Image Processing on Indian Roads

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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

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.

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 in roads 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 paper describes about image processing techniques and machine learning approach and a combination of both approaches together with the results that helps in increasing the efficiency of model to detect poor road conditions(potholes).

2. Related Work

Many works based on pothole detection have been carried out using different algorithms and various image processing techniques. The authors [1] proposed a paper based on crowd sourcing technique.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.(laser sensor/vechicle vibration sensor)[processing stereo imaging using digital image processing technology.After then transforms Object side and image side cordinate system.Then it can get acuurate width and depth of pothole with binocular stereo vision for error correction]. In [2], In this paper Image processing and machine learning have been combined for this 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. In [3] authors have proposed a methodology with various image processing 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, YOLOv3 Darknet53, and YOLOv4 Darknet53. 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. Methodology

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.

3.1. 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:

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.

3.2. Experiment-2: Deep Learning Approach-USING YOLO

Yolo is a Deep Learning algorithm specially designed for image classification and Object Detection (Deep Convolutional Neural Network). 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%.Yolo had been trained on a very large dataset.YOLO runs at 45 Frames per second so it has a latency of 15ms.It has an mAP (mean Average Precision) of 63.4% which is the highest among real-time object detectors.

We have used transfer learning here.Transfer learning is about speeding up a new learning task by reusing the results of previous learning.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. In our project, we will be using the YOLO v5 model for our custom object detection, that is, pothole detection. 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.

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

After performing the above techniques successfully we combined the 2 techniques and verified the results. We first labeled the dataset and trained the YOLOv5 model with that dataset.After that, we applied the Median Blur technique of image processing on the same dataset and then trained the YOLOv5 model. After that, we applied Erosion on the dataset obtained after applying median-blur and then again trained the model.Finally, we compared the result in all the 3 cases and this gave us information on how image preprocessing can affect the accuracy of the deep learning model.

4. Results

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

5. Limitations

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. Avoid using bit-mapped fonts if possible. True-Type 1 fonts are preferred.

6. Discussions

Type your main text in 10-point Times, single-spaced. Do not use double-spacing. All paragraphs should be indented 1/4 inch (approximately 0.5 cm). Be sure your text is fully justified-that is, flush left and flush right. Please do not place any additional blank lines between paragraphs.

Figure and table captions should be 10-point boldface Helvetica (or a similar sans-serif font). Callouts should be 9-point non-boldface Helvetica. Initially capitalize only the first word of each figure caption and table title. Figures and tables must be numbered separately. For example: "Figure 1. Database contexts", "Table 1. Input data". Figure captions are to be centered *below* the figures. Table titles are to be centered *above* the tables.

7. Future Research Agendas

For example, "1. Introduction", should be Times 12-point boldface, initially capitalized, flush left, with one blank line before, and one blank line after. Use a period (".") after the heading number, not a colon.

7.1. Second-order headings

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8. Conclusions

Use footnotes sparingly (or not at all) and place them at the bottom of the column on the page on which they are referenced. Use Times 8-point type, single-spaced. To help your readers, avoid using footnotes altogether and include necessary peripheral observations in the text (within parentheses, if you prefer, as in this sentence).

9. References

List and number all bibliographical references in 9-point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets, for example [3]. Where appropriate, include the name(s) of editors of referenced books.

References

[1] S. B. Anas Al-Shaghouri, Rami Alkhatib. Real-time pothole detection using deep learning. *Cornell University*, July 2021.

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