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Pothole Detection And Area Estimation System Using Mask R-CNN

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Abstract: Transportation has a crucial impact on a country's growth, with roads being a vital component. They play a major role in people's daily lives as many individuals travel from one place to another via roads. Neglect in maintaining the existing road infrastructure, combined with environmental changes and heavy rainfall, can lead to the formation of potholes on roads. The Ministry of Road Transport and Highways reports that potholes have resulted in numerous road accidents and fatalities in recent years. To tackle this problem, our project aims to develop an automated pothole detection and dimension measurement system. Our proposed solution uses Mask Region-based Convolutional Neural Network (M-RCNN) deep learning algorithm to detect dry and wet potholes, and image processing techniques to estimate the size of the potholes. The implementation of this system will enhance road maintenance, reduce road accidents caused by potholes, and support the overall development of the country.

Index Terms - Pothole Detection, Area Estimation, Deep Learning, MRCNN, Road Accident.

I. INTRODUCTION

Pothole Detection and Area Estimation System is a computer vision-based solution that utilizes the Mask R-CNN (Region-based Convolutional Neural Network) algorithm to detect and estimate the size of potholes on roads. Potholes are a major concern for road maintenance authorities as they pose a threat to vehicle safety and cause substantial damage to roads. The Pothole Detection and Area Estimation System can assist in identifying and repairing these potholes in a timely and efficient manner. Mask R-CNN is a deep learning algorithm that combines object detection and semantic segmentation techniques. It is an extension of the Faster R-CNN algorithm that can generate pixel-level masks for each object detected in an image. This makes it particularly useful for detecting and segmenting objects with irregular shapes, such as potholes.

The Pothole Detection and Area Estimation System utilizes Mask R-CNN to identify potholes in road images or videos. The algorithm first detects the potholes in the image and then generates a pixel-level mask for each pothole. The system can also estimate the area of each pothole based on the size of the corresponding mask.

Once the potholes are detected and their size estimated, the Pothole Detection and Area Estimation System can provide valuable information to road maintenance authorities. They can use this information to prioritize the repair of potholes based on their size and location and to plan road maintenance activities more effectively.

Overall, the Pothole Detection and Area Estimation System using Mask R-CNN is an innovative and effective solution for identifying and estimating the size of potholes on roads. It has the potential to significantly improve road safety and reduce the cost and time required for road maintenance activities.

II. OBJECTIVES

The main objective of this research is to develop an automated system for pothole detection and area estimation using Mask R-CNN, a deep learning-based algorithm. The system will be designed to capture images of roads using an Android application and process them to identify the presence of potholes. It will also estimate the area of the potholes and differentiate between dry and wet potholes. The proposed system aims to address the issues of road safety and maintenance by providing a reliable and accurate method for detecting potholes, allowing for timely repair and maintenance. The system's ability to estimate the area of potholes will also help authorities to plan the required materials and resources for repair. The development of this system will contribute to improving road safety, reducing the cost of vehicle maintenance, and minimizing the damage caused by potholes..

III. CONTRIBUTION

The primary contribution of this research is the development of an automated system for pothole detection and area estimation using Mask R-CNN. The system can differentiate between dry and wet potholes accurately in real time through deep learning-based algorithms. Additionally, image processing techniques have been employed to provide accurate estimates of pothole size and area.

Another contribution is the creation of an Android application that allows users to capture pothole images, which the system automatically analyzes. The system checks for redundancy and sends essential information, such as the estimated size and area of the pothole, to the relevant authorities for timely repair and maintenance.

The proposed system's contribution is significant as it provides an efficient and reliable method for detecting and estimating potholes' size, enabling timely repair and maintenance. The system's accuracy and real-time capabilities will help reduce the risk of accidents caused by potholes, improving road safety and minimizing vehicle maintenance costs. Furthermore, the system's automatic reporting feature will provide authorities with precise data on the state of the roads, facilitating efficient and effective maintenance planning.

IV. MOTIVATION

The motivation behind creating the Pothole Detection and Area Estimation System using Mask R-CNN is to address the serious issue of road safety and maintenance caused by potholes. Potholes are a common problem on roads that pose a significant threat to the safety of drivers, passengers, and pedestrians, as well as cause damage to vehicles and property. Moreover, recent data indicate an increase in road accidents caused by potholes. Therefore, there is an urgent need for a reliable and efficient method to detect and repair potholes. An automated system that uses Mask R-CNN for pothole detection and area estimation can be a potential solution to this problem. It would enable authorities to quickly and accurately identify potholes, facilitate timely repair and maintenance, and reduce the risk of accidents. Additionally, the proposed system can help in estimating the area of potholes, providing a clear understanding of the necessary materials and resources required for repair. The development of this system could significantly contribute to improving road safety, reducing the cost of vehicle maintenance, and minimizing the damage caused by potholes.

V. LITERATURE REVIEW

According to a research paper by X. Yu and E. Salari[1], a laser imaging method was used for pavement pothole detection and severity measurement. The system involves using a light source to project a pattern of laser beams onto a pothole, and a camera to capture the images. Image processing techniques such as laser line deformation and template matching are used to identify potholes, and a neural network is used to determine the type of crack. The disadvantage of this method is that it requires expensive hardware, making it inaccessible to many vehicle drivers.

Another study by S. Silvester and D. Komandur[2] proposed a deep learning approach to detect potholes in real-time using a smartphone. The system used the Single Shot Multibox Detector (SSD) algorithm for deep learning and validated the results against sensor readings to reduce false positives. However, this system does not quantify the characteristics of potholes like their area and shape.

Lokeshwor Huidrom and Lalit Kumar Das[3] proposed a system that uses image processing algorithms to detect road distresses like potholes, patches, and cracks. The system is based on predefined threshold values of standard deviation and circularity of the object. However, the drawback of this system is that the same thresholds cannot be used for different types of road distresses as they do not have a fixed shape or size.

SungWon Lee et al.[4] proposed a system that detects potholes based on discolorations in the image using an image processing technique that involves a wavelet energy field to show textures. The system checks individual cells for the presence of potholes, but the drawback is that discolorations on the road may not always indicate potholes as they can also be caused by other factors like wet roads, road markings, and zebra crossings

Nhat-Duc Hoang [5] developed a pothole detection system that uses Least Square Support Vector Machine (LS-SVM), a machine learning algorithm. The training dataset only includes 200 images, which restricts the model's ability to predict various types of potholes. Additionally, LS-SVM systems typically require longer training times compared to other algorithms.

VI. METHODOLOGY

DATA CREATION

To train the model, a unique dataset was compiled, comprising around 1283 pictures that display various potholes found on Indian roads. These images depict a range of pothole shapes and sizes, including dry and waterlogged potholes. Images were collected from Google Images, an extensive image search engine. Fig. 1 shows some potholes in the dataset. An open-source tool called "Make Sense" is used for annotating the images according to the Mask-RCNN standards. To train the model, 1128 images were used and 140 images were used for testing.

Fig -1: Images from Dataset

SYSTEM WORKFLOW

The proposed system involves two stages, pothole detection, and dimension estimation. The system uses a camera to capture images which are then processed by a deep-learning model to obtain bounding boxes. These bounding boxes are then passed onto the dimension estimation module. This module leverages the elevation of the camera from the ground to estimate the dimensions of each bounding box. The system is visualized as a block diagram in Fig. 2.

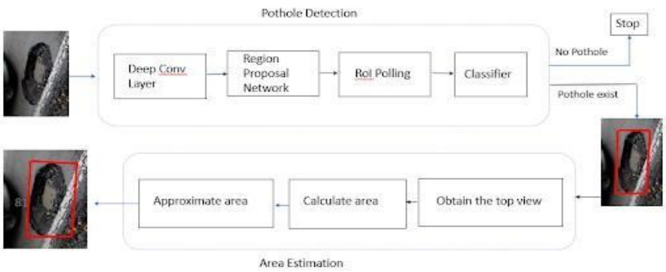

Fig -2: Block Diagram

POTHOLE DETECTION MODULE

MRCNN is a powerful model that can perform object detection and segmentation simultaneously, making it useful for large-scale applications such as autonomous driving, robotics, and medical imaging. The pothole detection stage of the proposed system uses the Mask R-CNN[6] object detection architecture. Mask R-CNN extends Faster R-CNN. The Mask R-CNN algorithm can accommodate multiple classes and overlapping objects. It is a well-known and widely used object detection method that incorporates convolutional neural networks. Mask RCNN is similar to other popular object detection methods, such as YOLO and SsSD. Fig. 3 shows the detected pothole.

The detection module utilizes a deep convolutional layer to identify patterns in the provided image. The region proposal network (RPN) generates a set of region proposals by analyzing the feature maps, which are then considered candidate object bounding boxes. By predicting the probability of a proposal being an object and refining its offsets, the RPN enhances the precision of the proposals. To align the extracted features with the region proposals, the RoI Pooling layer is employed. The RoI Pooling layer splits the proposal into a fixed-size grid, pools the features in each grid cell, and creates a fixed-size feature map for each proposal. This feature map is then forwarded to the classifier, which is a fully connected neural network responsible for predicting the object class and bounding box offset for each proposal. The classifier is typically a two-branch network that simultaneously predicts the class scores and the bounding box offsets. The class scores determine the object class of the proposal, while the bounding box offsets refine its location.

DIMENSION ESTIMATION MODULE

The proposed system's dimension estimation module uses image processing to determine the dimensions of the identified potholes.

$$F = (P * D) / W \qquad (1)$$

The above formula describes the relationship between the focal length (F), pixel length (P), camera distance (D), and image width (W). To maintain this relationship, it's important to note that the pixel length depends on the pixel density, which is measured in PPI (pixels per inch). An object will appear larger in an image with a higher PPI than in an image with a lower PPI, even when both images are taken from the same distance. Therefore, it's recommended to apply preprocessing to fix the PPI of the input image for consistency. However, in the proposed set-up where the same camera is used for calibration and testing, PPI conversion is unnecessary.

The perceived focal length is then calculated using the Eq.(1) for each image and its respective parameters. The final perceived focal length is obtained by taking the average of these values. During the pothole detection stage, the bounding box coordinates are obtained, from which the pixel length and width are determined. Using the fixed camera distance of 90cm and the previously calculated perceived focal length, the actual length of the pothole is determined using the Eq.(1).

Given the bounding boxes generated by the Mask R-CNN model, you can extract the coordinates of the top-left and bottom-right corners of each box. These coordinates can be represented as (x1, y1) and (x2, y2), respectively, where (x1, y1) is the top-left corner and (x2, y2) is the bottom-right corner. To calculate the length and width of each bounding box: as in Eq.(2) and

$$\text{Length} = y2 - y1 \qquad (2)$$

$$\text{Width} = x2 - x1 \qquad (3)$$

Finally, you can use the formula for the area of a rectangle to calculate the area of each pothole: as in Eq.(4)

$$\text{Area} = \text{Length} * \text{Width} \qquad (4)$$

The resulting area will be in square units, such as square pixels or square meters, depending on the units used for the coordinates of the bounding box.

VII. RESULT

The model is trained on the custom dataset for multiple iterations and the mAP value are recorded. The mAP metric is a combined metric that takes into account both precision as well as recall. In the training process, we employed the Mask-RCNN model from TensorFlow. The iterations consisted of a total of 100 steps over 10 epochs. During training, the maximum and minimum loss values observed were 1.17 and 1.03, respectively. Here, we have used, ResNet 101 model. We have achieved a mean average precision (mAP@50) as 0.48.

Fig -3: Detected Pothole

Fig -4: Detected Pothole with area

VIII. CONCLUSION

A proposed system aims to accurately detect potholes in real-time, reducing the reliance on human workers for road maintenance. The system utilizes an efficient model and is trained on a dataset that includes pothole images captured under varying conditions, such as lighting, road conditions, weather, and pothole shapes and sizes. The objective of the system is to estimate pothole dimensions with high accuracy and low error rate. The area estimation model requires images of potholes captured from a specific distance, ideally 90 cm, to produce accurate results. The generated reports of potholes will assist authorities in taking appropriate action to maintain road conditions.

REFERENCES

[1] X. Yu and E. Salari. Pavement pothole detection and severity measurement using laser imaging. In 2011 IEEE INTERNATIONAL CONFERENCE ON ELECTRO/INFORMATION TECHNOLOGY, pages 1–5, 2011.

[2] S. Silvister, D. Komandur, S. Kokate, A. Khochare, U. More, V. Musale, and A. Joshi. Deep learning approach to detect potholes in real-time using a smartphone. In 2019 IEEE Pune Section International Conference (PuneCon), pages 1–4, 2019.

[3] Lokeshwor Huidrom, Lalit Kumar Das and S.K. Sud, "Method for automated assessment of potholes, cracks, and patches from road surface video clips," Conference of Transportation Research Group of India (CTRG), 2013, pp. 312-321, doi:10.1016/j.sbspro.2013.11.124, Elsevier.

[4] SungWon Lee, SeokJin Kim, Kwang Eun An, Seung-Ki Ryu, and Dongmahn Seo, "Image Processing-based Pothole Detecting System for Driving Environment," International Conference on Consumer Electronics (ICCE), 2018, pp. 1-2, doi:10.1109/ICCE.2018.8326141, IEEE.

[5] Nhat-Duc Hoang, "An Artificial Intelligence Method for Asphalt Pavement Pothole Detection Using Least Squares Support Vector Machine and Neural Network with Steerable Filter-Based Feature Extraction," Advances in Civil Engineering, vol. 2018, 2018, pp.
1-12, doi:10.1155/2018/7419058, Hindawi.

[6] Kaiming He, Georgia Gkioxari, Piotr Dollar, Ross Girshick," Mask R-CNN"

[7] Pranjal A. Chitale, Hrishikesh R. Shenai, Jay P. Gala, Kaustubh Y. Kekre, Ruhina Karani, "Pothole Detection and Dimension Estimation System using Deep Learning (YOLO) and Image Processing"