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Pothole Detection and Cost Estimation using Deep Learning

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ABSTRACT: Effective road maintenance is essential for public safety and urban infrastructure longevity, yet traditional methods for pothole detection and repair are often labor-intensive, costly, and prone to inaccuracies. This project presents an automated solution to streamline the pothole detection and repair cost estimation process through advanced computer vision and depth estimation techniques. Leveraging the YOLOv8 object detection model, this system processes road video footage to identify potholes within each video frame accurately. Once detected, each pothole's dimensions are determined using monocular depth estimation, which provides data on the width and depth of the pothole, enabling precise volume calculations.

The estimated volume is used to calculate the amount of material required to fill the pothole, followed by a repair cost calculation. This system thus provides a comprehensive approach to road maintenance that reduces the need for manual inspection, enhances accuracy in damage assessment, and supports optimized resource allocation for repair efforts. This automated and cost-effective solution has the potential to streamline road inspection processes, increase infrastructure examination efficiency, and promote more strategic road repair scheduling. The proposed system not only aims to improve road safety by identifying hazardous potholes but also seeks to contribute to sustainable infrastructure management by lowering maintenance costs and extending road lifespans

KEYWORDS: Pothole Detection, YOLOv8, Deep Learning , Machine Learning

I. INTRODUCTION

Potholes are a significant concern for road safety and infrastructure maintenance, leading to vehicle damage, accidents, increased and traffic congestion. The presence of potholes not only compromises the safety of drivers but also contributes to traffic jams, resulting in longer travel times and reduced efficiency on the roads. The prevalence of potholes highlights the urgent need for effective monitoring and maintenance strategies to ensure safe driving conditions and faster mobility.

Traditional methods of pothole detection often rely on manual inspections or static imaging techniques, which can be time-consuming and prone to human error chances of false repairing and corrruption.

This project introduces an innovative approach to address these challenges through the development of a system that utilizes video input for real-time pothole detection and dimension calculation. By employing the YOLOv8 object detection model, the system processes video frames to accurately identify potholes and calculate their dimensions using monocular depth estimation techniques.

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Fig. 1: Road Pothole

It also considers some problems faced in creating trustworthy online nursery like data control, safe payment, user identification process as well as tips for increasing its speed. Moreover, it looks into various literature materials concerning e-commerce as well as internet technology focusing on the role played by MERN kind of stacks integration toward improving customer experience within the online merchandising space.

II. LITERATURE REVIEW

1.**Dr. Rohit Rajan, Mohammad Khaja Faizan** - "Deep Learning Based Pothole Detection", published in the 2023 International Conference on Emerging Smart Computing and Informatics. This work focuses on deep learning techniques for pothole detection, highlighting advancements in image analysis for transportation safety.

2.**Surya Sasank Ch, Teja Tallam** - "Pothole Detection and Dimension Estimation by Deep Learning", presented at the IOP Conference Series: Earth and Environmental Science, 2023 (CISCE-2023). This study discusses the application of deep learning methods for detecting and estimating the dimensions of potholes, contributing to civil engineering infrastructure.

3.**Zhaohui Zheng, Ping Wang** - "Distance-IoU Loss: Faster and Better Learning for Bounding Box Regression", featured in the Innovative Applications of Artificial Intelligence. The paper introduces a novel Distance-IoU loss function, which improves both the speed and accuracy of bounding box regression, a key component for object detection systems like YOLO.

4.**Pranjal A. Chitale, Hrishikesh R. Shenai** - "Pothole Detection and Dimension Estimation System using Deep Learning (YOLO) and Image Processing", published by the Institute of Electrical and Electronics Engineers (IEEE) in 2020. This research develops a pothole detection and dimension estimation system using the YOLO architecture and image processing, aiming to achieve accurate measurements of pothole size and location.

5.**Lieskovská, E., Jakubec, M., Bučko, B** - "Automatic Pothole Detection", presented at TRANSCOM 2023: 15th International Scientific Conference on Sustainable, Modern and Safe Transport. This study proposes an automated pothole detection system designed to enhance road safety and monitoring, utilizing image processing and machine learning techniques.

III. SYSTEM ARCHITECTURE

The illustration shows an efficient system built to identify potholes from videos, ascertain their measures and also help assess the cost of road repair in an organized manner so as to schedule maintenance activities properly. Each component in the system has a distinct functionality thus making it possible to detect, measure and perform the necessary repairs with precision and effectiveness. Here's a more relatable picture of how it actually functions:

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The flow of information in the system is handled by the Input/Output Module. The process begins by recording a video of the corridor that is to be scanned for potholes. Upon running through the system, the Output/Cost Module gives the accrued output, which contains all the information about the costs associated with filling the potholes. This output contains also the information about the Gantt chart and the materials needed making it easier for the maintenance crews to schedule the works better.

As soon as the video is captured, the Preprocessing Module acts to convert the video into a suitable format for processing. This phase involves adjusting every single image frame to fit into the required dimensions, in order that all images are uniform and able to work with the machine that will analyze them. The frames become monochrome as well, which lessens the amount of information and the processing power required hence enhancing the speed of the model's operation. This preprocessing guarantees that no potholes will be missed when detecting their presence in images.

In the Pothole Detection Module, the System uses the prepared pictures and a model like YOLOv8 to detect potholes. The Training Model for Detection step is of primary importance in this respect; this is where the model is contrived to change its parameters to identify the multitude of shapes, sizes, and appearances of potholes seen in different images. Once the training has been completed, the model passes through a Testing and Fine-Tuning stage during which more data is fed to it, for the purposes of enhancing its accuracy.

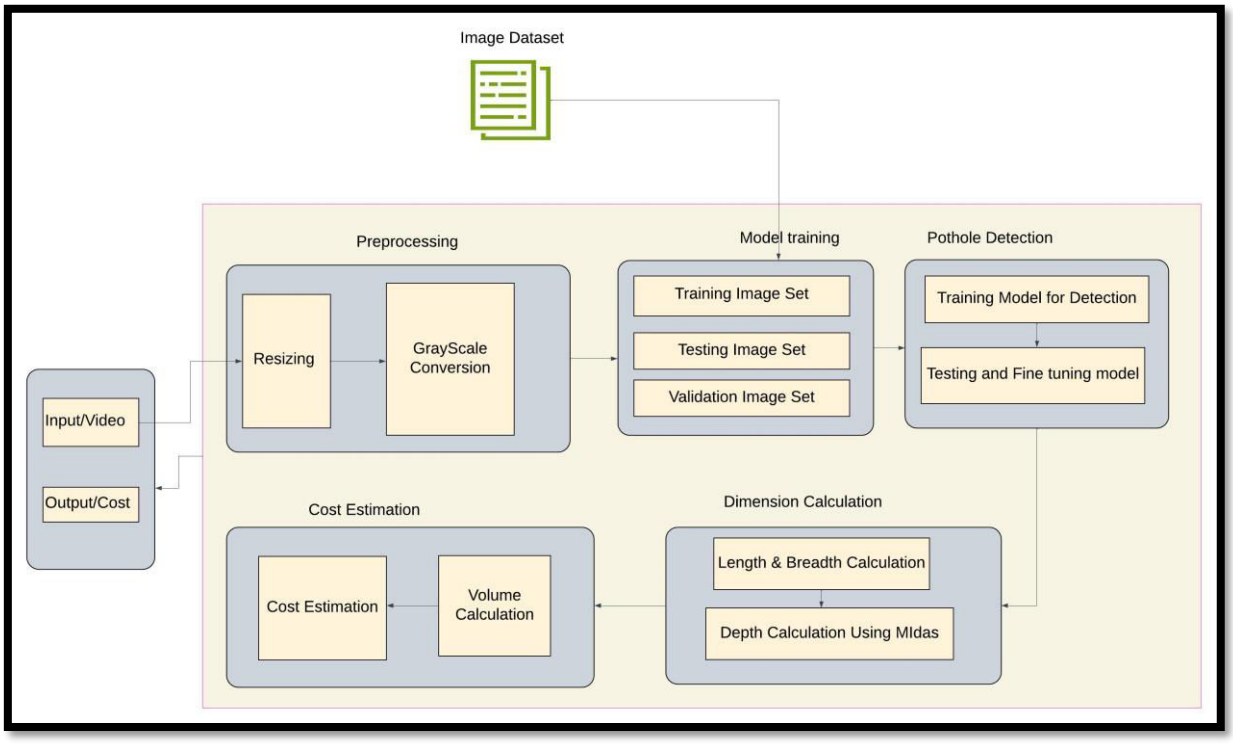

Fig. 2: Proposed System Architecture

IV. BENEFITS OF PROPOSED SYSTEM

High Detection Accuracy: YOLOv8's real-time object detection capabilities allow it to accurately identify potholes in road images or videos. This accuracy reduces false positives and negatives, making it a reliable choice for practical use.

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Real-Time Processing: The YOLOv8 model can detect potholes quickly as data is captured, enabling on-the-go assessment. This is especially useful for vehicles collecting data during routine drives, allowing for immediate identification without interrupting traffic flow.

Automated Cost Estimation: By integrating a cost estimation model, the system not only detects potholes but also predicts repair costs based on pothole characteristics. This enables municipalities to efficiently budget and prioritize repairs.

Reduced Labor and Cost: Automation reduces the need for manual inspection, cutting down on labor costs and time associated with traditional pothole detection methods.

V. OUTPUT

VI. CONCLUSION

In conclusion, our presentation has offered a comprehensive overview of the Blindsight project, including its objectives, system architecture, and proposed outcomes. We have discussed the key technical requirements, such as real-time obstacle detection, voice navigation, and fail-safe mechanisms, along with the tools and methodologies utilized to develop an accessible and effective solution. Moving forward, we will focus on optimizing the system's performance, ensuring accuracy in real-world testing, and delivering a reliable and user-friendly application within the project timeline.

VII. FUTURE WORK

Enhancing the YOLOv8 model to handle diverse environmental conditions, such as low light, fog, rain, and shadowed areas, can improve detection accuracy in all weather and lighting scenarios. Adding depth sensors or using stereo cameras could help capture the depth and volume of potholes more accurately, contributing to a more precise cost estimation and a better understanding of the repair materials required. Extending the system to detect other road anomalies, such as cracks, bumps, and surface erosion, would allow for a comprehensive road maintenance solution beyond just pothole detection. Integrating geographic location data with detection results can provide spatial mapping of potholes across a region. This could facilitate better visualization of high-damage areas and help prioritize regions for maintenance based on historical data and trends. Currently, the cost estimation model might use fixed parameters. Future work could involve adaptive cost estimation that accounts for fluctuating material and labor costs in different regions, seasonal cost variations, and the impact of regional regulations.

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