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Deep Learning Based Pothole Detection System

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Abstract— **India has a vast network of roads which connects the various cities and villages, due to which its maintenance becomes a challenging task and also many accidents takes place because of the damaged roads and also the accident rate are increasing year after year due to the up-surging potholes count. As the road maintenance process is done manually in most places, it consumes enormous time, requires human labor and is subjected to human errors**. Also, as the road network is very large, it is not feasible for the Authority travel to all the places for inspection. In order to solve this problem and to increase the efficiency we can use various Image Processing techniques (such as CNN, YOLO V5) in order to find the damages and then comparing the same to find the technique with maximum accuracy. This data can further be sent to the government for repairing the roads and this helps in reducing accidents and further ensuring the safety of the citizens especially during rainy season. By using these techniques, the problem of damaged roads can be solved and also a lot of resources can be saved by repairing the roads in the right time and also by reducing the labor cost.**

Keywords— *PotHole , Image Processing , Deep Learning Neural Network , CNN Algorithm , YOLO Algorithm*

I. INTRODUCTION

In recent years, due to advancement in transportation, poorly maintained highways and roads results in traffic and also leads to accidents. This can be reduced by properly maintaining the roads and filling the potholes regularly which also reduces the maintenance cost. As road inspection is done manually, it becomes a time consuming job and it also requires human labour and it is also subjected to errors. Due to the damaged roads, traffic jams occur which is indirectly responsible for economic losses. Also, if these damaged roads are not repaired timely the conditions of the roads may become worse and the cost of repairing these roads also increases immensely. But it is difficult to monitor the road conditions by visiting all the roads and checking for the damages manually as it is a labor-intensive process and it also involves high inspection cost. In order the solve these problems modern techniques can be used. In the proposed system, first the images of the roads are collected after which the images are then being processed using various machine learning algorithms such as YOLO V5, CNN, etc. The dataset used to train the model are collected from various websites such as Roboflow , Kaggle ,etc .Then the dataset collected are divided for training , for testing and for validation. After training and testing the algorithm with the most accuracy is used to develop an application in which the video of the road is processed and is converted into images after which the images are processed using the algorithm with the best accuracy and the potholes are found. These reports can then be sent to the concerned department to look into the matter and repairing the damaged roads thus reducing the traffic and accidents.

II. RELATED WORK

This problem statement has been extensively studied over the past years by researchers in a bid to create a solution, and all their solutions vary from the algorithms used to the approaches taken for predicting the damaged roads.

The work of Mr. Anup Kumar Pandey [1] introduced a system for the detection of potholes in which the accelerometer present in the phone was used to collect the data which was further processed by training the ID-CNN model.

Deepak Kumar Dewangan [2] proposed a pothole detection system using a smartphone and a raspberry pi camera in which the setup is placed on the vehicle and the pi camera records the road condition and then the recorded video is converted into images which is then processed and the pothole is detected using the various CNN algorithms.

Lei Chen [3] presented an image recognition system using various deep learning techniques such as CNN models to process the images and finding the agricultural disease using image processing.

Nachuan Ma [4] proposed a system for road imaging and pothole detection using various cameras , laser scanners and various other devices for road imaging which is placed on the vehicle and the images are then processed using various machine learning algorithms for pothole detection.

Ratnajit Mukherjee [5] proposed an AI based road maintenance inspection in which the images are processed for predicting the damaged roads and damaged road signs using RGPNet algorithm and then visualizing the damages on the map.

Dharneeshkar J [6] proposed a deep learning based system for the detection of potholes which uses various image processing techniques such as YOLO v3, YOLO v2, etc and the results are compared using precision and recall for best accuracy.

Byeong-ho Kang and Su-il Choi [7] developed a system for the detection of potholes using 2D Lidar and Camera in which first the images are captured using a 2D Lidar sensor and the potholes are detected using various algorithms and after this step, the Camera setup is used to increase its accuracy.

Kavitha R and Nivetha S [8] proposed a system for the detection of potholes which uses a Raspberry pi for recording images and then using various object detection techniques for the detection of potholes.

K. Vigneshw B. Hema Kumar [9] developed a system for the detection of potholes using various image processing techniques such as Gaussian-Filtering and clustering based image segmentation methods for the detection of potholes.

III. PROPOSED METHODOLOGY

YOLO v5 and CNN namely are the two methods , which has been used in training and testing of the pothole detection model.

The dataset used in the training of YOLOv5 model, are the road images with labelled potholes, for each image there exist a text file which gives the annotation based width, height, depth and size of potholes image that form a boundary box around the potholes in the images, where as the dataset used in the CNN model, is divided in two categories Plain and Pothole images and it does not contain any type of predefined annotation or boundary boxes.

For YOLOv5 the dataset is imported from Roboflow website , Roboflow is a website which provide datasets in different format options available.

Then the default architecture of YOLO v5 is modified according to the model need, in our case number of classes is 1 (i.e pothole) so the nc is declared as 1 in the architecture and is saved as custom YOLO v5 model. Then, the training of custom yolov5 model is done using the imported dataset and epochs set to 280. 280 epochs are completed in 0.608 hours.

The training took almost 1 hour and the best weights are saved.

Now, we can use the best trained weights to detect the potholes in the road images.

For CNN the dataset is downloaded from kaggle website. Here the dataset contains two categories of images i.e plain and pothole images. Data Augmentation has been performed for each of the categories using image data generator to increase the image for each of the category as because initially the dataset was balanced but was very less to be trained on.

We need to prepare data by labelling each of the images 0 - Plain and 1 - Pothole. After the preparation of data we do shuffling of data so that our model does not get overfitted and splits the data in two parts X and Y , features and target variable respectively.

The architecture of our model consists of 4 convolution layer, followed by activation "Relu" and max pooling layer with size of [2,2] respectively. At last two dense layers are added with "Relu" and "Softmax" as activation function respectively.

Then the X and Y data is splitted in train and test data (80:20) and the train data is used in the training of model.The training took around 1 hr for 150 epochs.

After the training is completed the cnn model is evaluated using the test data and the model is saved and is used to detect potholes in the road images.
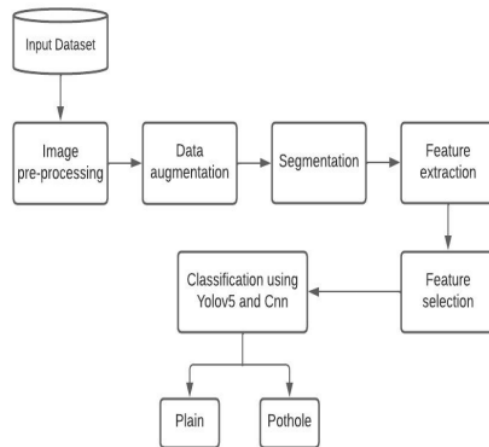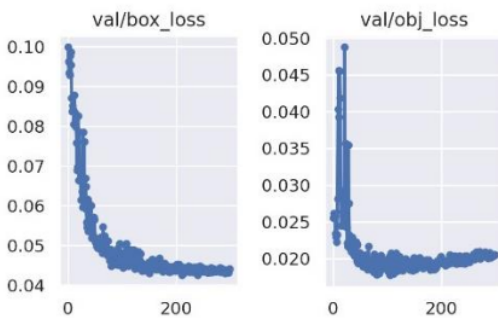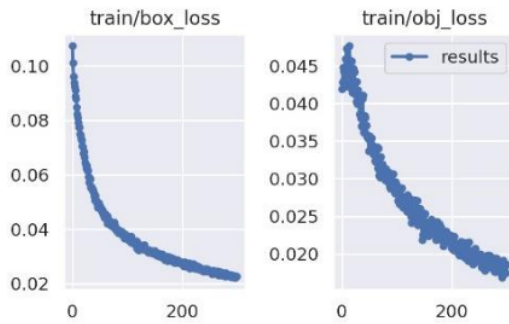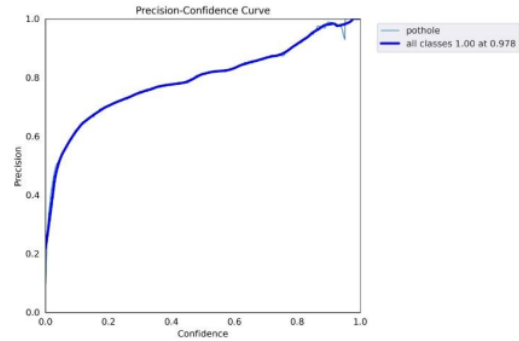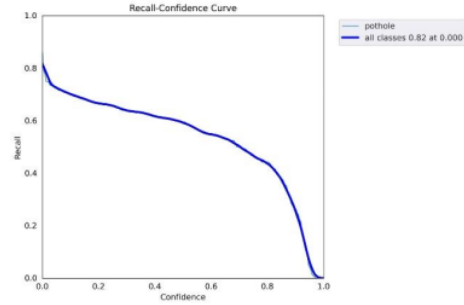

IV. RESULTS AND DISCUSSION

For YOLOv5 , the training has been done on different epochs and batch sizes, then the epoch value which results in better accuracy was taken into consideration.

The total of 465 images data has been used in the training

Batch size	Epoch	Accuracy(mean average precision)	Time taken(in hrs)
2	100	0.669	0.673
20	100	0.677	0.238
20	180	0.715	0.421
32	280	0.734	0.608

Here are a few screenshots from the YOLOv5 model :

Recall-Confidence Curve

Precision-Confidence Curve

train/box_loss

train/obj_loss

val/box_loss

val/obj_loss

For Cnn , the training has been done on different epochs and on different architectures, batch size taken was default i.e 32 .

And, the dataset which is used consist total of 960 images of data, out of which 486 are of plain images and 474 are of pothole images.

While forwarding the data to the model for training, the dataset was splitted into two parts train and test in 80:20 ratio.

Therefore 768 image data was passed to the model for training and 192 image data was kept for testing.

The accuracy for CNN comes out to be 93.34%.

V. CONCLUSION

The identificaton of various deep learning - image processing techniques for pothole detection was done by comparing the accuracy obtained from various models. The CNN algorithm was preferred over YOLO v5 algorithm as CNN algorithm gave 93.34% accuracy were as YOLO v5 algorithm gave 73.34% accuracy. Further the accuracy of the YOLO v5 algorithm can be increased by training the model using a large volume of training dataset. The best model obtained can be used in future for various other applications. Further, my future work would be implementing this model in real world environment in which an camera placed in an vehicle can be used to collect live data and then performing live processing of the data and then using the results to design an application in which the location of the damaged roads can be mapped and the same images can be shown on the map.

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