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Object Detection Model for Pothole Identification using Region based Convolution Neural Network

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Abstract:- Potholes are one the major concerns of underdeveloped and developed nations. Roads are the essential means of transportation for a country and when this road becomes bad safe driving is threatened, this may result to road traffic crashes hence the need to provide an intelligence system that can detect this potholes in real time and give drivers real time feedback to enable them make adequate decisions while driving. This paper presented the pothole detection model that was trained with data extracted from Google and some real time data. Region Convolution Neutral Network (R-CNN) as an object detection model was used to analyze images captured via cameras used for image detection specifically for Pothole Detection, and only part of the image is processed instead of the background; hence very large data and consequently tedious computations, pixel matching, parameter updating and sorting were significantly decreased. This work used the comparative analysis, Microsoft Common Object in Context (COCO) and TFLITE mobile net. The model was evaluated and their strengths and limitations were analyzed based on metric parameters such as accuracy, precision and F1 score. The results analyzed show that the suitability of the algorithms over is depended to a great extent to the use cases they were applied in. In a good testing environment, Region Convolution Neural Network (R-CNN) gave a good classification report with the parallel testing proof that the model is not perverse.

Keywords: *Machine Learning, Object detection, Pothole detection, Region Convolution Neural Network.*

I. INTRODUCTION

Pothole is a natural cave or a hollow on the road surface formed as a result of erosion or aging of asphalt [1]. Potholes pose a lot of dangers for road transport users in many developing countries, especially in Nigeria. The task of maintaining roads and removing these road anomalies is an expensive and tedious one, due to the nature of landmass and climate conditions in Nigeria. It is reported that pothole is the second largest cause of accidents in Nigeria apart from over speeding and reckless driving with annual reported accidents surpassing 45% [2]. The problem of potholes in Nigeria cannot be eradicated completely by government but rather how to manage it and drive safely. The roads have been a concern of authorities to avoid unwanted circumstances. These roads are vulnerable to scenarios such as traffic load, weather conditions, age, poor material used for construction, and miserable drainage system, exhibiting two major road failures such as cracks and potholes. Potholes are essentially the concave-shaped depressions in the road surface that requires attention as they induce awful circumstances such as accidents, unpleasant driving experiences, and malfunctioning of vehicles. Potholes should be dealt with on a priority basis to minimize their contribution towards unfortunate scenarios.

According to the prediction made by WHO (World Health Organization), road accidents will become the fifth leading cause of death in 2030 [3]. The significance of potholes created conspicuous interest for the researchers of the civil community. The developing nations use manual inspection methods to recognize the potholes leading to inaccurate estimation as it is highly dependent on individual experience. These manual inspection methods require human interventions that are time consuming and costly. Many technical solutions exist for pothole detection such as scanning based with 3D reconstruction [4–6], vibration sensor based [7–10], thermal imaging [11, 12], and computer vision based [13–15].

II. MATERIALS AND METHOD

This section focused on the concept of an Object Detection Model for Pothole Identification using Fast Region Based Convolution Neural Network (FR-CNN). The approach was based on the sample of Pothole Detection data that was collected from real life and extractions from Google search, and this sample was categorized with respect to their class label. Based on this fact, the system was built with the available data used to perform the analysis on this paper.

A. Data Source and Collection

The dataset used in this paper was scraped from online platforms using Google search engine and real time data, this was used for the analysis. This dataset consists of feature and instances.

B. Experimental Set Up

The dataset were divided into 70% for the training set and 30% for the testing set. All the experiments carried out are computed using open- source python library and python programming language with Jupyter notebook IDE. The Jupyter notebooks is well suited for combined software code,

computational output, explanatory text, and rich content in a single document. Notebooks allow in- browser editing and execution of code and display computation results. Jupyter notebook was used to build the model. We used python programming language to implement the system and then used the proposed algorithm to develop a classification model, then perform the model evaluation and report.

C. Machine learning Approach

- Collect the sample data (driver driving event image)
- Pre-processing (that is the data were annotated with three labels, braking, speeding, and safe driving; and since it is a supervised learning approach, then it is a multiclass classification.
- Apply feature extraction with python scripts library (to convert the dataset into a multiclass classification analysis)
- Resizing the sample data into training set, validation set and testing set during the system implementation design.

D. Object Detection Method

Region Based Convolution Neural Network was used in this work.

E. Pre-processing Dataset

This contain sample images file with labels, data preprocessing and a multiclass value sample data preprocessing with respect to their content using the labeling tool to label images for both potholes and normal road in an image.

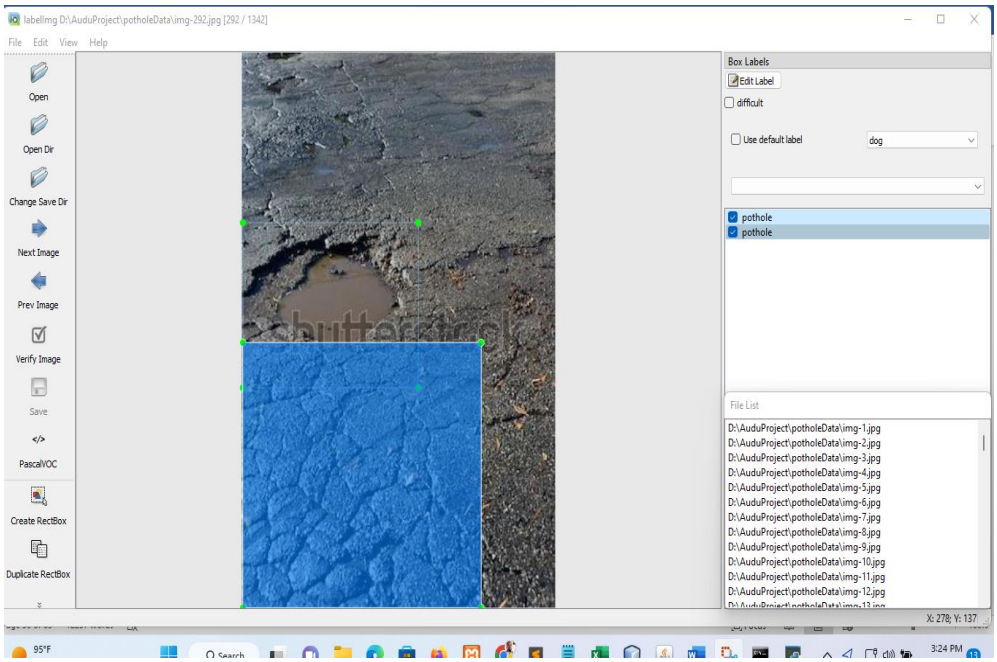

Fig. 1: Label Image for Potholes

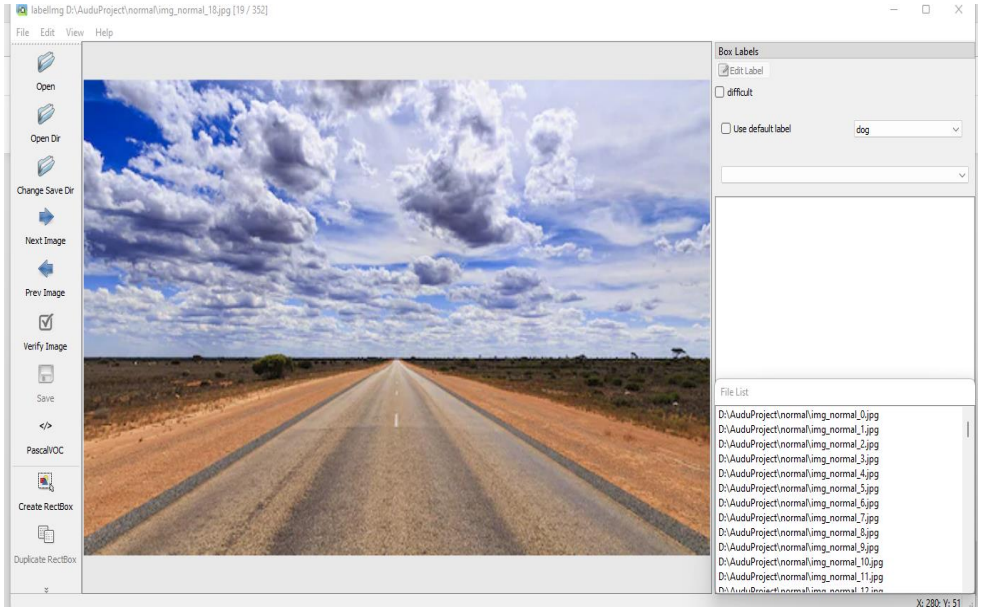

Fig. 2: Label Image for normal road

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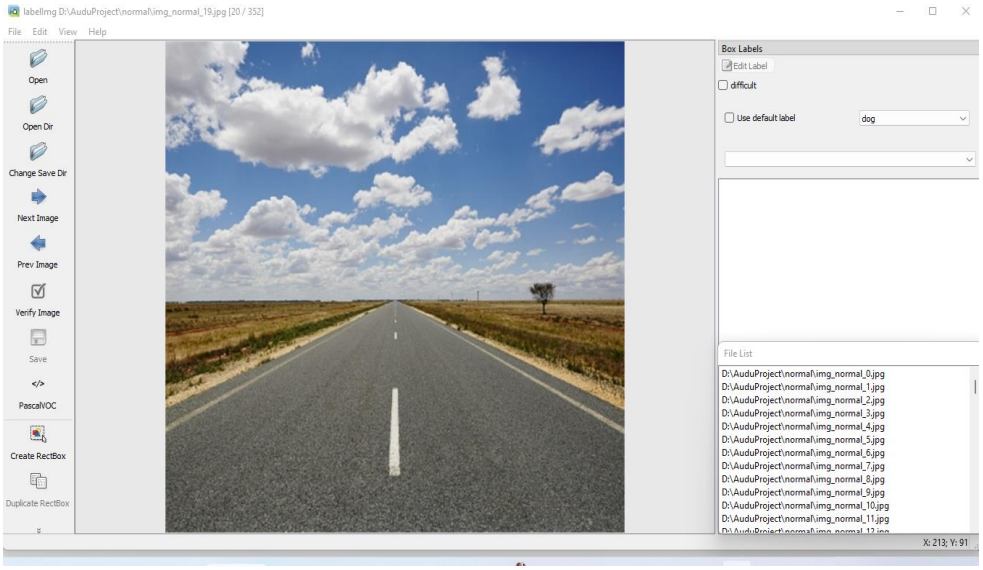

Fig. 3: Label Image for normal road

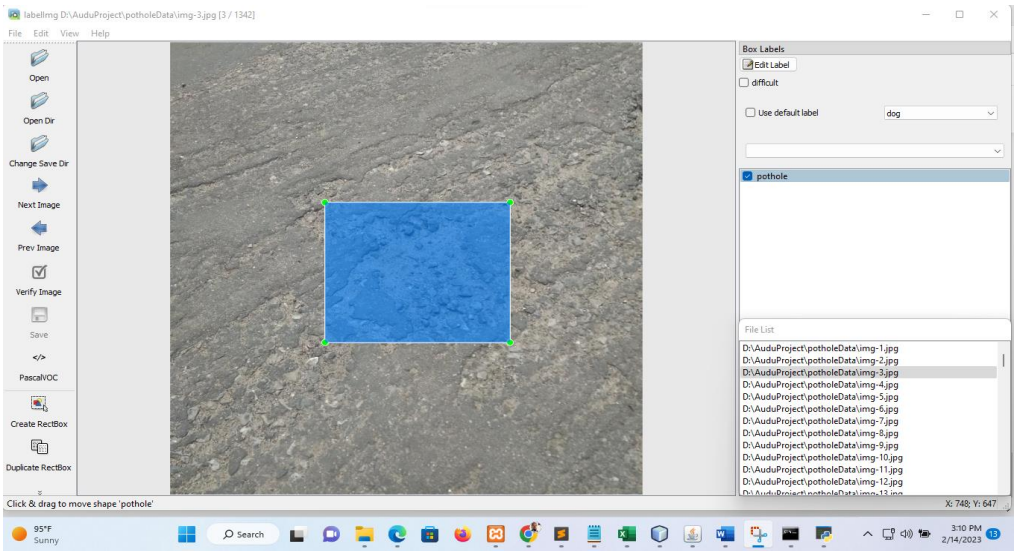

Fig. 4: Label Image for Label Image for Potholes Module

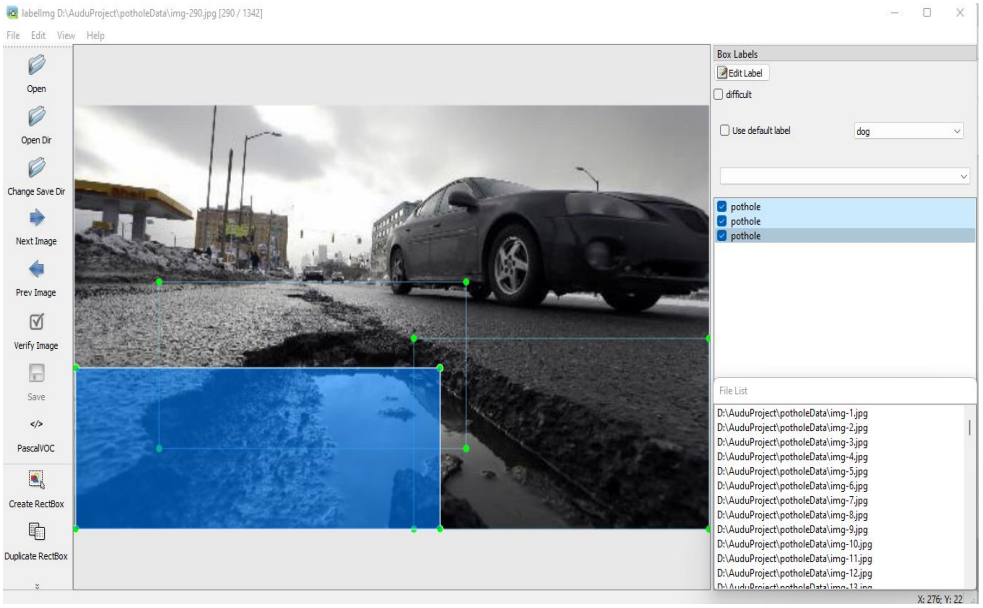

Fig. 5: Label Image for Potholes Module

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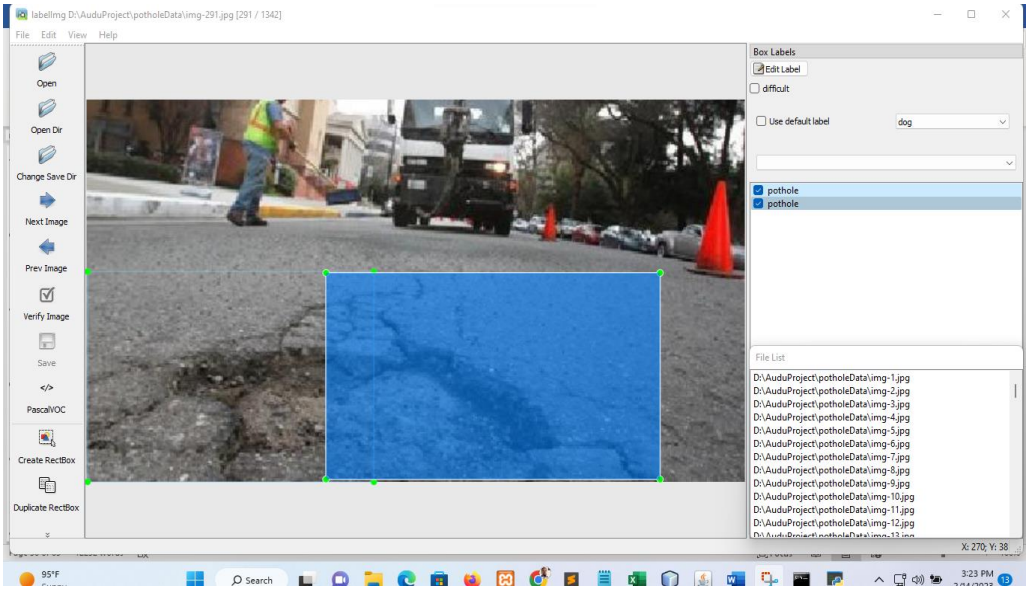

Fig. 6: Label Image for Label Image for Potholes Module

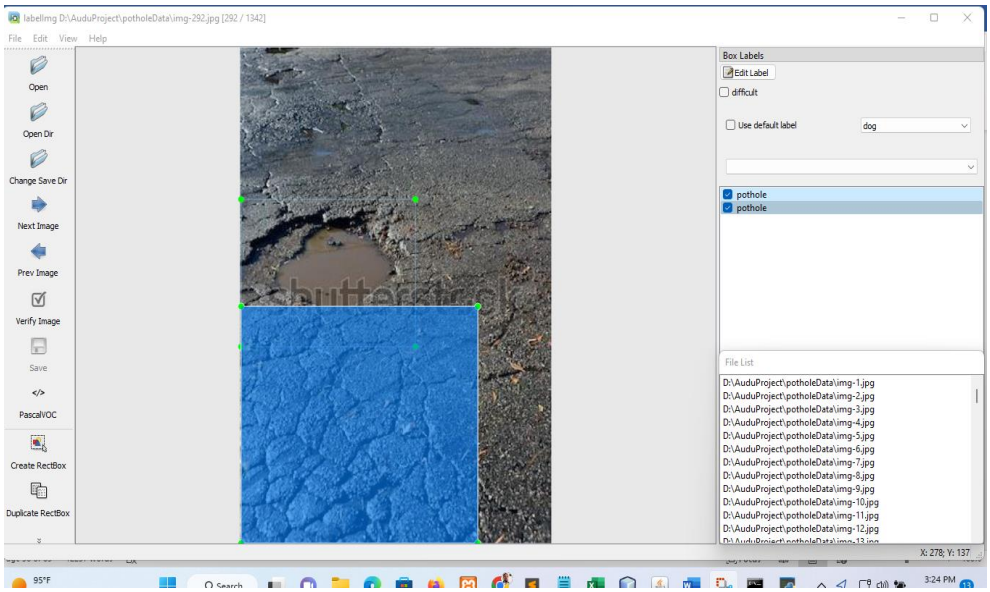

Fig. 7: Label Image for Potholes

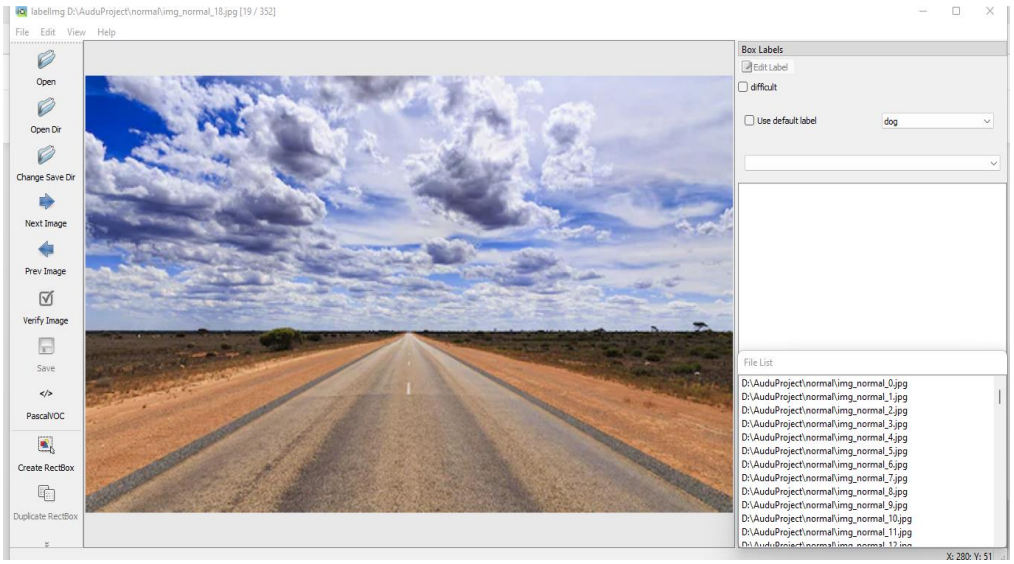

Fig. 8: Label Image for normal road

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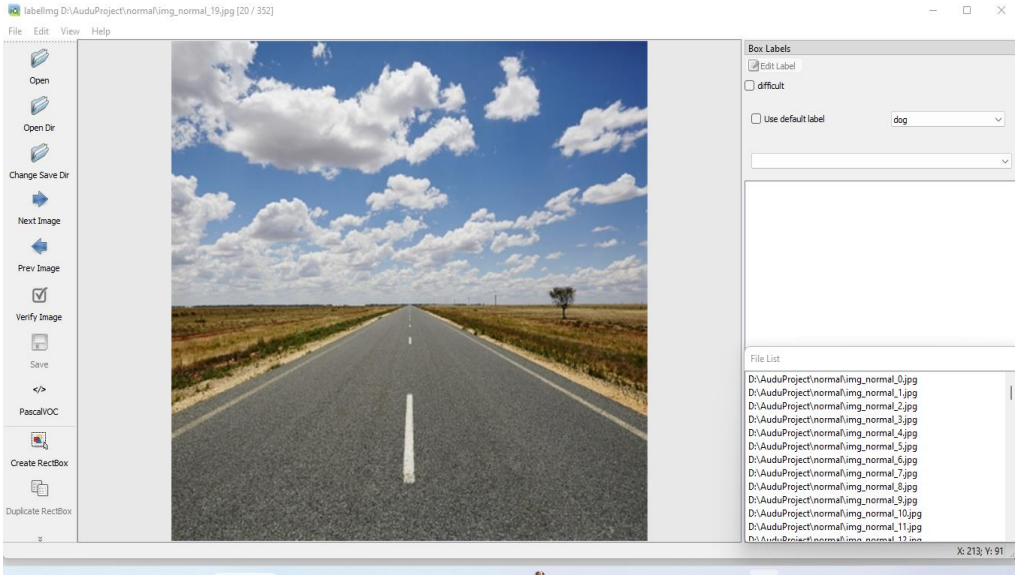

Fig. 9: Label Image for normal road

III. RESULT AND DISCUSSIONS

Experiment of classification model was done with the training set, which was used to build the model. The test set now used for detecting and predicting the result with class label as well as predicting a new class label with their respective class. The individual model results and analysis are presented hereunder.

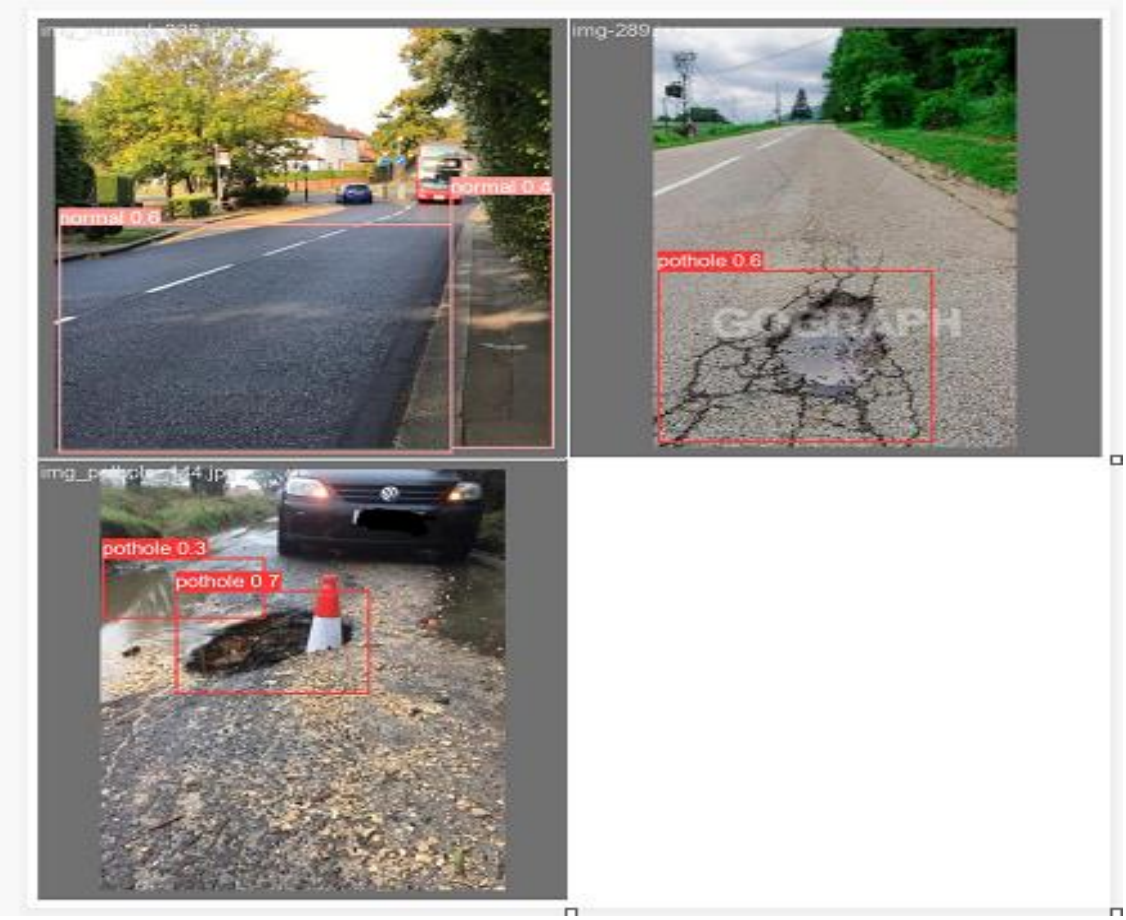

Fig. 10: Tensorboard- Image trained Modules

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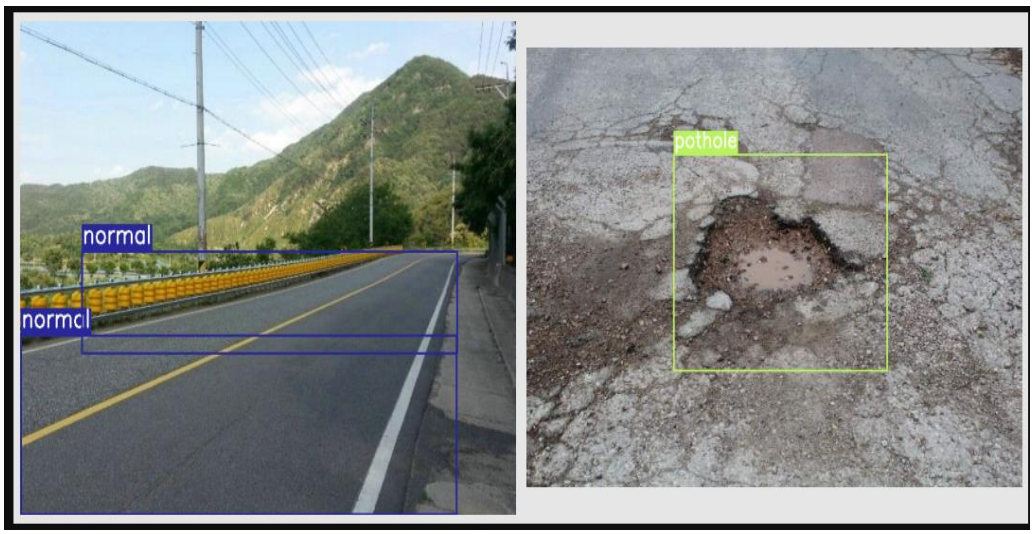

Fig. 11: Tensorboard- Image trained Modules

Figure 11 above described the training model of a normal road and a road with potholes from our model. The training model was able to detect and identify two road classes.

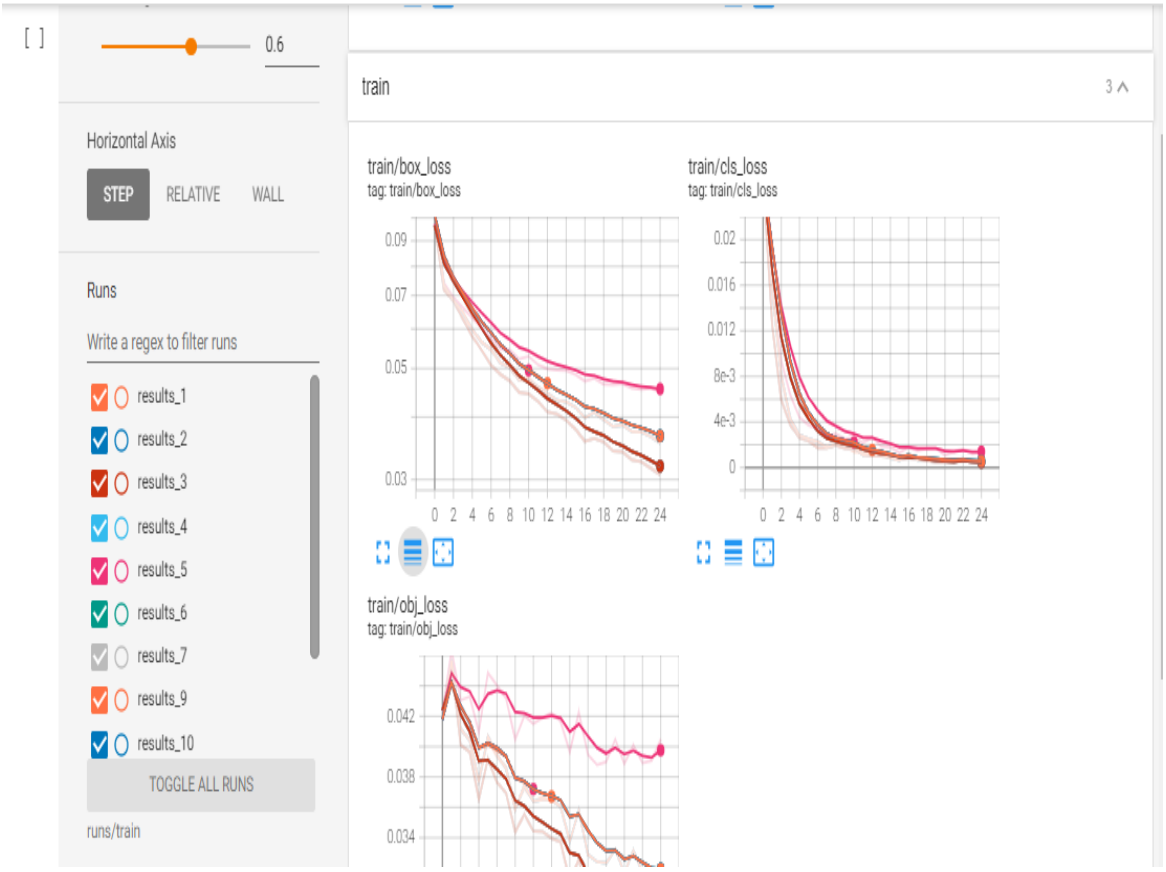

Fig. 12: Tensorboard- Image trained loss metrics

The fig. 12 showed the full model that was trained and the losses which are minimal.

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Fig. 13: The visualization grounds truth images from the trained model

The process was done by annotating the text files, which are normalized in scale of x, y, width, and height. This function was written as x minimum, y minimum, x maximum, y maximum format. With this the model was trained and visualization of trained model was achieved.

A. Performance Evaluation for Region based Convolution Neural Network (RCNN)

RCNN is a specialized object detection model that use CNNs as a backbone to identify objects in an image. While the general CNN approach can be used for a variety of image classification tasks, object detection model like RCNN are specifically designed to identify objects in an image and are optimized for performance and accuracy in this task.

Table 1: Model Performance Evaluation For R-Cnn Iteration Of Epoch 5/5

Epoch 1/5	[==========]	48s 203ms/step	loss	accuracy	val_loss	val_accuracy
			0.3359	0.8629	4.0452	0.6781
Epoch 2/5	[==========]	39s 190ms/step	loss	accuracy	val_loss	val_accuracy
			0.2668	0.8953	-	-
Epoch 3/5	[==========]	38s 187ms/step	loss	accuracy	val_loss	val_accuracy
			0.2492	0.9014	-	-
Epoch 4/5	[==========]	39s 191ms/step	loss	accuracy	val_loss	val_accuracy
			0.2256	0.9148	-	-
Epoch 5/5	[==========]	39s 189ms/step	loss	accuracy	val_loss	val_accuracy
			0.2031	0.9219	-	-

The table above illustrate the level of R-CNN model train with batch size of 16 and iteration epoch of 5 respectively for model loss, accuracy, validate loss and validate accuracy. The performance of the model is 0.92 or 92%, based on this the last epoch is recorded and loss is 0.2 or 2%. Hence below graph depict the differences between the model accuracy and model loss.

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Fig. 14: Model accuracy and loss

B. Classification Report for model evaluation metrics

Table 2: Classification By Class Model

Class		Precisson	Recall	f1-score	Support
Normal	**0**	1.00	0.04	0.08	236
Pothole	**1**	0.60	1.00	0.75	345

IV. CONCLUSION

Recent studies have shown that researchers have proposed various techniques for pothole detection using data collected from different parts of world. This work presented a unique set of data with real time data collected from Nigeria and the unstructured dataset extracted from Google which is now proven to be trainable with good predictions that can be adopted by researchers working on intelligent transport systems and pothole surveillance systems in Nigeria and indeed Africa. Among many other models that has been adopted for this related study, Region Based Convolution Neural Network has proven to be a good model with good prediction and perfect detection of the two classes of data trained in this research. This research will go a long way in deploying an embedded system for pothole detection and prediction in automobiles by the industries. Therefore there is need to train more road characteristics to help improve safe driving in the world.

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