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POTHOLE DETECTION SYSTEM USING YOLO v4 ALGORITHM

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Abstract - *There are many potholes present on the road. This can lead to major accidents. Every year around 3597 people die due to these potholes. To tackle and detect such potholes we have come with this project. The goal of this project was to create a pothole detection system that is specifically designed to detect potholes. This model was developed using the YOLO (You Only Look Once) algorithm for real time object detection. It is a pretrained model which detects the pothole using YOLO v4. Previously sequential CNN (Convolution Neural Network) Algorithm was used but later we figured out after a comparative analysis that YOLO gave better results in real time. A GUI (Graphical User Interface) was added to the model so that we can simulate the model using the start and stop button. This system consists of a camera that, when activated, extracts images from live camera recording in order to detect potholes. It will display potholes in real time, and the pothole will be highlighted with boxes, as seen in real-time object detection systems. This system provides us with an accuracy of 80-85%.*

Key Words*: *You Only Look Once Algorithm, Convolutional Neural Network, real time detection, Graphical User Interface, pothole detection, accuracy

1. INTRODUCTION

Obstacle detection has been the subject of extensive research in the past, with different methods for avoiding various types of impediments in diverse environments being tested. However, the focus has been mostly on autonomous agents avoiding impediments, which has been confined to extruding obstacles. As a result, the detection mechanism became exceedingly system-specific and unsuitable for widespread use. Road transportation has been very simple and cost-effective, albeit the comfort of the ride is determined by the state of the road. Potholes on roadways are a big source of frustration for people who travel by car. Accidents and loss of human lives are caused by potholes generated by severe rainfall and heavy vehicle activity.[1] As a result, potholes are becoming a significant concern to drivers, who risk accidents and car damage. Unexpected humps and ditches on the road could lead to more collisions. As a result, the potholes must be filled to make the ride more comfortable and to eliminate potential hazards. As a result, the suggested system employs the YOLO (You Only Look Once) v4 Algorithm to detect potholes. We utilized the following ways to test this model:

- Building a model that will detect the potholes in its path.
- Highlighting the potholes so that the person is alerted.

Fig -1: Conditions of roads with potholes.

Manually examining and evaluating visual pavement data is a time-consuming and costly process, and the findings are heavily impacted by the subjectivity and experience of evaluations.[5] The primary objective of this system is to detect the potholes present on the road through deep learning approach which helps automate the task of detecting potholes and helps one to easily understand that they are heading towards a pothole present on the road. The following is discussed in the rest of the paper: Section 2 discusses some of the related projects or literature review. Section 3 provides the methodologies used. The technical components used is presented in Section 4. Section 5 presents the implementation and Section 6 presents the comparative analysis between CNN (Convolutional Neural Networks) and YOLO v4 of the proposed system and Section 7 describes the conclusion and further research work.

2. LITERATURE REVIEW

(1) In a paper titled 'Deep Learning Based Pothole Detection and reporting System (IEEE 2020)', they have used accelerometer and ultrasonic sensor, mounted it in

the bottom of a car, and driven the car at 25 km/hr and also used a GPS to identify the location. The micro controller detects the pothole and gives the location to the control room. The microcontroller (ATmega328) initializes the GPS and provides us the Coordinates. The methodology used was Comparative study between CNN, KNN (k-Nearest Neighbors), Kirchoff's Theory Method. (2) In the paper, 'A Modern Pothole Detection technique using Deep Learning (IEEE 2020)', they have mounted a camera on the car and then detected the potholes and marked the location using the app that is developed by them so the car which does not have the camera can get the information about the pothole using the application and give the driver the required alerts. They have not mentioned about the accuracy of their project. The methodology used was F-RCNN (faster region based Convolutional neural network). (3) In the paper 'Development and Analysis of Pothole detection and Alert based on Node MCU (IEEE 2020)', one can depict the depth and danger accompanied with it. The location is shared using GPS module and IFTTT (if this, then that) server to the mails of the maintenance authorities who can take the necessary actions. The methodology used was a model created using node MCU, GPS module, Ultrasonic sensor, IFTTT Webhooks. (4) In the paper 'Smart Detection and Reporting of Potholes via Image-Processing using Raspberry-Pi Microcontroller (IEEE 2018)', The whole system was successfully implemented using the Raspberry-Pi microcomputer with a 100% reporting success rate. The methodology from a moving car, it was able to locate and report potholes, the system used image- processing, the integration of which was used to produce an algorithm using Python Language from the OpenCV library to detect and report potholes automatically. The reported image of the pothole and its location was stored and viewed through the Internet, Dropbox, and the webserver. (5) In the paper titled 'Deep learning algorithm based on YOLO Neural Network for detecting potholes in asphalt pavement. (International Seminar on Intelligent Technology and Its Applications (ISITIA) 2019)', the model with Yolo neural network succeeded in detecting potholes for asphalt pavement images. It shows a satisfactory detection accuracy of the applied architecture, Yolo v3, Yolo v3 Tiny, Yolo v3 SPP. Which present the mAP of 83.43%, 79.33%, and 88.93% respectively, and the area measurement accuracy of 64.45%, 53.26%, and 72.10% respectively. Also, it needs an average detection time of 0.04 seconds per image. Therefore, it has a high opportunity to be developed and implemented. They used the Yolo V3 Algorithm.

3. METHODOLOGY

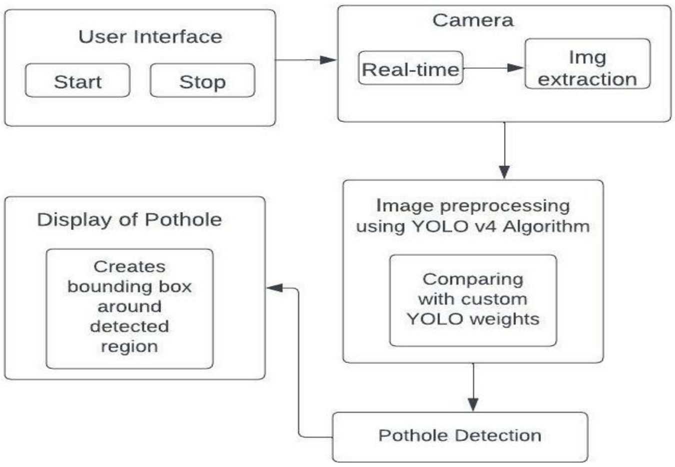

Fig -2: System Block Diagram

The system block diagram is shown in Fig -2. The proposed system works with the help of a very simple and user-friendly GUI which provides you with two options, "Start" and "Stop", and helps you achieve real-time potholes detection using YOLO v4 algorithm.

When one selects the "Start" Option, the Camera switches on and live detection of potholes takes place. Now the camera keeps on recording while the YOLO v4 algorithm works in the back-end simultaneously. The required information necessary for detecting the potholes is captured.

The images are extracted throughout the live recording and accordingly a detection process is carried out. The YOLO v4 algorithm takes these images one by one and processes it. It compares the information recorded from the images with the yolo weights. When a pothole is detected, it predicts a bounding box around it. The bounding box consists of a Box Label and Predicted Accuracy Percentage where Accuracy Percentage refers to the percent of how accurately a pothole is detected. Whatever number of potholes are detected in each image gets reflected on the console output.

As you select the "Stop" option, the system exits the GUI and thus the detection process stops.

4. TECHNICAL COMPONENTS OF PROPOSED SYSTEM

i. HARDWARE REQUIREMENTS

a. Laptop or PC:

A good laptop with Nvidia 1660 GPU and 8 GB RAM was good enough for this system as YOLO requires a good GPU to make it efficient.

b. Camera:

A camera is connected to the system in order to capture the images or videos of the potholes detected on the road.

ii. SOFTWARE REQUIREMENTS

Visual Studio:

Microsoft Visual Studio is a Microsoft integrated development environment. It's used to make websites, web apps, web services, and mobile apps, among other things. We have done the coding part of this system using Visual Studio.

5. IMPLEMENTATION

Improving the safety of traffic is an important issue in Indian telecom services (ITC). This proposed model is a pothole detection system based on machine learning and image processing using the YOLO Algorithm. This system will help to detect the potholes present on the road and give a warning to the driver. The motivation here is to serve humanity better with the help of technology.

5.1 Pre-processing of Data

Data preprocessing is a crucial phase in the data mining process that involves manipulating or removing or adding data before it is utilized to ensure or improve performance. In data mining and machine learning initiatives, the phrase "garbage in, trash out" is especially apt. Since our YOLO v4 Model is pretrained we had to input a few images or videos as our data while now, with real time detection system, images are automatically extracted from live recording through the camera and are further processed using the YOLO v4 Algorithm.

5.2 Deep Learning Approach

The YOLO V4 algorithm is used in the suggested system. "You Only Look Once" is the acronym meaning "You Only Look Once." It is a state-of-the-art, real-time object identification system developed by Joseph Redmon that can distinguish several items in a single frame. YOLO takes a completely different technique to detection than earlier technologies. It uses a single neural network to process the entire image. The image is divided into regions by this network, which predicts bounding boxes and probabilities for each region. The projected probabilities are used to weight these bounding boxes.

YOLOv4 is well with its AP and FPS improvements. On a single CPU, YOLOv4 optimizes real-time object detection and training. On the COCO dataset, YOLOv4 achieved state-of-the-art performance with 43.5 percent speed (AP) at 65 frames per second (FPS) on a Tesla V100.

The basic concept of YOLO is illustrated in the diagrams below. YOLO divides the input image into a S x S grid, with each grid cell anticipating the object that is centered in that grid cell.

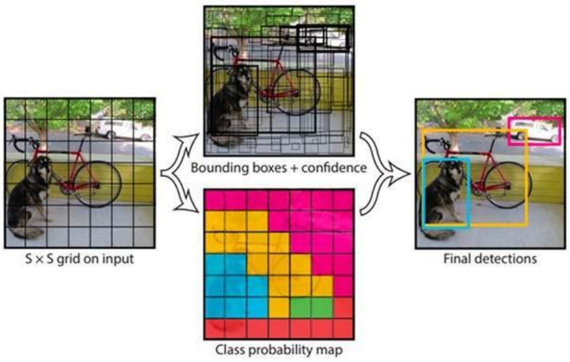

Fig -3. S x S Grid

Bounding boxes and confidence scores for those boxes are predicted in each grid cell. These confidence scores represent the model's belief that the box contains an object as well as the accuracy with which it believes the box it forecasts is.

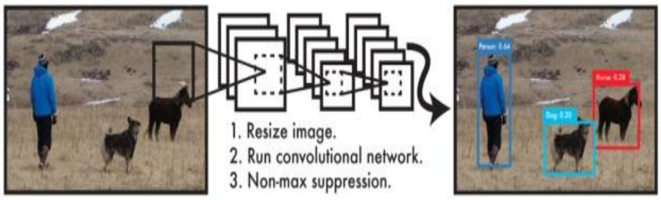

Fig -4: YOLO Concept

5.3 GUI for simulation

A simple GUI (Graphical User Interface) using Tkinter was made so that we can turn on and off the simulation of the detection of potholes. When you turn on the system, the camera starts capturing and you can detect the pothole. You will see if the pothole is detected or not and then can turn off the simulation by clicking on the stop button. The GUI is displayed in fig 5 below.

Fig -5: GUI

5.4 SYSTEM FLOW

This is how the model works as shown in the flowchart below.

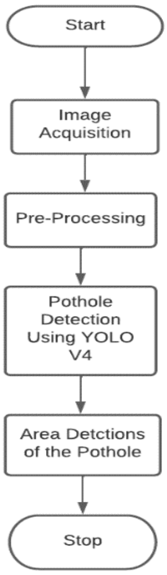

Fig -6: Flowchart of the model

In this model first we had to upload the image/ video in the code to get the desired output. So, for the improvement and to make it usable we connected our model to a live camera to get a real time detection of the potholes.

The system flow is as follows:

When the system starts, the camera is switched on and real time detection of potholes using Yolo V4 algorithm takes place. The images are extracted from live video and processed in order to detect potholes. The detected potholes are displayed in bounding boxes and as a result real-time potholes detection is achieved.

Here are a few images of our results:

Fig -7: Result image of Detected pothole (1)
Class Label: D40, Accuracy achieved: 82%

Fig -8: Result image of Detected pothole (2)
Class Label: D40, Accuracy achieved: 83%

6. COMPARATIVE ANALYSIS AND EXPERIMENTAL RESULTS

A comparative analysis of two Algorithms was done. CNN and YOLOv4 were tested and the table 1 below, explains the results.

Table -1: Comparative analysis of Different Algorithms

Algorithm Used	Description	Accuracy
CNN Model	The previous tested system used CNN module to train and test the model and created a confusion matrix as an output to show whether the image belonged to the normal category or the pothole category. It was not a great option to go ahead with this as it was not able to perform well in real time.	We achieved a good accuracy of about 80 - 82% but this model took much longer time to detect the pothole
YOLO v4 Model	We used the Yolo v4 image classification algorithm for detecting the potholes. In this proposed system the potholes are detected in real-time instead of uploading some image/video in the code. It was a pretrained model and could easily detect potholes in real time as compared to CNN.	This model easily achieved a great accuracy of 85% - 90% on average in real time pothole detection system.

Below are a few images of our results that show the accuracy of the pothole detection using YOLO v4.

Fig -9: Pothole Accuracy of 69% and 63%

Above Fig 9 shows the detected pothole in bounding boxes. Two potholes are present and both are successfully detected with 69% accuracy and 63% accuracy with D40 as class labels.

Fig -10: Pothole Accuracy of 64%

Above Fig 10 shows the detected pothole in a bounding box. One pothole is present and is detected with 64% accuracy with D20 as class label.

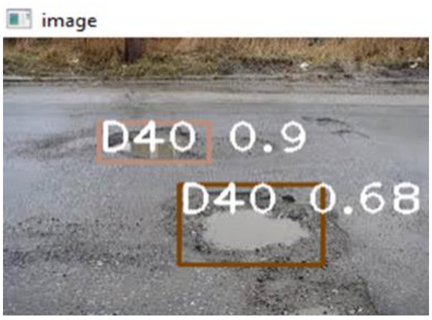

Fig -11: Pothole Accuracy of 90% and 68%

Above Fig 11 shows the detected pothole in bounding boxes. Two potholes are present and both are successfully detected with 90% accuracy and 68% accuracy with D40 as class labels.

Note: In the above images, 'D40' and 'D20' are class labels. The following table 2 can be referred to know its detailed information:

Table -2: Road Damage Types

Damage Type		Detail Information	Class Label
Crack	Longitudinal	Wheel-marked part	D00
	Transverse	Equal Interval	D10
	Alligator	Partial/ Overall pavement	D20
Other Damage		Pothole	D40

7. CONCLUSIONS

In this paper we have discussed the pothole detection system using YOLO V4 Algorithm.

Decision of using YOLO V4 was great because the biggest advantage of using YOLO is its superb speed – it's incredibly fast and can process 45 frames per second. YOLO also understands generalized object representation. It is one of the best object detection algorithms, with a performance that is comparable to that of the R-CNN algorithms. The system provides several benefits and can operate with less manpower. Hence, we have successfully completed the training and testing of our model using YOLO V4. The system successfully detects the potholes with a good accuracy of approx. 85%.

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