Pothole Detection in Indian Roads

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1 Abstract

Maintenance of road infrastructure is very important for ensuring safe and efficient transportation systems. Potholes are among the most common road defects that can lead to accidents, vehicle damage, and traffic congestion. This study intends to develop an efficient and accurate automated pothole detection system using object detection techniques. This system uses image processing algorithms and machine learning techniques such as Roboflow and YOLO object detection algorithms to provide timely and accurate information about potholes, sewer covers, and drain holes. This study compares the performance of YOLOv5 and YOLOv8 algorithms. When validated, the results reveal that YOLOv8 performs better than YOLOv5.

2 Introduction

Traditionally, human inspections have been the only method used to discover potholes, sewer covers, and drain holes. These techniques, however, are frequently time-consuming and ineffective, delaying repairs and raising dangers. With the advancement of computer vision and machine learning technologies, there is a chance to create automated systems that can quickly and precisely locate potholes on road surfaces, repair them, and maintain sewer covers and drain holes in a proper condition to ensure road safety and reduce associated costs. The real-time detection of potholes, sewer covers, and drain covers is the main goal of this project.

2.1 Motivation

Road users are at a high risk of accidents, car damage, and injuries due to potholes, neglected sewer covers, and drain holes. The old-fashioned way of doing manual inspections can be expensive and time-consuming. Pre-maintenance rather than post-repairs are made easier by an automated pothole, sewer cover, and drain hole identification. The initiative aims to stop road infrastructure from deteriorating, increasing its lifespan and lowering long-term maintenance costs by spotting potholes, sewer covers and drain holes before they become serious. Using image processing methods and machine learning approaches, this system examines real-time video material captured by cameras mounted on vehicles or other roadside infrastructure. The appropriate authorities in charge of maintaining the roads are then given fast and precise information, allowing them to take preventative action to fill potholes and maintain sewer covers and drain covers in order to guarantee traffic safety.

3 Prior Work and Challenges

In [1], one of the approaches proposed for pothole detection involves the implementation of YOLOv5 and YOLOv4, where 8000 augmented photos were utilized in the dataset, which was divided into training, and validation sets in the ratio of 80:20 respectively. Based on the results, YOLOv5 showed the highest mAP@0.5 of 95 % among other models, but it exhibited misclassification and no detection of potholes at long distances. Whereas, the YOLOv4 model has a 90 % detection accuracy.

Another strategy proposed for pothole detection in [3] involves the implementation of YOLOv8, YOLOv5, YOLOv4, and YOLOv3 models. A custom dataset of 6243 images was used, which was divided such that 80 % of images were allocated for the training set and the remaining 20 % for the validation set. The YOLOv8 model had a precision of 97 % and an mAP of 51.3 % when compared to the YOLOv5 model which only had a precision of 96.2 % and an mAP of 51.1%. Figure 1 shows the comparison between YOLOv8 and YOLOv5.

YOLO Algorithms	YOLOv8	YOLOv5
Release Date	January 2023	June 2020
Model Type	Object Detection and Instant Segmentation	Object Detection
Backbone	EfficientNet	CSPNet
Framework	PyTorch Framework	PyTorch Framework
Inference speed (FPS)	62.5-90.0	140.0-200.0
Input resolution	640x640	640x640
Mean Average Precision (mAP) on COCO dataset	51.1% (YOLOv8-L)	48.4% (YOLOv5-L)

Figure 1: Difference between YOLOv8 and YOLOv5

As we can be seen from the table, YOLOv8 is more complex and accurate than YOLOv5, but also slower and heavier. YOLOv5 is more simple and fast than YOLOv8, but also less accurate and robust. In the end, we decided to choose YOLOv8 as our main model of focus due to its precision, accuracy, and efficiency.

4 Our Approach

4.1 Data Collection

The dataset for the pothole detection system was collected from the Indian Driving Dataset (IDD)[7], which consists of 10,000 images, finely annotated with 34 classes collected from 182 drive sequences on Indian roads. From this huge dataset, a subset with 151 images focusing on potholes was created. Several images of potholes from Kaggle [6], a research paper[2], and images of drain holes and sewer covers from Roboflow Universe [4] [8] were also augmented as well. Out of 3800 images, 70 % was used for training, 10 % for validating, and 10 % for testing.

4.2 Annotation

The collected data was then accurately annotated using Roboflow. Roboflow is a computer vision platform that provides an intuitive interface for annotating and labeling training data. Users can analyze precision, recall, and other metrics, as well as visualize model predictions and ground truth annotations to gain insights into model accuracy. The classes that were used while annotating the dataset are Pothole, Sewer Cover, and Drain Hole.

4.3 Experiments

Generally, YOLO algorithms work by dividing the input image into a grid and predicting bounding boxes and class probabilities directly. By utilizing a single forward pass through the network, YOLO is able to detect objects by optimizing both localization and classification simultaneously. The platform we used for programming, training, and deploying the models was Google Colab. Table 1 shows the hyperparameters that were applied while training the YOLOv5 and YOLOv8 models

Sl. No.	Model	Input Image Size	Batch	epochs
1	YOLOv5	416	16	100
2	YOLOv8	800	16	100

Table 1: Applied hyperparameters for training YOLOv5 and YOLOv8 models

5 Results

The study employs precision, recall, and mean average precision (mAP) as evaluation metrics. Table 2 presents the results obtained while evaluating YOLOv8 and YOLOv5 on the test data.

Sl. No.	Model	Precision	Recall	mAP
1	YOLOv8	92.7%	87.6%	92.8%
2	YOLOv5	94.5%	82.9%	89.3 %

Table 2: Performance comparison of YOLOv8 and YOLOv5

The results suggest that YOLOv8 provides better performance than YOLOv5. The generated model YOLOv8 and YOLOv5 of this dataset were uploaded to Roboflow and it can be accessed by the following links.

Try Model ***YOLOv5 Model[5]*** ***YOLOv8 Model[5]***

References

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