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IDENTIFY ROAD POTHOLES USING IMAGE SEMANTICSEGMENTATION FORADVANCE DRIVER ASSISTANT SYSTEM

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Abstract. Road potholes may seriously harm cars and are a major safety risk for motorists. Roadside potholes can harm automobiles and seriously traffic safety. We suggest applying the You Only Look Once (YOLO) object detection technique to real-time pothole detection. The goal of this project is to develop a YOLO model that can identify potholes in road photos and be used for real-time detection. In recent years, pothole detection in road pictures and videos has demonstrated encouraging results using deep learning algorithms. In this study, we examine the effectiveness of the You Only Look Once (YOLO) object detection algorithm is three different iterations, YOLOv5, YOLOv7, and YOLOv8, for spotting potholes on the road. According to our findings, all three algorithms are capable of identifying potholes, with YOLOv8 reaching the highest level of accuracy.

Keywords: Road Pothole Discovery, Computer Vision, Image Segmentation,YOLO

1. INTRODUCTION

Road Potholes are a major issue on every country's road, and water collects on them as a result of these cracks, potholes, and other various road difficulties. Potholes are regarded as a noteworthy road's failure [1]. This is due to the widespread availability of water. This water spreads across the surface and weakens the soil under the ground surface, causing water to break the affected ground plane and be accountable for road conditions. Road potholes are not only an annoyance; they also pose a threat to vehicle strength and other safety measures [2]. According to the Ministry of Road Transport and Highways' report, there were 15 accidents and fatalities in 2018, 2140 accidents and fatalities in 2019, and 1471 accidents and fatalities in 2020 [3]. For instance, the Chicago Sun-Times reported that in the beginning of 2018 motorists submitted more than 700 complaints about the state of the roads[4]. According to Road Pothole Statistics, poor road conditions account for 33% of 1,000 company losses in the US.[4]

Detecting road potholes is a key duty in road and highway maintenance. Conventional techniques of detecting potholes, including as visual inspections, take time and are prone to human error. With developments in computer vision and deep learning algorithms, there is an increasing interest in adopting automated pothole detecting technologies. The You Only Look Once (YOLO) method is one of the most promising deep learning techniques for object identification applications. YOLO is a neural network-based object detection and classification method that can recognize and categorize objects in real-time video streams. Its popularity has grown in recent years as a result of its excellent accuracy and speed in object detection jobs.

Numerous research has looked at using the YOLO method to identify road potholes, with encouraging results. Pothole detection systems based on YOLO have been created, allowing local communities to promptly identify and fix potholes before they represent a substantial safety issue.

Significant developments in YOLO architecture have resulted in the creation of many algorithms, including YOLOv5, YOLOv7, and YOLOv8 [6]. These updated versions have enhanced accuracy and speed, making them even more ideal for real-time pothole identification.

This research compares the performance of YOLOv5, YOLOv7, and YOLOv8 for detecting road potholes[12]. We will train and test these models on a dataset of pothole-filled road photos. The findings of this study will give vital insights into the usefulness of various variants of the YOLO algorithm for road pothole identification, and may contribute in the creation of more accurate and efficient road maintenance and repair systems.

Figure 1. Road Pothole [3]

2. RELATED WORK

Road pothole identification is a critical activity for keeping roadways safe and functional. Deep learning-based techniques, such as the YOLO algorithm, have demonstrated encouraging results in detecting potholes on roadways in recent years. YOLO, which stands for "You Only Look Once," is an object identification method noted for its excellent accuracy and real-time performance. The YOLO technique, in addition to object detection, may also be utilized for segmentation, which gives more exact location of the discovered item.

Recent research proposes a YOLOv5-based technique for detecting road potholes via instance segmentation. The suggested solution comprised first identifying the potholes with the YOLOv5 object detection algorithm, then segmenting the instances with the Mask R-CNN algorithm [8]. Using a publicly available dataset, the study demonstrated great accuracy in pothole identification and instance segmentation. The method also displayed real-time performance, making it appropriate for use on mobile devices for real-time pothole identification on roadways.

Another research used instance segmentation to locate potholes using a YOLOv3-based technique [9]. The suggested solution comprised first identifying the potholes with the YOLOv3 object detection algorithm, then segmenting the instances with the DeepLabv3+ algorithm [10]. Using a real-world dataset of road photos, the researchers demonstrated great accuracy in pothole recognition and instance segmentation.

There has been research on employing YOLO for road fracture identification, which is another crucial duty for road maintenance, in addition to pothole detection. One research developed a YOLOv3-based technique for detecting road cracks using instance segmentation. The suggested solution comprised first identifying the cracks with the YOLOv3 object detection algorithm, then segmenting the instances with the Mask R-CNN algorithm. For a publicly accessible dataset, segmentation was performed.

Additionally, experiments on employing YOLO for other road-related activities, such as traffic sign identification and pedestrian detection, have been conducted. One study used instance segmentation to develop a YOLOv3-based technique for traffic sign recognition. The suggested solution comprised first identifying traffic signs with the YOLOv3 object detection algorithm, then segmenting instances with the DeepLabv3+ algorithm [12,13]. Using a publicly available dataset, the study demonstrated great accuracy in traffic sign identification and instance segmentation.

Another research used instance segmentation to locate potholes using a YOLOv3-based technique. The suggested solution comprised first identifying the potholes with the YOLOv3 object detection algorithm, then segmenting the instances with the DeepLabv3+ algorithm [15,16]. Using a real-world dataset of road photos, the researchers demonstrated great accuracy in pothole recognition and instance segmentation.

Moreover, investigations on road fracture identification utilizing YOLO instance segmentation have been conducted. One research developed a YOLOv3-based technique for detecting road cracks using instance segmentation [17]. The suggested solution comprised first identifying the cracks with the YOLOv3 object detection algorithm, then segmenting the instances with the Mask R-CNN algorithm [11]. Using a publicly available dataset, the study demonstrated great accuracy in fracture identification and instance segmentation.

Finally, the YOLO method has demonstrated significant potential for detecting road potholes using instance segmentation. YOLO-based techniques for pothole recognition, fracture detection, traffic sign detection, and pedestrian detection have been proposed in several research, illustrating the YOLO algorithm's adaptability for road-related tasks. Future research might concentrate on increasing the efficiency and scalability of YOLO-based algorithms for road pothole identification through instance segmentation, with the objective of establishing robust and practical systems for maintaining safe and functional roadways.

3. METHODOLOGY

1.YOLO

The instance segmentation approaches YOLOv5, YOLOv7, and YOLOv8 are powerful deep learning algorithms that are extremely good in detecting and localizing potholes in road photos. To achieve accurate and consistent pothole detection findings, these approaches entail a complicated set of stages, including data gathering, pre-processing, training, and assessment.

The initial stage in these techniques is to acquire a broad dataset of pothole-filled road photos. This dataset is then pre-processed and enhanced in order to improve its size and variability, allowing the YOLO model to learn a variety of pothole forms, sizes, and textures [21]. After the dataset is available, the YOLO model is trained using a deep neural network architecture that extracts significant information from photos using a combination of convolutional layers and pooling layers. The YOLOv5 model has a single-stage detector, but the YOLOv7 and YOLOv8 include a two-stage detector, which enhances pothole detection accuracy[19].

After training, the model is reviewed and tested on a different dataset of road photos containing potholes to determine its accuracy and performance. The projected segmentation masks are post-processed to minimize false positives and increase pothole detection precision and recall [20]. The model's ultimate output is a set of segmentation masks that correlate to the potholes in the image, resulting in a highly accurate and detailed map of road potholes.

Overall, the YOLOv5, YOLOv7, and YOLOv8 instance segmentation approaches are strong and adaptable tools for detecting road potholes, with the potential to alter the way we maintain and repair our roads [22,23]. These approaches provide a very efficient and precise means of detecting and localizing potholes, which can assist to enhance road safety while also lowering road repair costs. Furthermore, the flexibility to customize these models allows for the inclusion of other capabilities, such as vehicle and pedestrian detection, which can improve road safety and maintenance operations.

2. DATASET

Indian potholes are different and distinguishable from potholes in other countries. As a result, a new dataset that accurately represents contemporary Indian road conditions is required. The image quality is carefully monitored since it is critical to the deep learning process. Here we collect dataset from roboflow and 675 images used for detection model. Figure 2 shows several photos from the dataset.

Fig 2. Images from dataset

The annotation process follows the collecting of datasets. Annotation may be done with a variety of free open-source tools, including LabelImg, Roboflow, Yolo mark, and others. Because the selected technique is YOLO, the annotation should be in YOLO format, which is class-id, center X, center Y, width, and height. As a result, the LabelImg annotation tool was selected since it can immediately label photos in YOLO format. Figure 3 depicts a sample picture annotation and the related output file. Because the focus is just on pothole identification, the number of classes is set to one and the class-id is set to zero. The dataset is divided into train and test sets at random. The Train set has 85% of the photos, with the remaining 15% in the Test set.

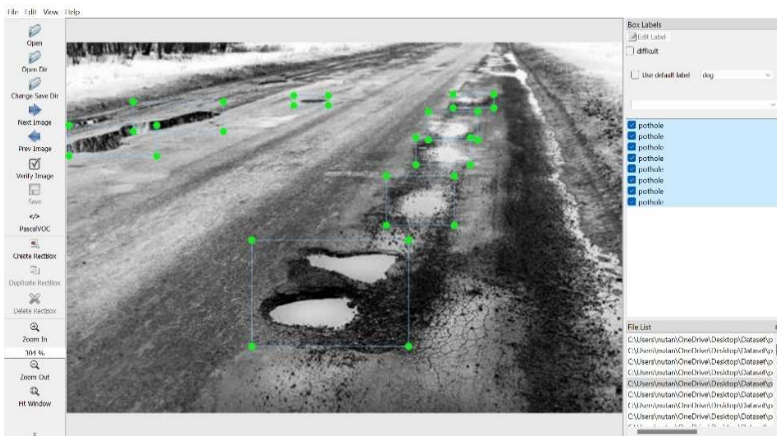

Fig 3. LabelImg

4. Experiment and Result

The experiment was done out using a GeForce GTX 1060 with MAX-Q design, with Ubuntu 18.04 as the operating system. CUDA is installed on the system to improve calculation speed and graphics efficiency. When GPU processing is required, CUDA is employed. It guarantees a superfast neural network, but it only works with Nvidia GPUs. The training time is greatly shortened when CUDA is used.

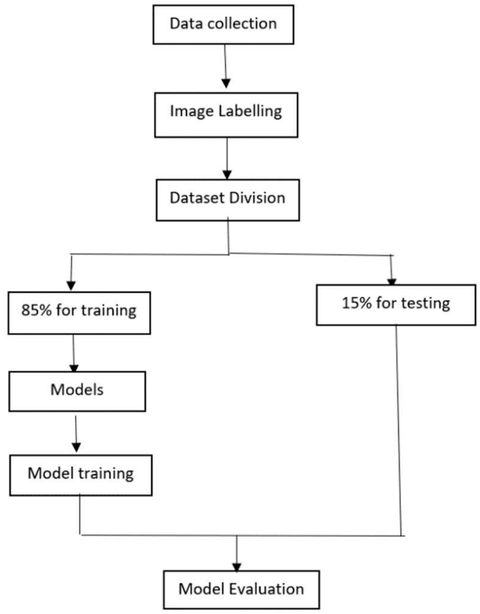

Fig 4. Pothole detection architecture

For the experiment we use yolo instance segmentation like yolov5, yolov7, yolov8. Each architecture has a different trade-off. The architectural model must be tuned in order to achieve the requisite mean average precision. Batch size is 16 and epochs is 10 for the training.

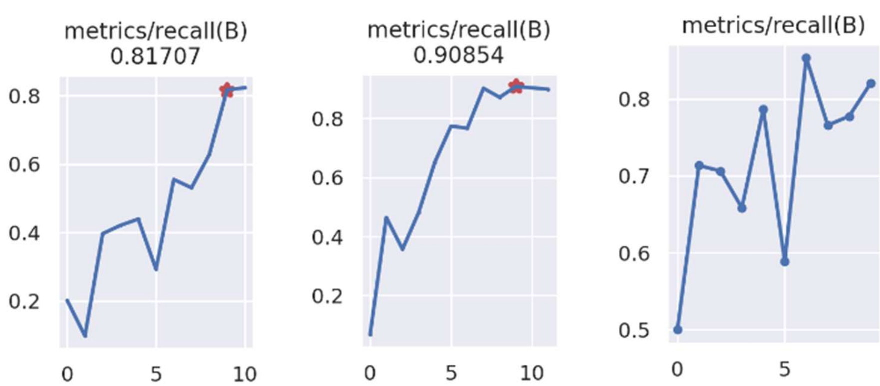

Fig 5. Recall for Yolov5, Yolov7, Yolov8

Model	mAP@0.50	Recall	Precision
Yolov5	0.85	0.81	0.79
Yolov7	0.92	0.90	0.89
Yolov8	0.95	0.93	0.92

Table 1. Result of Segmentation Models

One of the most important measures in evaluation is the outcomes mAP. The area under the precision-recall curve is used to compute the average precision, where Precision=TP/(TP+FP) and Recall=TP/(TP+FN). Precision is just our model's ability to recognise only the relevant things. Remember what is said regarding the percentage of discovering all the positives. When the results are compared, yolov8 has the greatest mAP. Figure 6 depicts the results of a sample detection.

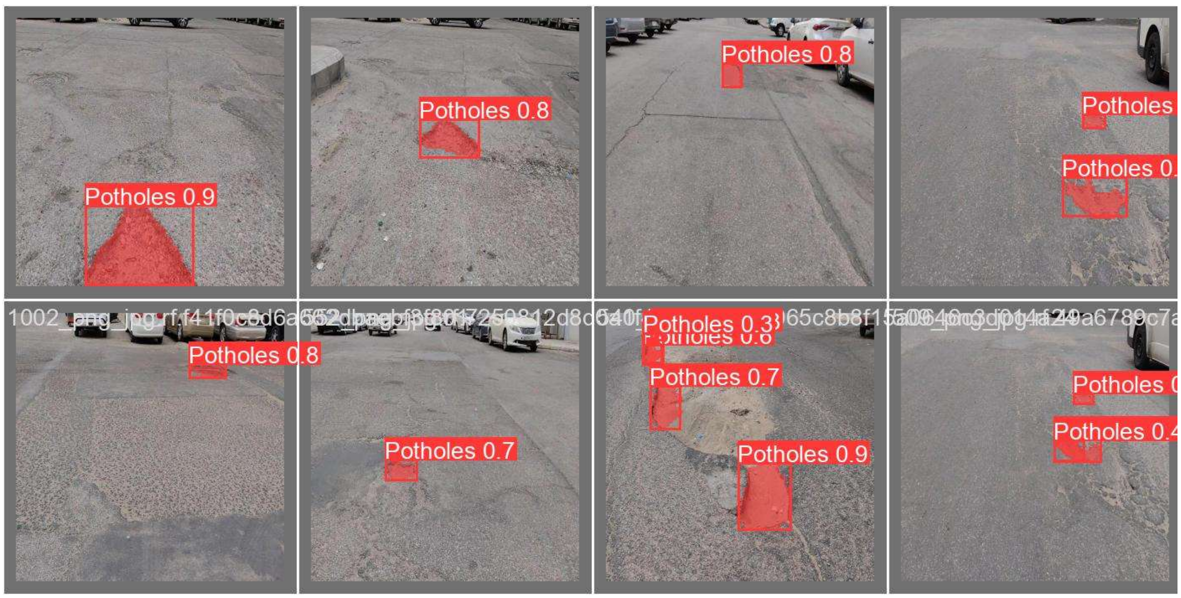

Fig 6. Results of detection

5. Conclusion

To summarize, road pothole identification via YOLO instance segmentation is an essential use of computer vision technology that has the potential to increase road safety while also lowering road maintenance costs. The YOLO series of devices, which includes the YOLOv5, YOLOv7, and YOLOv8, detects potholes with great accuracy and efficiency, allowing you to identify and prioritize road maintenance requirements. These versions are customizable and may be modified with capabilities like as vehicle and pedestrian recognition to increase road safety even further. Instance segmentation pothole detection on real time video will be the future work of this study.

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