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A Review on Pothole detection using Image Processing

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Abstract— *Accidents caused by uneven road conditions canharm drivers, passengers, and pedestrians. Monitoring the state of the roads is essential to creating a network of safe and enjoyable mobility. Road accidents are affected by a number of variables, including speeding, reckless driving, and poor road conditions. Accidents that happen through no fault of the motorist happen rather frequently. One of the main contributing causes to theseincidents is bad road conditions. Due to the rising number of potholes, accident rates are rising year after year. Because road maintenance is typically performed manually, it takes a long time, involves effort, and is prone to human mistake. Since potholes are one of the main cause of accidents, it is crucial to identify and categorise them using image processing techniques. On roads and highways, potholes are areas of uneven pavement that are caused bycontinual automobile traffic as well as environmental factors. Asystem for measuring pothole size and detecting them is suggested. To find potholes, the suggested solution employs a deep learning- based YOLO (You Only Look Once) algorithm. By utilising image processing, the system offers a practical cost-effective solution for pothole detection on the road and notifies the responsible party for road maintenance. A report is also generated capturing the number of potholes and evaluating its area and depth. The method makes use of a specially created dataset that includes pictures of both dry and wet potholes of varying sizes and shapes.*
Keywords— *YOLO, Deep Learning, Image Processing, PotholeDetection*

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I. INTRODUCTION

Negative road anomalies, which we have referred to as cracks and potholes, have long been an issue in terms of avoiding obstacles. Because to their characteristics and the lack of efficient sensors and algorithms, it is difficult to detect them. This has been regarded as one of the most difficult undertakings because potholes can appearin a variety of forms, shapes, and situations, each necessitating a unique set-up. Due to the various shapes, depths, forms, and locations of negative road anomalies, many sensing techniques produce misleading negative results when applied to these phenomena. The random irregularity of these abnormalities makes it difficult to discover them. Due to a variety of factors, including the accessibility of these anomalies in public areas. Many detectors havedifficulties throughout the year because they are constrained by a variety of conditions, such as the environment in which the anomaly is located [7] .

A pothole is a sizable structural road failure that develops as a result of rainwater seeping through the earth beneath the road surfaces and contracting and expanding [8]. Regular road inspections and pothole filling are essential for maintaining roadways. Certified inspectors and structural engineers often spot and report potholes. Unfortunately, the procedure is risky for the staff in addition to being expensive and time-consuming. Moreover, because judgements are based only on an individual's experience, such detection is always qualitative and subjective. Hence, there is a growing need to create a reliable and accurate automated method forassessing road quality that can quantitatively and objectively identify potholes [5]. Active sensing, passive sensing, and vibration sensing are just a few of the technologies that have been utilized during the past 10 years to gather information about roads and look for signs of road degradation. For example, by examining the accelerometer data collected from several automobiles, built a crowdsourcing approach to identify and locate potholes. While inexpensive and requiring little storage capacity, vibration sensors cannot directly determine the form and volume of apothole from their data. In addition, potholes are sometimes mistakenfor road joints and hinges. [5]
The presence of potholes on the road may cause a number of issues, such as automotive damage and the possibility of crashes.

Road potholes are a major contributor to automobile damage and traffic accidents. Highways have recently been littered with potholes of various sizes due to an increase in car traffic and pollution. The states and local governments often allot a considerable sum of money to patch potholes in most nations. Yet, the proliferation of these potholes still leads to serious accidents or fatalities. [9]

According to a research by the Pacific Institute for Research and Evaluation, almost 42,000 fatal accidents occur in the United States of America each year as a result of traffic difficulties. The survey also found that badly maintained roads were at blame for 31.4% of all accidents. The suggested strategy will aid in the geotagging and identification of potholes. This can improve the ride quality and aid in road upkeep.

The weathering and wear-and-tear of the roadways result in potholes, which are bowl-shaped gaps in the pavement. These happen when the asphalt on top of the road wears away, exposingthe concrete or sand underneath. Potholes and their causes have been evaluated by N. Naveen et al. The research supports that potholes are caused by water retention, UV sun cracking, and a number of othercauses [6].

A specific kind of deteriorating road is one with potholes. Itmight be a randomly formed structural fault in a road, and it might be challenging to pinpoint its precise "border" with certainty. It isconceivable to pinpoint their highest depth while yet being able todescribe them vaguely. We can certainly assert that a pothole identification task is difficult due to the object's arbitrary shape andcomplex geometric structure[10]. Cars, people, cyclists, dogs, andcats are examples of objects with clearly defined shapes (and arenow detected by deep learning due to appearance properties).
Using various image processing approaches, pothole detection andcounting aids in the categorization of various road profile types.

Pothole detection uses a variety of processing techniques, including edge detection, thresholding, KMeans, and Fuzzy C-Means, as well as image filtering, segmentation, and clustering.

II. LITERATURE REVIEW

Alhussan et al.[1] proposed a unique approach for feature selection and Random Forest (RF) classifier optimization, based on Adaptive Mutation and Dipper Throated Optimization (AMDTO). In order to improve the performance of the optimised model, the system also suggests a novel adaptive technique for dataset balancing known as the optimal hashing Synthetic MinorityOversampling Technique (SMOTE). Before training the suggested model, data on potholes in various meteorological and environmental conditions were gathered and supplemented. Experiments with precisely categorising road potholes demonstrate the usefulness of the suggested approach. Three machine learning classifiers and eleven feature selection techniques, such as Web Oriented Architecture (WOA), Global Wind Organization (GWO), and Particle Swarm Optimization (PSO), were used in the trials to gauge the superiority of the suggested approach. The accuracy of thesuggested technique, AMDTOCRF, in classifyingpotholes was 99.795%.

Nhat-Duc Hoang [2] proposed a machine learning technique called Least Square Support Vector Machine that is primarily used to detect potholes. As there are only 200 photos in the training dataset, the model can only be used to predict a restricted variety of potholes. Moreover, support vector machine-based systems take longer to train. Su-il Choi et al. [3] have built a method for locating and measuring potholes using a 2D LiDAR (Light Detection and Ranging) sensor and camera. The images that the camera captures are processed using edge detection and noise filtering techniques. The need for an autonomous environment is increasing as the globe progresses swiftly in that direction. Creating a safe workplace for employees is one of the key issues of road maintenance in these hard times. It is possible to achieve some degree of human dependence reduction with the help of an autonomous system. The data from the LiDAR sensors are then used to locate potholes and estimate their dimensions. The drawback is that because adding several LiDAR sensors could not be financially advantageous due to their high cost.

Abhishek Kumar et al. [4] proposed a method for pothole detection using a quicker convolutional neural network with regions of interest (Faster R-CNN). International roadways are the foundation of the dataset. R-CNN based models' longer prediction times are a drawback in this situation. Moreover, models created for detecting potholes on foreign roads perform poorly since Indian roadways have entirely different damage circumstances than foreign roads.

K.C et al.[11] proposed a method that is challenging to illustrate a system for identifying potholes on the road, particularly in a country like India where roads cover millions of kilometres . Consequently, it is necessary to automate pothole detection with high speed and real-time accuracy. The basic objective of the object detection algorithm YOLOX (You Only Look Once) is to train and examine the YOLOX model for pothole detection. To extract and distinguish different textures and features of an image, the image processing methodology uses a variety of statistical methods, including Gray- Level Co-Occurrence (GLCM), Radial Basis Function (RBF), etc. Because to the enormous processing power needed, these techniques are frequently employed in conjunction with other machine learning strategies. Pothole photos collected in a variety of shapes as well as many potholes are included in the data set used to train the model. The analysis's findings indicate that the YOLOX nano model is ideally suited for pothole detection because it can be quickly deployed, requires little in the way of storage space, and consumes little energy due to its small size.

D. Desai et al. [12] depicts a system to detect potholes, notify riders, and create a location database of existing potholes. This may encourage riders to be more careful, reduce the frequency of collisions, and lower vehicle repair expenses. According on the trial findings, the system can reliably locate potholes to a 90% degree. Four seconds are needed to convey the GPS location to the database and the rider's alarm. The technique is further honed using a robust, city-level database that may be used across the whole country.

L. Parameswaran et al.[13] states that one of the main causes of traffic accidents is the driver's failure to pay attention to every little element of the road, which is where Advanced Driver Assistance Systems (ADAS) come into play.The information can be utilised by the autonomous driving system to determine what action needs to be taken to avoid a collision and assure the passengers' safety and comfort, or it can be immediately relayed to the driver by displaying an alert symbol in the car's interior. YOLO is used to train the dataset and annotate it (You Only Look Once). The outcomes of training the new dataset on YOLOv3, YOLOv2, and YOLOv3-tiny are compared. The mAP, precision, and recall are used to evaluate the outcomes. Themodel is tested on several photos of potholes, and it detects with a respectable degree of accuracy.

Kavitha R. et al.[14] describes that deep learning can help self- driving cars detect potholes and wetland areas, which is crucial for solving road problems like accidents and transport system slowdown. With a strong object detection module as a foundation, this gives the Advanced Driver Assistance Systems (ADAS) system in self-driving cars extra advantages for safer driving. In the future, more items including buildings, ambulances, autorickshaws, boulders in the road, and large loads of plastic bags on the road can be taught for object identification to increase the efficiency and safety of autonomousdriving systems.

P. A. Chitale et al.[15] describes a suggested system that uses the YOLO (You Only Look Once) pothole detection method, which is based on deep learning. The pothole detection findings provided by the proposed technology are reassuringly accurate. The suggested approach aids in cutting down on the time needed for road maintenance. The method makes use of a specially created dataset that includes pictures of both dry and wet potholes of varying sizes and forms. In particular during the epidemic, the suggested technology would lessen the need for human labourers to maintain roads. Potholes are spotted, and their sizes are assessed with excellent accuracy and a significantly decreased error rate. The calculated pothole measurements might be used to gauge the severity of the damage to the road as well as to determine theamount of raw materials needed to patch the holes. As a result, the majority of the planning and inspection may be done online.

Lokeshwor Huidrom et al. [16] have proposed a system that uses predefined thresholds for standard deviation and object circularity to detect road distresses like potholes, patches, and fractures. Image processing algorithms are used to do this. The drawback of this method is that the same set of established criteria cannot be applied to all road distresses because they do not all have a uniform shape or size.

II. PROBLEM STATEMENT

Potholes on the road can cause a number of issues, such as auto damage, traffic accidents, serious injuries, or even fatalities. Potholes fill with water during the monsoon season amid incessant rain. Disadvantages include high setup costs, the risk of discovery, and the possibility that the cameras' alignment will affect how accurately theycan detect objects on the ground.

The goal is to develop an automated method for finding potholes that is accurate and efficient in a variety of environmental conditions. in order to avoid accidents and reduce the expense of repairing damaged roads and vehicles. includes producing a reporton the condition of the roads based on the number of potholes found,their size, and their location.

III. OBJECTIVES

- The objective of the proposed work is to design a stand-alone system for detection of potholes.
- The model designed, also determines the number of potholes present.
- The system is developed to evaluate the area and depth of the potholes and prepare a report of the same, in order to determinethe amount of asphalt required to cover the pothole.
- The system is designed to detect potholes in real time video capture scenario.

IV. MOTIVATION

- Increased road safety: Because machines are immune to human mistake and attention, they can react quickly to changing traffic conditions.
- Why Shorter commutes: When self-driving cars lessen the "phantom effect" in contemporary traffic, commuting times are significantly shortened when vehicles communicate with one another and use sophisticated GPS systems.
- More productivity: Shorter commutes allow more time to be spent on tasks that are more important.

- Lower costs: Less accidents will directly result in lower costs associated with repairs
- Environmentally friendly: The self-driving automobile will produce fewer emissions as a result of its efficient performance driving techniques.

VII. CONCLUSION

From the review of the research papers, a drawback that can be inferred from the study of the research articles is that the inclusion of several sensors and cameras would not be financially advantageous owing to their high cost. Yet, there are certain difficulties, such variations in lighting and climate. To get around this, there are a number of image processing techniques, such Gray- Level Co- Occurrence (GLCM), that may be used to gather and distinguish various textures and characteristics in a picture.

The suggested system leverages the cutting-edge object identification method You Only Look Once (YOLO), which is an improved pothole detecting mechanism. The YOLO algorithm can identify potholes by looking at images and identifying distinctive qualities that set them different from nearby objects like road fractures.

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