IMAGE PROCESSING FOR INDIAN ROADS

B.TECH SEM – VII Mini PROJECT

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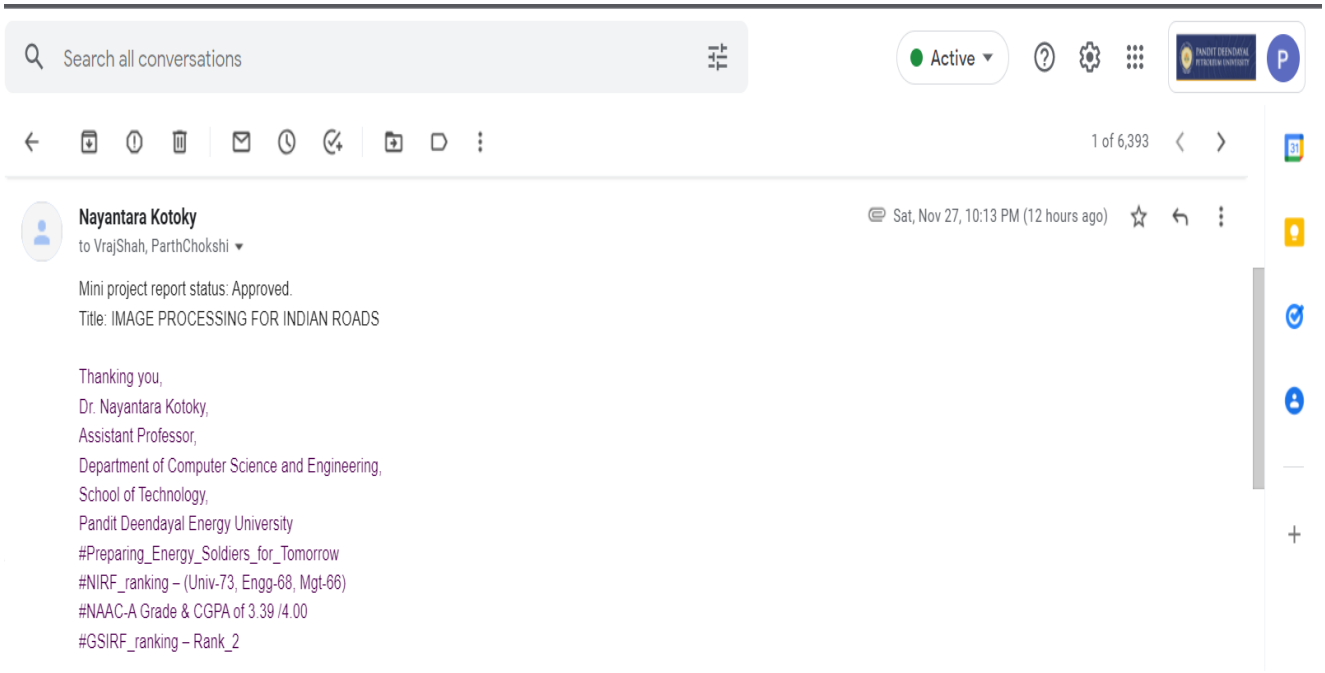

ABSTRACT

In developing nations such as India, the vehicular growth rate is increasing exponentially which is worsening the traffic operations. Most of the urban cities in India are facing traffic related problems such as congestion, accidents, pollution, etc. during peak hours. The main cause for traffic congestion in such cities is mainly due to uncontrolled urbanization and extensive usage of private vehicles. The traffic congestion leads to many problems like increase in travelling time, health disorders and accidents. Road accidents in India claimed over 1.5 lakh lives in the country in the year 2018, with over-speeding of vehicles being the major cause. The Ministry of Road Transport and Highways report on Road accidents in India stated that road accidents increased by a rate of 0.46 % in the year 2018 when compared to 2017 .

Due to this there is a need to develop a model which can analyze and detect poor road conditions like potholes.This project aims in building a system which can detect the poor road conditions and can notify the driver as well as the government beforehand to improvise the road conditions.

Pothole detection is being carried out using two techniques namely image processing and machine learning techniques. Those two techniques are used for a study of the detection and occurrence of potholes. In this project, we implemented both of them individually and then a combination of the techniques to see how image pre-processing can affect the performance of a deep learning model.

The image pre-processing steps like erosion,median blur etc applied in this project removes the noise in the image which helps in better training of the model.First of all, we implemented the image processing techniques on a single image in the order: median blur, erosion, canny edge detection, contour detection, bounding box prediction. After that we labelled a dataset of around 800 images and passed it to the YOLOv5 model and noted the results.Secondly, we applied median blur on the already labelled dataset and then passed it to the YOLOv5 model and noted the results. Lastly, we applied median blur and erosion both and passed it to the model and noted the results. We compared the results at last.

The conclusions reached are that a combination of machine learning and image processing techniques generates good performance in pothole detection and machine learning techniques provide better results than the usual image processing models.

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1. INTRODUCTION

The government needs accurate information for effective road maintenance at regular intervals. But road inspection requires enormous manpower every year. This obviously slows down the process due to the distance involved. Automation techniques for road damage detection and classification are highly effective in road management. Machine learning algorithms and image processing techniques can be highly effective while analyzing road conditions. Usually, the images obtained from the data do not completely suit the purpose of the analysis. A pothole is the kind of damage inroads that is caused as a result of cracks and by water and traffic. There are many kinds of textures that are found on the road and arise from many factors like different zones of the image. Hence it is quite difficult to categorize the damage to the road. Each road image has exclusive features like the shape of the road and width of the road making it difficult to apply defect detection processes.

With an increasing number of vehicles on the road, increasing physical and mental strain of the driver's chances of accidents are increasing by every day and sophisticated onboard systems are needed for driver assistance. Using the intelligent design of hardware like camera, InfraRed, UltraSound, sophisticated systems can be designed that can guide the drivers, alert them over possible problems on the road and help minimize accidents. When a camera is fitted with the vehicle, it continually captures the frames. Such frames contain many details including the scene of either side of the road. We can then analyze these details using image processing techniques and various machine learning algorithms.

Hence, given the importance of maintaining good road conditions, this project aims in building a system that can detect the poor road conditions and can notify the driver as well as the government beforehand to improvise the road conditions.

2. LITERATURE REVIEW

1) "A Research of Pavement Potholes Detection Based on Three-Dimensional Projection Transformation" by Wang Jian, Qiu Hanxing, ZhangWei, Xie Jianfang

In order to detect the three-dimensional cross-section of pavement potholes more effectively, this paper proposes a method that employs the optical imaging principle of three-dimensional projection transformation to obtain pictorial information of potholes' cross-sections in pothole detection. Multiple digital image processing technologies, including image preprocessing, binarization, thinning, three-dimensional reconstruction, error analysis, and compensation are conducted in the series of image analyses and processing. Experimental results indicate that the method is markedly superior to traditional methods in many aspects. For its simple detection principle, low cost, and high efficiency, the method suggests great practical and promoting value.

2) "Detection of Road Conditions Using Image Processing and Machine Learning Techniques for Situation Awareness." by Md Asaduzzaman

In this modern era, land transports are increasing dramatically. Moreover, self-driven cars or the Advanced Driving Assistance System (ADAS) is now the public demand. For these types of cars, road conditions detection is mandatory. On the other hand, compared to the number of vehicles, increasing the number of roads is not possible. Software is the only alternative solution. The Road Conditions Detection system will help to solve the issues. To solve this problem, Image processing, and machine learning have been applied to develop a project namely, Detection of Road Conditions Using Image Processing and Machine Learning Techniques for Situation Awareness. Many issues could be considered for road conditions but the main focus will be on the detection of potholes, Maintenance signs, and lanes. Image processing and machine learning have been combined for our system for detecting in real-time. Machine learning has been applied to maintain signs detection. Image processing has been applied for detecting lanes and potholes. The detection system will provide a lane mark with colored lines, the pothole will be a marker with a red rectangular box and for a road Maintenance sign, the system will also provide information of maintenance sign as maintenance sign is detected. By observing all these scenarios, the driver will realize the road condition. On the other hand, situational awareness is the ability to perceive information from its surroundings, make decisions based on perceived information and make decision-based on prediction.

3)” Real-Time Pothole Detection Using Deep Learning” by Anas Al-Shaghouri, Rami Alkhatib, Samir Berjaoui

Roads are connecting lines between different places, and are used daily. Roads' periodic maintenance keeps them safe and functional. Detecting and reporting the existence of potholes to responsible departments can help in eliminating them. This study deployed and tested different deep learning architectures to detect potholes. The images used for training were collected by cell phone mounted on the windshield of the car, in addition to many images downloaded from the internet to increase the size and variability of the database. Second, various object detection algorithms are employed and compared to detect potholes in real-time like SDD-TensorFlow, YOLOv3Darknet53, and YOLOv4Darknet53. YOLOv4 achieved the best performance with 81% recall, 85% precision, and 85.39% mean Average Precision (mAP). The speed of processing was 20 frames per second. The system was able to detect potholes from a range of 100 meters away from the camera. The system can increase the safety of drivers and improve the performance of self-driving cars by detecting potholes ahead of time.

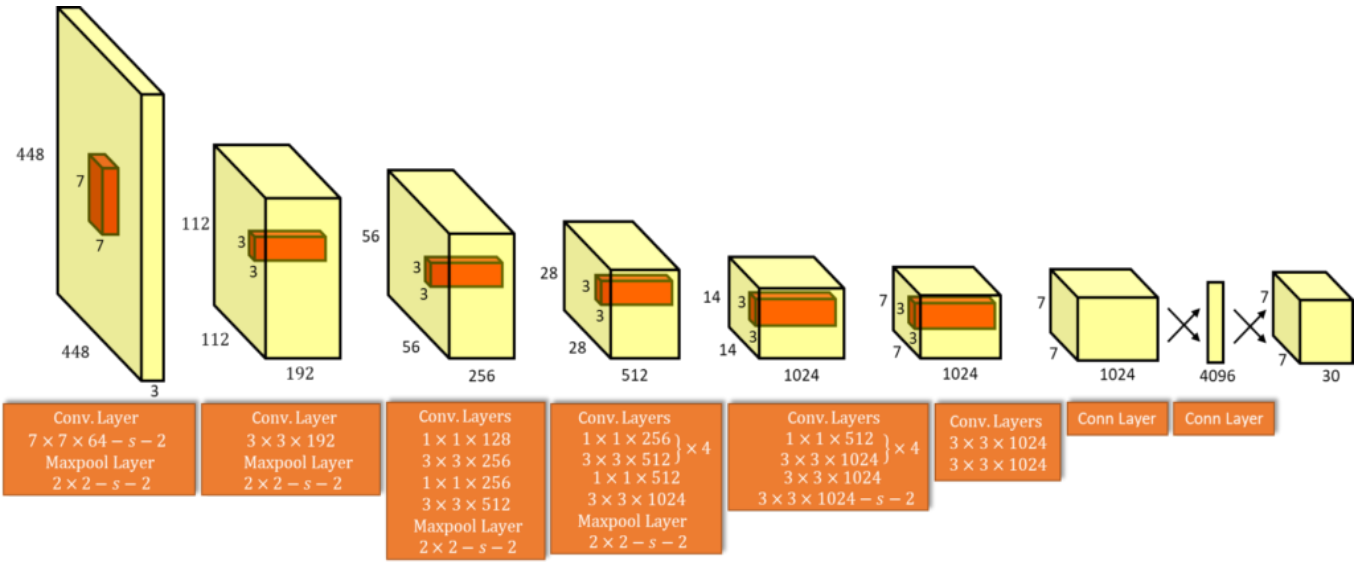
3. SYSTEM MODEL

3.1) Image Processing Technique:

Following steps were performed in respective order to gain the output:
a)Median Blur
b)Erosion
c)Canny-edge detection
d)Contour-detection
e)BoundingBox prediction

3.2) Deep Learning Approach:YOLO:

1. Yolo is a Deep Learning algorithm specially designed for image classification and Object Detection (Deep Convolutional Neural Network). It contains a very large number of hidden layers for processing the input data.
2. The architecture of YOLO contains 24 convolutional layers, 4 max-pooling layers, and 2 fully connected layers.
3. The architecture of the YOLO base model is shown below:



4. PROPOSED WORK

Pothole detection is being carried out using two techniques namely image processing and machine learning techniques. Those two techniques are used for a study of the detection and occurrence of potholes. In this project, we propose both of them individually and then a combination of the techniques to see how image pre-processing can affect the performance of a deep learning model. First of all, we implemented the image processing techniques on a single image in the order: median blur, erosion, canny edge detection, contour detection, bounding box prediction. After that we labelled a dataset of around 800 images and passed it to the YOLOv5 model and noted the results. Secondly, we applied median blur on the already labelled dataset and then passed it to the YOLOv5 model and noted the results. Lastly, we applied median blur and erosion both and passed it to the model and noted the results. We compared the results at last. These experiments gave us information on how image pre-processing could affect the accuracy of the model.

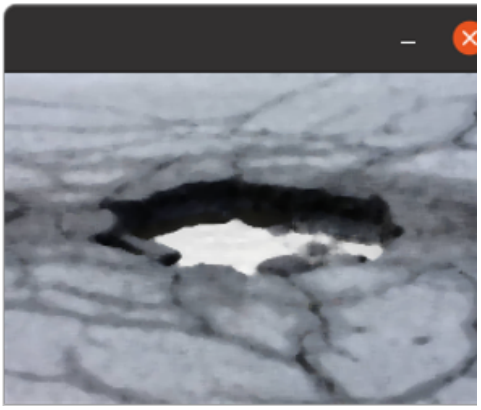
Experiment-1: Image Processing Technique

We first performed image processing techniques using python and openCv on images and following are the results on one of the image:

Steps:

a)Median Blur:

The Median blur operation is similar to the other averaging methods. Here, the central element of the image is replaced by the median of all the pixels in the kernel area. This operation processes the edges while removing the noise. It is very useful in removing salt and pepper noise.



b)Erosion:

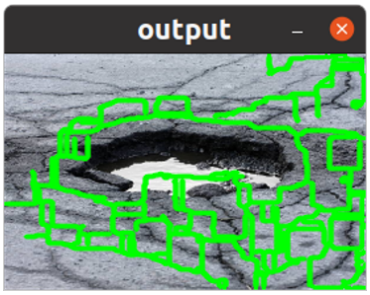
Erosion erodes away the boundaries of the foreground objects.It is used to diminish the features of an image.

c)Canny Edge detection:

The Canny edge detector is an edge detection operator that uses a multi-stage algorithm to detect a wide range of edges in images.

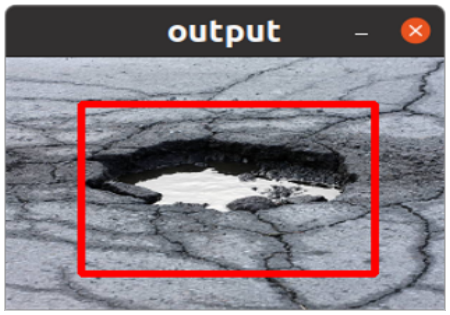
d)Contour Detection:

When we join all the points on the boundary of an object, we get a contour. Typically, a specific contour refers to boundary pixels that have the same color and intensity.



e) Bounding Box Prediction:

Finally, place a bounding box across the contour.



Experiment-2: Deep Learning Approach: USING YOLO

About YOLO:

1) Yolo is a Deep Learning algorithm specially designed for image classification and Object Detection (Deep Convolutional Neural Network).
2) The model was trained over a week by the authors of the paper "You Only Look Once: Unified, Real-Time Object Detection" and obtained a whopping accuracy of 88%.
3) Yolo had been trained on a very large dataset.
4) YOLO runs at 45 Frames per second so it has a latency of 15ms.
5) It has an mAP (mean Average Precision) of 63.4% which is the highest among real-time object detectors.

Our Approach: Transfer Learning

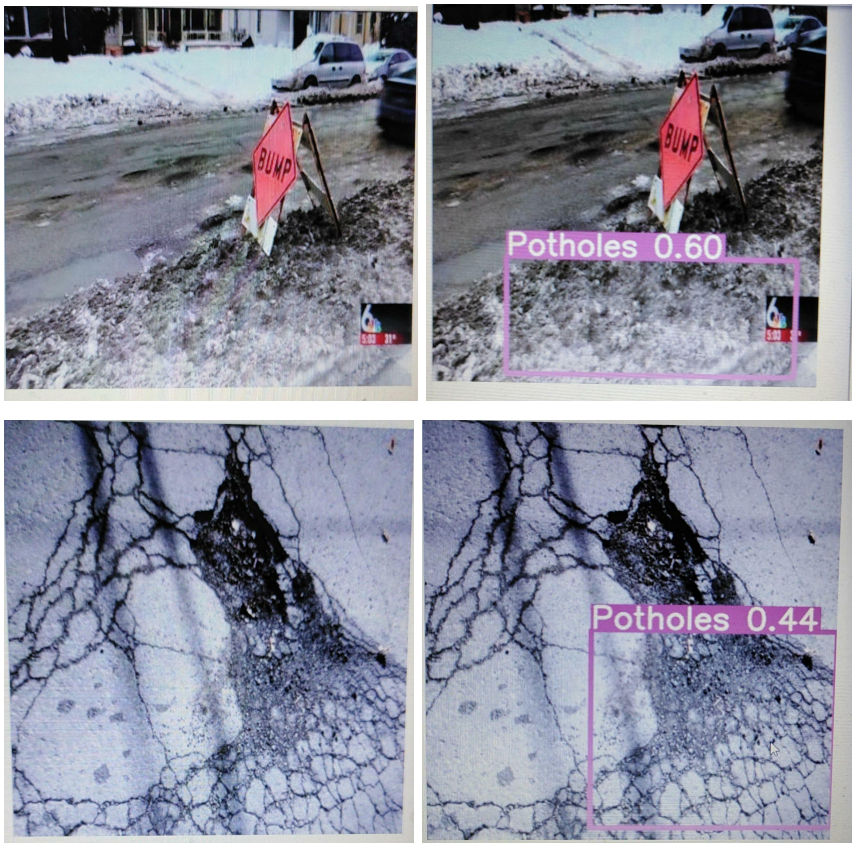
1) Transfer learning is about speeding up a new learning task by reusing the results of previous learning.
2) The already-trained model is referred to as the base model. Transfer learning involves retraining the base model or creating a new model on top of the base model.
3) In our project, we will be using the YOLO v5 model for our custom object detection, that is, pothole detection.
4) YOLO was chosen after going through a number of research papers and techniques used in them and it was found by us that it has the best real-time object detection accuracy.

Experiment -3: Combination of 2 techniques (Image processing & Machine learning)

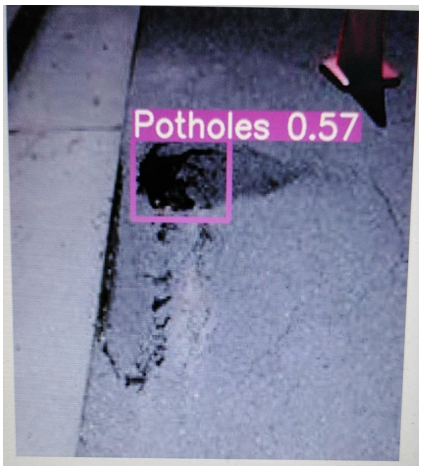
1) After performing the above techniques successfully we thought of combining the 2 techniques and verifying the result.
2) We first labeled the dataset and trained the YOLOv5 Model with that dataset.
3) After that, we applied the Median Blur technique of image processing on the same dataset and then trained the YOLOv5 model.
4) After that, we applied Erosion on the dataset obtained from step 3 and then again trained the model.
5) Finally, we compared the result in all the 3 cases and this gave us information on how image pre-processing can affect the accuracy of the deep learning model.

These are some of the output images of YOLOv5 model in the following respective order:

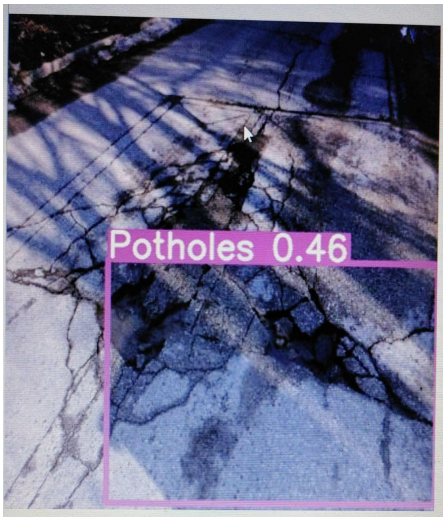
a) Normal Image Dataset **b) Image processing techniques applied**




Potholes 0.42


Potholes 0.57


Potholes 0.51

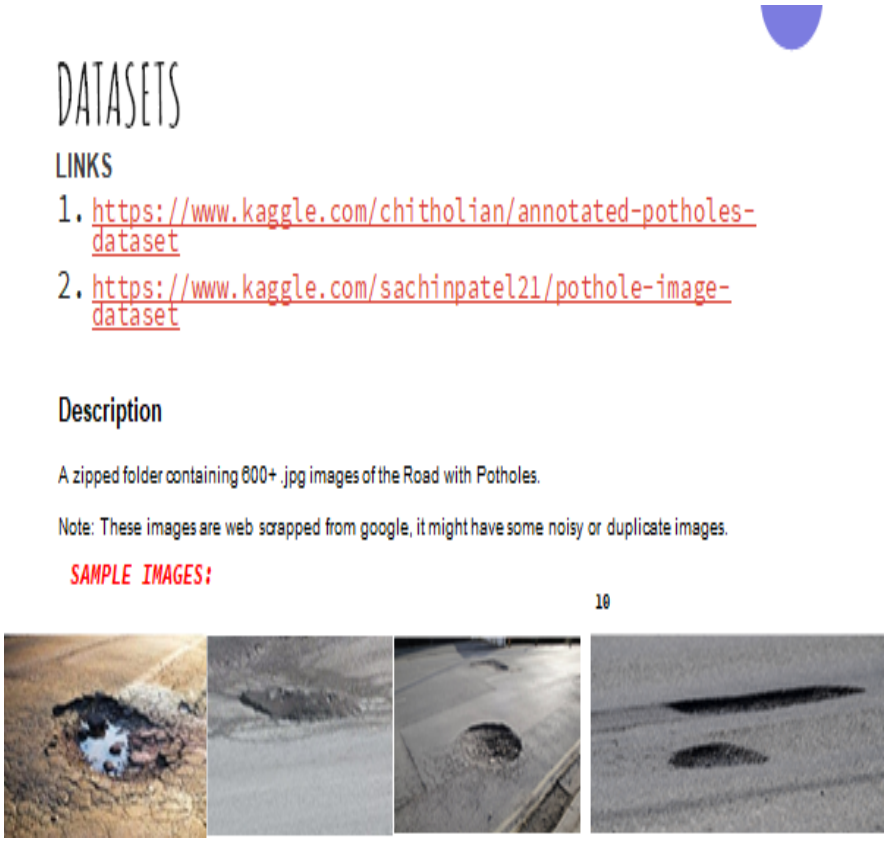

Potholes 0.46

5. IMPLEMENTATION DETAILS

5.1 Tools and Technologies Used:

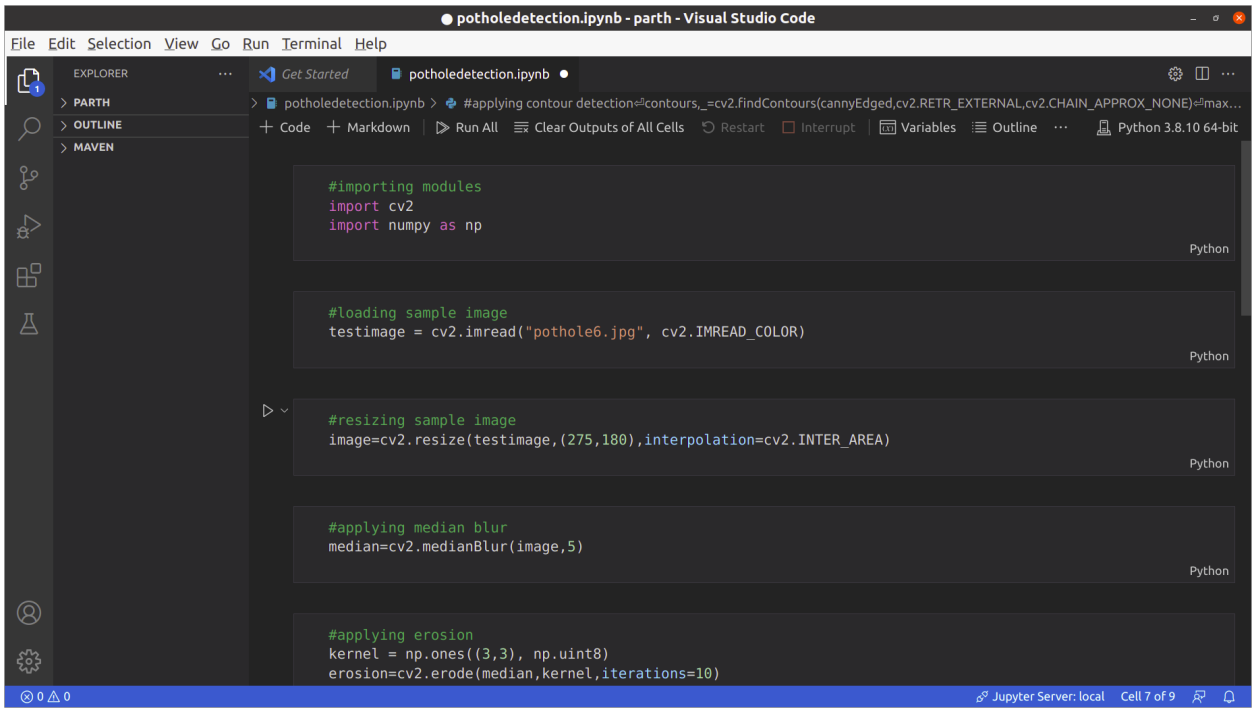
1. Python
2.OpenCv
3.Roboflow
4.Jupyter Notebook
5.Vscode
6. Darknet framework
7. CNN

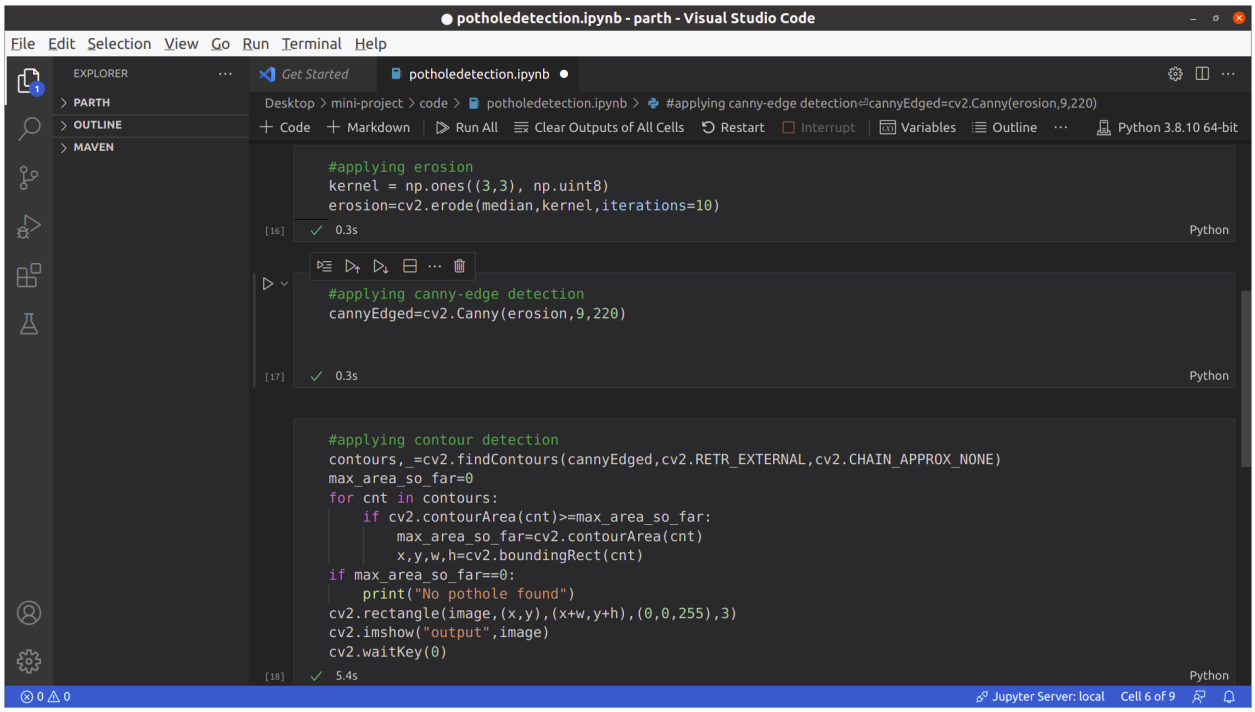
5.2 Dataset:



5.3 Code Snippets:

Image Processing Technique:





6. RESULTS AND COMPARISON WITH THE EXISTING WORK

Experiment-1: Image Processing Technique

Testing set: 34 images

Steps Performed	Images	% accuracy
Image processing techniques 1)Median blur 2)Erosion 3) Canny Edge detection 4)Contour Detection 5)Bounding box	16/34 images showed correct potholes	47.05

Experiment-2: Deep Learning Approach(YOLO)

The dataset used for this approach was divided into following set:
Training set: 734 images
validation set: 72 images
Testing set: 34 images

Steps Performed	Images	% accuracy
Without pre-processing on images	23/34 images showed correct potholes	67.647
Applied median-blur on images	25/34 images showed correct potholes	73.529
Applied median-blur+erosion on images	26/34 images showed correct potholes	76.470

7. SUMMARY AND FUTURE DIRECTIONS

Summary:

During the course of this project, we first did the literature survey and found various existing technologies for pothole detection. We first applied image processing techniques like median blur, erosion, canny-edge detection, contour detection, bounding box prediction. During contour detection there were multiple contours detected but we only wanted the contours with potholes in it. To solve this we passed a threshold value and only the contours with area greater than this threshold were considered. After this, we implemented the deep learning approach where we used the YOLOv5 model for custom object detection(here, pothole) using transfer learning.Transfer learning is about speeding up a new learning task by reusing the results of previous learning. For this, we used the roboflow tool to label the dataset. Around 800 images were taken for training purposes. We used a test set of 34 images to check the accuracy and tabulated the result. After this, we used a combination of image processing technique approach and deep learning approach. We applied median blur on the labelled dataset and then passed it to the YOLOv5 model and tabulated the results and lastly we applied erosion on the dataset and noted the results of the model.

Out of the 34 images of the test set, 23 images detected correct potholes in the first case where no image processing technique was applied. In the second case where median blur was applied, around 25 images detected the correct potholes. In the last case with median blur and erosion, 26 images showed correct output. These results gave us information on how image pre-processing can affect the accuracy of a deep learning model.The conclusions reached are that a combination of machine learning and image processing techniques generates good performance in pothole detection and machine learning techniques provide better results than the usual image processing models.

Future Directions:

The image pre-processing steps used here surely increased the accuracy of the model. In future,more such image processing techniques can be identified and applied as a pre-processing step which will enhance the efficiency of the model. Also, this system can be integrated with Google maps.Images from satellites can be passed to this model which can detect any potholes present on roads and then it can be viewed on google maps. This will help the government to improve the road conditions.