed that Cartesian profiling of orthogonal axes features works well with Decision Tree (DT), and regional profiling works well with Support Vector Machine (SVM) achieving F-measures of 0.877 (0.864 Recall) and 0.875 (0.873 Recall) respectively

Lan Uong et al . proposed Effective and timely identification of cracks on the roads are crucial to propitiously repair and limit any further degradation. Till date, most crack detection methods follow a manual inspection approach as opposed to automatic image-based detection, making the overall procedure expensive and time-consuming. In this study, we propose an automated pavement distress analysis system based on the YOLO v2 deep learning framework. The system is trained using 7,240 images acquired from mobile cameras and tested on 1,813 road images. The detection and classification accuracy of the proposed distress analyzer is measured using the average F1 score obtained from the precision and recall values. Successful application of this study can help identify road anomalies in need of urgent repair, thereby facilitating a much better civil infrastructure monitoring system. The codes associated with the study including the trained model can be found in [11].

Shan Luo et al. proposed Research on Road Crack Detection based on Machine Vision.Road cracks will damage the pavement structure, seriously affect traffic safety and driving comfort. Aiming at the deficiency of manual detection, in order to improve the efficiency of crack detection, machine vision technology and image processing method are used to detect road cracks and extract crack parameter information. Firstly, the collected crack image is processed by graying, smoothing and grayscale stretching. Then threshold segmentation is carried out, and the background noise is removed to extract the crack target. Finally, according to the statistical curve change trend of the number of crack target pixels from different directions for different types of cracks, the type of cracks is judged; The length of the crack is calculated by extracting and refining the skeleton of the crack, and the average width, maximum and minimum width of the crack are calculated. The area is calculated by the minimum circumscribed rectangle. The test results of the detection system show that the accuracy of crack detection is basically more than 90%, the accuracy of crack area, length and average width are more than 95%, and the accuracy of crack classification is 100%.

Zhang Yuhan et al introduced detection of road crack on PYNQ.This project aims at the problem of road surface image denoising and crack recognition by using embedded camera. Using Gaussian filter to blur the image, over the threshold zero processing and the morphology on and off operation are binarization and further denoising. And the crack contour is marked by FAST feature point recognition, which reach for different road crack damage can be identified. After the simulation, the algorithm is transplanted to the Python on Zynq (PYNQ) system to achieve the purpose of crack identification. There are two parts to the innovation: First, using a lower-cost embedded camera to capture photos, and second, using the characteristics of large difference in gray value between crack region and other regions, the crack profile is marked by the way of FAST feature point recognition and use PYNQ to process. It makes the identification system more integrated and portable, and can judge the crack more accurately and reduce the cost.

Munish Bhardwaj et al improved road car detection based on FCM. The road cracks are one of the major concerns in all over the world nowadays. It may cause road safety and increase the chance of accidents on the road. Every year a lot of the money is allocated for the maintenance and repair of the roads. This cost can be reduced if the cracks are early detected. If this detection performs manually then it is mostly dependent on labourers.

The manual detection will consume more time and offer small accuracy. In the past, many algorithms have been developed to achieve the exact region of the crack. In this paper a novel technique will detect the cracks automatically by introducing Manhattan distance and histogram equalization in FCM called MHFCM. The crack detection from images is an intricate work due to background noise, scarce contrast, and intensity inhomogeneity. The experimental result shows that the novel segmentation technique provides the better result than the FCM and K-means for alligator, traverse and longitudinal cracks.

III. OVERFLOW

we proposed a system for real-time pothole detection using vehicles involves transforming regular moving vehicles into mobile sensing units capable of identifying and reporting potholes as they travel on roads. This is achieved by equipping vehicles with a set of sensors, primarily an accelerometer, gyroscope, and GPS module. The accelerometer detects sudden vertical vibrations caused by potholes, while the gyroscope helps distinguish between potholes and other surface irregularities like speed breakers The proposed system leverages the YOLO (You Only Look Once) algorithm and OpenCV to create an automated, real-time pothole detection solution. This system processes images of roads to accurately identify and highlight potholes without human intervention. The advantages of this system include increased efficiency, as it eliminates the need for manual inspections and buzzer alert. It offers real-time detection, ensuring that potholes are identified and reported immediately, which enhances road safety. The system is also cost-effective and scalable, making it suitable for deployment across various regions and road conditions.

IV. DESIGN AND IMPLEMENTATION

The design and implementation of a real-time pothole detection system using vehicles and machine learning involve integrating sensor data collection, real-time processing, and predictive modeling to accurately identify potholes. The system is designed by installing a sensor suite on vehicles, typically including accelerometers, gyroscopes, and GPS modules, which continuously monitor the vehicle's motion and geographical location. As the vehicle moves, raw data from these sensors are collected and transmitted to an onboard processing unit such as a Raspberry Pi or microcontroller. This data is preprocessed to remove noise and normalized for consistency. In the implementation phase, a machine learning model—commonly a supervised learning algorithm like Support Vector Machine (SVM), Random Forest, or a Convolutional Neural Network (CNN) for time-series data—is trained using labeled datasets containing both pothole and non- pothole events. Features such as acceleration spikes, vibration patterns, and orientation changes are extracted and used to train the model. Once trained, the model is deployed on the vehicle’s processing unit to classify road anomalies in real time. When a pothole is detected, its GPS coordinates and severity score are sent to a cloud server via mobile communication (e.g., 4G/5G). The server aggregates data from multiple vehicles for validation and maps the confirmed potholes on a dashboard accessible to road maintenance authorities and drivers. This machine learning-based system enhances detection accuracy, reduces false positives, and supports dynamic, data-driven road infrastructure maintenance.

V. CONCLUSION

We have successfully laid a strong foundation for our proposed work, “real time pothole detection using vehicles in machine learning. we studied a detailed overview of the existing survey paper and understand the existing road damage detection techniques and identified the critical challenges, such as high cost implementation and limitations in real time accuracy on existing road damage detection we also completed the setup of our development environment ,installing the necessary tools and configuring software like python and flask to support our model development. The scope of this project focuses on enhancing road safety and infrastructure management through real-time pothole detection using the YOLO algorithm and OpenCV. The system is designed to identify potholes in live camera feeds or recorded videos with high accuracy, making it suitable for diverse environmental conditions. It aims to assist municipal and government agencies by automating pothole detection, reducing dependency on manual inspections, and saving time and costs.

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