ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24NOV509

Pothole Detection and Geological Mapping through Aerial Vehicle

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Abstract:- The construction and development of good roads is important for the economy and prosperity of today's countries. Road maintenance faced many challenges due to heavy traffic, insufficient funds, and lack of resources. These roads and highways are very dangerous for drivers due to damage such as potholes. Bad roads can lead to dangerous problems such as damaged wheels, tires, damaged vehicles, serious accidents, irregular traffic, and poor driving. To better solve this problem, this project presents a deep learning method that can identify and classify pots according to their size and severity. Drones, also known as unmanned aerial vehicles (UAVs), can be utilized to modernize road safety practices and so enhance the nation's infrastructure. The image library is employed for the development of a pothole detection model, which is subsequently utilized within an algorithmic framework that integrates a road color model with fundamental image processing techniques, including a Canny filter and contour detection. This approach enhances the level of accuracy in identify ing potholes.

Keywords:- *Pothole, Unmanned Aerial Vehicles (Uavs), YOLO V8, Geotagging and Geomapping.*

I. INTRODUCTION

Potholes are 10-inch-deep, bowl-shaped gaps in the road brought on by excessive wear and ageing of the pavement. They can be seen growing on the top layer of a road, which typically deteriorates from weathering, heavy load, bearing trucks, or normal wear and tear. One of the most frequent causes of vehicle accidents is a pothole, which can deepen to several inches with rain. They frequently cause auto accidents, but they can also be fatal for motorcycles. Road potholes are extremely dangerous while travelling at high speeds since they are difficult to see from a distance.

Two-dimensional (2D) vision-based) methods can also be used to find potholes. The evaluated shape of the pothole is decided employing a square tile matrix to speak to pothole-related locales. The 2-dimensional perception method is limited to uniform lighting conditions and is unable to gauge the precise depth of potholes. To get over the drawbacks of earlier systems, a 2-dimensional parameter checking method based on computer stereo vision issued.

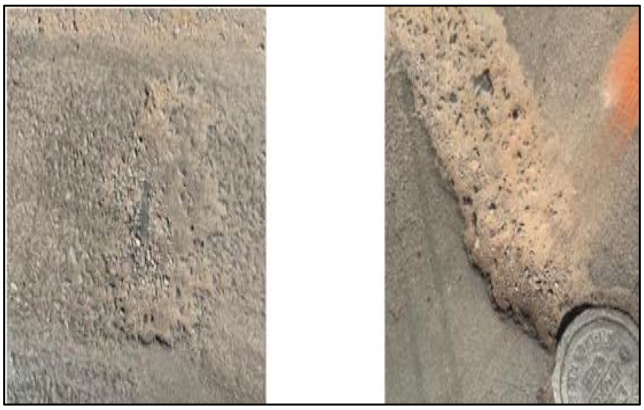

Fig 1: Potholes

The existing pothole detection systems are deficient in some areas, such as high accuracy rates or a large need for computing resources, which is not practical everywhere in the world. Tens of thousands of deaths are attributed to potholes every year across the world. The ability to detect these potholes using image processing enables us to identify and categorize them based on their condition and the level of harm they possess. Such a serious situation calls for a faster response. I was motivated to develop an algorithm that can accurately identify them and warn users of potholes that pose a higher risk. The goal in creating this algorithm was to help save lives and stop traffic accidents.

II. LITERATURE REVIEW

To detect potholes, Buza E. [1], Seung-KiRyu [2], Christian Koch [3], and Manisha Mandal [4] employed a segmentation method based on a histogram and clever edge detection. To identify potholes, many researchers most frequently employ the edge detection and thresholding techniques. Vignesh War K et al. [5] categorized potholes using a variety of methods, including edge detection, image segmentation, and clustering methods including K-Means, thresholding, and fuzzy C-Means. Instead, then creating a stand-alone product, this article primarily compares several image segmentation algorithms. According to Shambhu Hegde et al. [6], an ultrasonic sensor that measures pothole depth is installed on the car. A microcontroller uses and processes the sensor's output before transmitting the data to other cars. Potholes are found using computed sensor readings; no specific classification process is employed. Vinay Rishiwal et. al.[7] made advantage of an accelerometer that is already present in an android handset.

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After that, it was built, and the axis acceleration data was obtained. The z-axis acceleration, which experiences abrupt changes when a pothole is met, is monitored in order to identify potholes. To detect potholes, Kiran Kumar et al. [8] equipped the car with a laser and camera setup. The camera takes an image of the reflected laser and uses it as a reference. Given that it is a physics-based approach and requires intricate mathematical calculations, it might not be very accurate. In Danti et al. (2012), the primary method for detection and classification was an image processing algorithm-based system. The study sought to identify several traffic-related items, including lanes, road signs, and potholes. A black and white threshold that would emphasize the pothole area was added to the image in order to correctly partition the pothole zone.

III. PROPOSED METHODOLOGY

The proposed study aims to create a drone-based pothole detection system. It helps the relevant authorities identify and address the problem. The pothole detecting technology will be installed on a drone that is either manually or automatically piloted. A "Camera" is used as a sensor to check the road for potholes. The main layout of our model is shown in Figure 2.

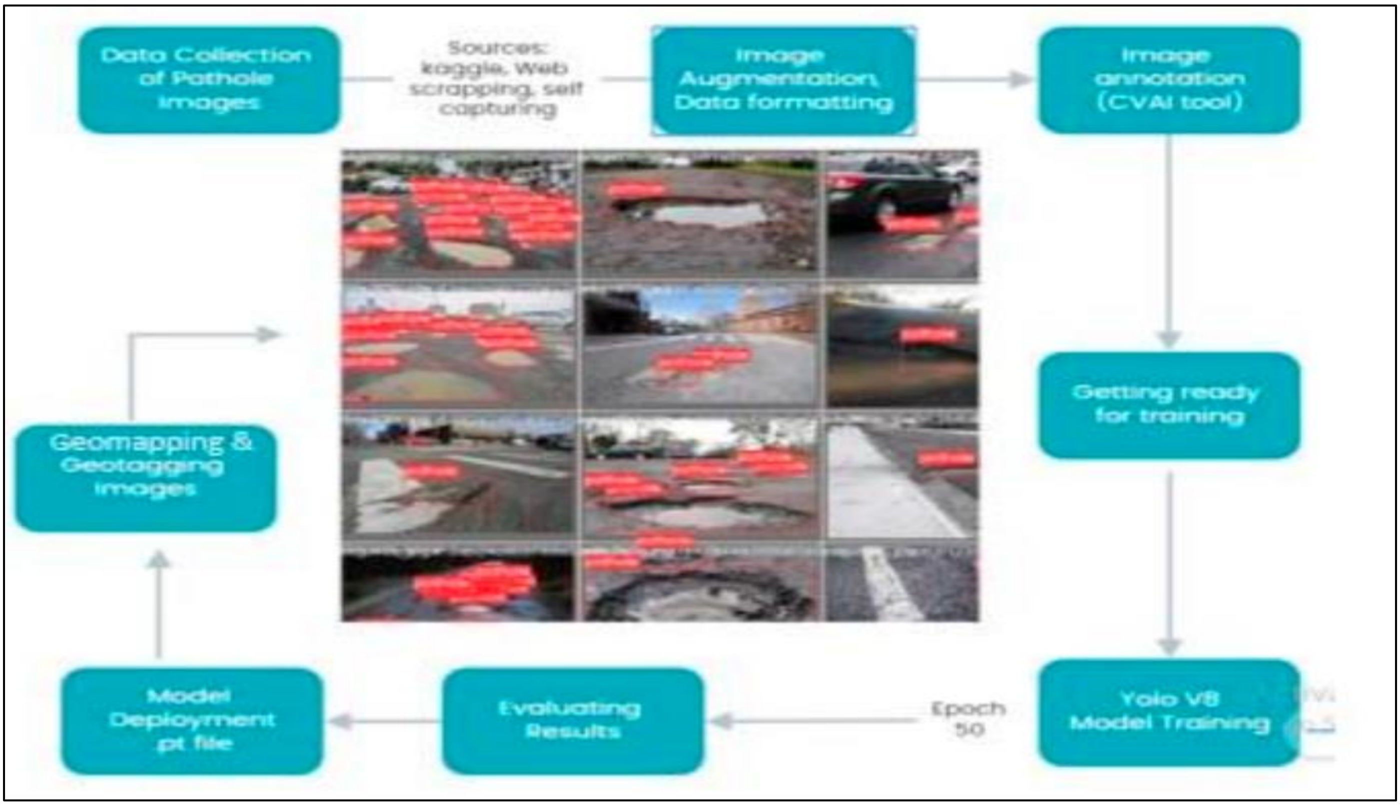


Fig 2: Block Diagram

A. Data Collection and Preparation

There are just a few officially sanctioned publicly available datasets for pothole identification and no online potholes dataset. We thus gathered pothole photographs for our study from many sources, including Kaggle and Roboflow, and we utilized drone to gather more images from roadways.80 photos were used to test the model that was produced, 183 images were used to validate the model, and 450 images were utilized for training. The dataset's photos contain a variety of potholes with various sizes, areas, and depths. Our PASCAL/VOC-formatted photos were labelled using CVAT, an open-source graphical annotation tool, before being converted to.txt format for YOLOv8.

B. Image Augmentation and Data Formatting

Over-fitting may result from the dataset's small size. Deep learning models, however, need a sufficient volume of data to provide reliable findings. As a result, we have used augmentation strategies to benefit from regularization while avoiding over-fitting. For augmentation, a number of factors were employed, including scale, color modifications and rotation.

C. Image Annotation

Labels were applied to the photos that were acquired using image annotation. A human operator examines a collection of photos and spots any pertinent potholes. To construct a training dataset for computer vision models, these annotations can be employed. The model learns to recognize items or label photos on its own using human annotations as its ground truth. Models for tasks including image classification, object identification, and picture segmentation may be trained using this procedure. We have annotated oven 450 images using CVAT tool. CVAT is a online tool for annotation. We can annotate in boxes, polygon shapes. Then the data is exported in the format of yolo1.1. The annotated images having text files followed by their bounding box coordinates as shown in Figure 3.

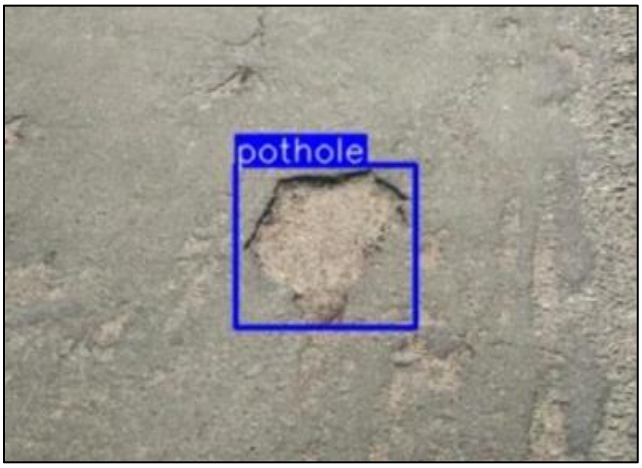


Fig 3: Image Annotation

D. YoloV8 Model Training

The Colab runtime notebook is used to complete the training. The COLAB runtime has been loaded with the whole dataset. The dataset includes the text files for the photos. 3.8 Python is employed. It uses the Yolov8n model. We are using Python to copy the Yolov8n model from the Ultralytics package. There were 70 training epochs. It is split the validation dataset. Tesla K80 GPU is the one being used.

With 70 epochs, the total workout lasts around 45 minutes. With epochs, the mAP@50 and mAP@50-95 are dramatically rising. Class loss and box loss both declines. The model is stored with the Python extension (.pt) during execution.

E. Geo Tagging and Geo Mapping

The program receives pictures taken by drones. Python was used to create the program. It extracts coordinates in latitude and longitude from picture information using the exifread library.

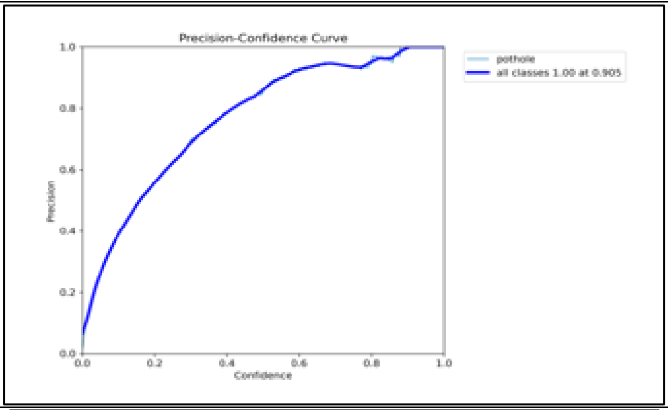
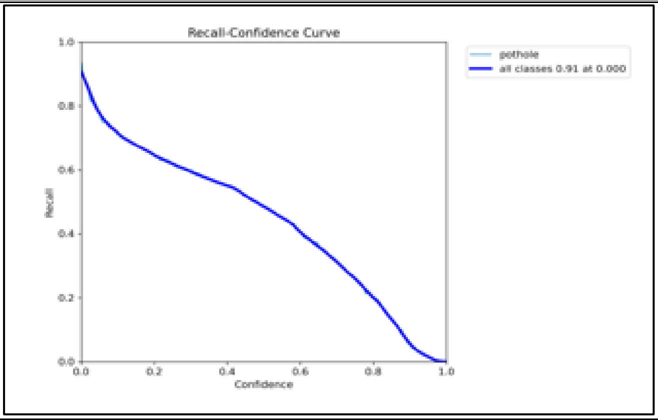
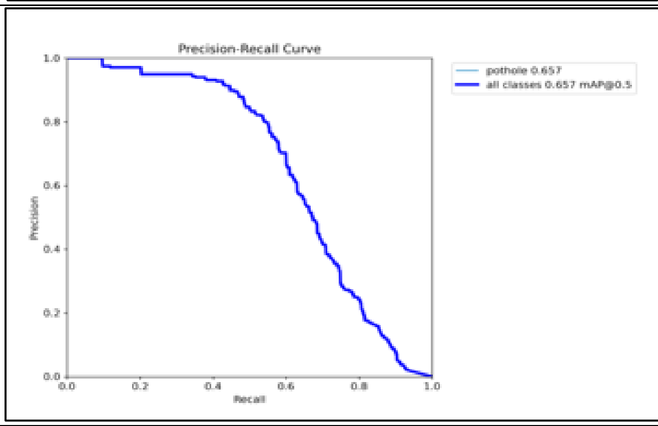
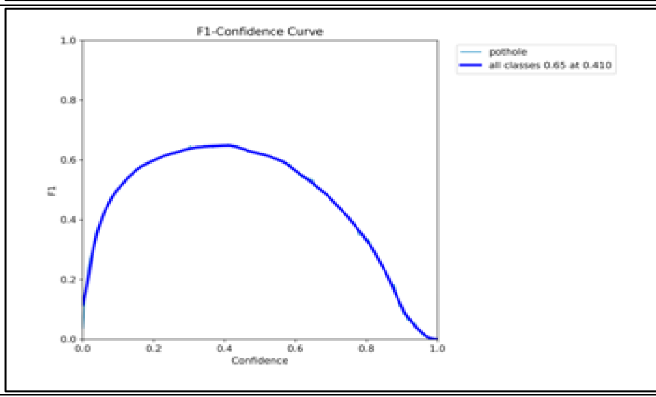
IV. RESULT AND DISCUSSION

Using the training and testing data acquired from the tagged photographs, the performance of the YOLOv8 model in terms of recognizing and categorizing potholes was evaluated. After the algorithm has been trained and validated, it is ready to be tested against datapoints of different pothole severity levels. It can successfully classify them and determine whether work needs to be done. The YOLOv8 may produce results with high accuracy of 90% or more.

Following is some sample predictions on validation dataset.

Fig 4: Detected Pothole Samples

Table 1: Training Results for yolo v8 Model

Sr. No	Parameters	Patterns
1	Precision curve(p-curve)	
2	RecallCurve(R-curve)	
3	PR Curve	
4	F1 Curve	

A. WebApp for user Interface

The website has been created for detecting and geotagging potholes to help the user to identify and repair potholes in a timely manner. We started by planning the website and designing the user interface to make it easy for users to report. The most important task was creating an algorithm for detecting potholes from image and video footage. The Web App image is mentioned in fig 5.

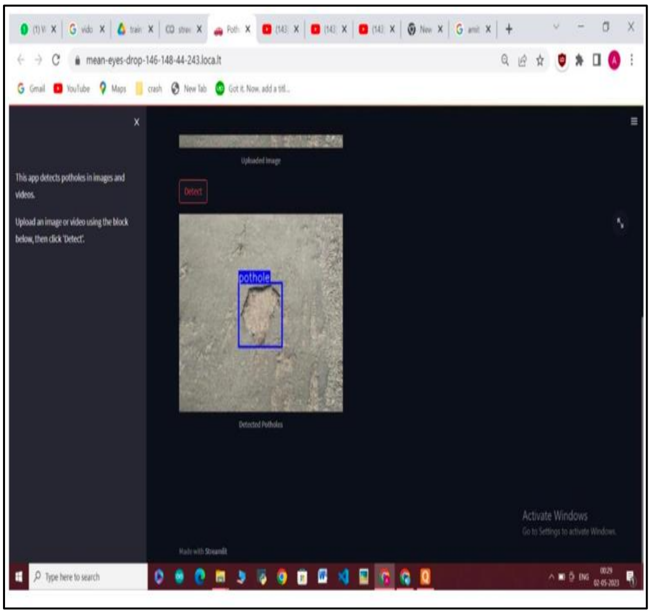


Fig 5: Website to Detect Potholes

B. WebApp for user Interface

By using the coordinates, it becomes easy to locate potholes on google maps through Geo mapping. Fig 6 shows the detected potholes on the maps for quick access to the location.

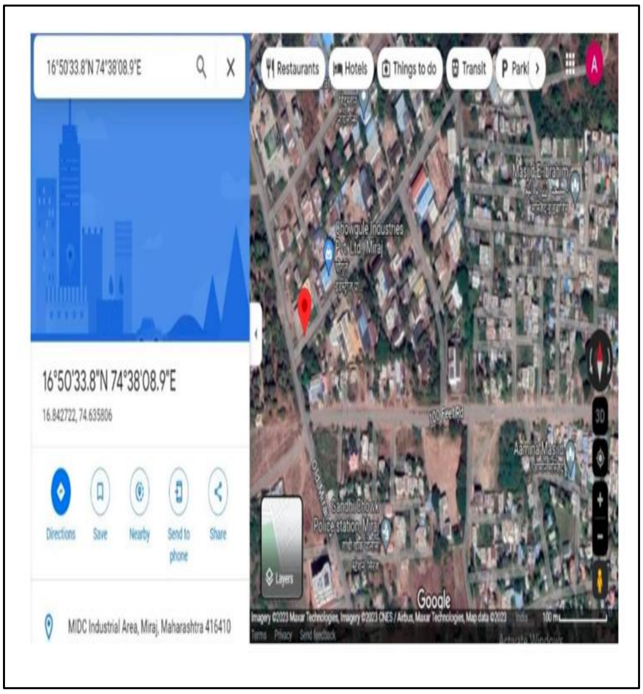


Fig 6: Location on Google Maps

C. Detected Pothole using YOLO

The Model which was trained and tested can be deployed to detect the potholes in new images and videos as shown in figure 7.

Fig 7: YOLO v8 Output

V. FUTURE SCOPE AND CONCLUSION

It's critical to recognize the potential of this developing sector for enhancing road maintenance and safety as it relates to the future use of pothole identification using satellite photography. It may be able to create systems that can monitor roads in real-time and find potholes as soon as they appear to the expanding accessibility of satellite images. Another option is to equip drones with sophisticated sensors in addition to their cameras, such LiDAR or radar. These sensors can offer additional information on the road surface, such as the size and depth of potholes, which can aid in determining the priority of maintenance and repairs. A website that is connected with the government allows individuals to contribute information about the state of the roads in their area, and the government receives the coordinates to locate the area where potholes are likely to appear quickly.

In conclusion, the monitoring and mapping system for potholes is deemed essential in averting traffic accidents and ensuring enhanced roadconditions nationwide, thereby fostering accelerated development.

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