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Road Damage Detection Using Image Processing

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ABSTRACT: Road accident detection and avoidance are a more difficult and challenging problem in India as poor quality of construction materials get used in road drainage system construction. Due to the above problems, roads get damaged early and potholes appear on the roads which cause accidents. According to a report submitted by the Ministry of Road Transport and Highways transport research wing New Delhi, approximately 4,64,910 accidents happen per year in India. This paper proposed a deep learning-based model that can detect potholes early using images which can reduce the chances of an accident. This model is basically based on Transfer Learning, Faster Region-based Convolutional Neural Network (F-RCNN) and Inception-V2. There are many models for pothole detection that uses the accelerometer (without using images) with machine learning techniques, but a less number of pothole detection models can be found which uses only machine learning techniques to detect potholes. The results of this work have shown that our proposed model outperforms other existing techniques of potholes detection

I. INRODUCTION

Road damage detection is essential for maintaining safe and efficient transportation. Traditional inspection methods are time-consuming and costly, making automated detection a valuable solution. Using Python and image processing, we can analyze road images to detect cracks, potholes, and other damage quickly and accurately. This project aims to develop a simple and efficient method for detecting road damage through image analysis, which can improve road maintenance and safety.

II. LITERATURE SURVEY

Lin, J., & Liu (2010) There are much more researches on the recognition of the cracks on the distress pavement, but the research on the potholes is relatively less. In this paper, Texture measure based on the histogram is extracted as the features of the image region, and the non-linear support vector machine is built up to identify whether a target region is a pothole. Based on this, an algorithm for recognizing the potholes of the pavement is proposed. The experimental results show that the algorithm can achieve a high recognition rate.

Pereira (2018) This research proposes a low-cost solution for detecting road potholes image by using convolutional neural network (CNN). Our model is trained entirely on the image which collected from several different places and has variation such as in wet, dry and shady conditions. The experiment using the 500 testing images showed that our model can achieve (99.80 %) of Accuracy, Precision (100%), Recall (99.60%), and F-Measure (99.60%) simultaneously

M. Aly(2018) We present a robust and real time approach to lane marker detection in urban streets. It is based on generating a top view of the road, filtering using selective oriented Gaussian filters, using RANSAC line fitting to give initial guesses to a new and fast RANSAC algorithm for fitting Bezier Splines, which is then followed by a post-processing step. Our algorithm can detect all lanes in still images of the street in various conditions, while operating at a rate of 50 Hz and achieving comparable results to previous techniques.

S. Nienaber (2018) Potholes are a nuisance, especially in the developing world, and can often result in vehicle damage or physical harm to the vehicle occupants. Drivers can be warned to take evasive action if potholes are detected in real-time. Moreover, their location can be logged and shared to aid other drivers and road maintenance agencies. This paper proposes a vehicle-based computer vision approach to identify potholes using a window-mounted camera. Existing literature on pothole detection uses either theoretically constructed pothole models or footage taken from advantageous

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vantage points at low speed, rather than footage taken from within a vehicle at speed. A distinguishing feature of the work presented in this paper is that a thorough exercise was performed to create an image library of actual and representative potholes under different conditions, and results are obtained using a part of this library. A model of potholes is constructed using the image library, which is used in an algorithmic approach that combines a road colour model with simple image processing techniques such as a Canny filter and contour detection. Using this approach, it was possible to detect potholes with a precision of 81.8% and recall of 74.4. %.

S. Nienaber (2015) Consider a single camera mounted on the inside of a vehicle's windscreen used for detecting potholes and other obstacles on the road surface. This paper outlines three approaches to the depth estimation problem of determining the distance to these obstacles in the range of 5 m to 30 m. We provide an empirical evaluation of the accuracy of these approaches under various conditions, and make recommendations for when each approach is most suitable. The approaches are based on the pinhole camera model: the simplest approach is based on the geometry of similar triangles, another employs the cross-ratio of a set of collinear points, and the final approach relies on calibration of the camera matrix. We recommend the use of the cross ratio approach for a fixed camera setup and depth estimation almost directly ahead, and an approach using similar triangles when predicting distances at wide angles or adjusting the camera height may be necessary

III. METHODOLOGY

1.Image Acquisition
- Capture road images using cameras or drones
- Image types: RGB, grayscale, or infrared images

2. Image Preprocessing
-Enhance image quality, remove noise, and resize images

3. Edge Detection
-Identify edges and boundaries of damage using algorithms like Lanny or Sobel

4. Feature Extraction
-Extract characteristics like shape, color, and texture from detected damage

5. Classification
-Classify damage into types like cracks, potholes, or fading using machine learning
6. Post-processing-Refine results, remove false positives, and improve accuracy

Disadvantages Of Existing System:
- It does not execute very well when the data set has more sound i.e. target classes are overlapping. It doesn’t perform well when we have large data set because the required training time is higher.
- The duration of the network is unknown.
- Unexplained functioning.

Proposed System
The proposed modern based pothole detection method using the transfer learning technique detects potholes in images in real-time. The method uses common techniques like “use of F-RCNN”, “inception v2 model” which are described below. After pre-processing the data, we created a system for the detection of potholes in images so that the driver can get an early alert about the pothole on the road. The main advantage of this method is small training time with an easy training process and higher accuracy

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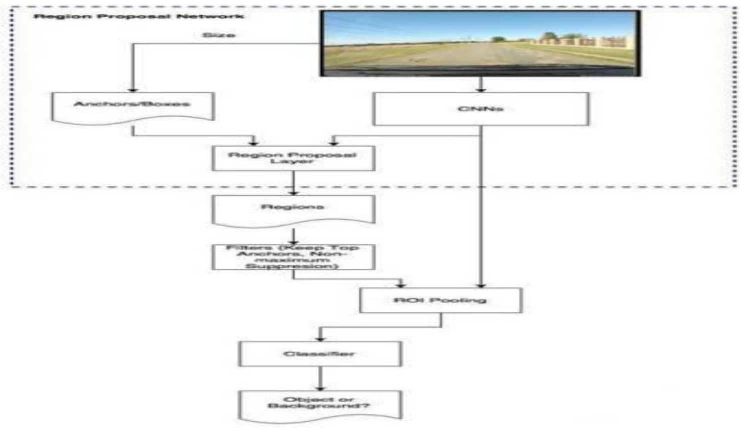
System Architecture:



Explanation:

This image depicts a flowchart of a Region-Based Convolutional Neural Network (R-CNN) or a similar object detection framework, focusing on the process of identifying objects, possibly road damage in this case. Here’s a breakdown of the key steps:

1. Region Proposal Network (Rpn)

Input Image: A road image is given as input.

Anchors/Boxes: The RPN generates multiple anchor boxes over the image, which are potential object regions.

Region Proposal Layer: It filters these anchor boxes to keep only the most likely ones by applying techniques like Non-Maximum Suppression (NMS).

2. Cnn Feature Extraction

The image is passed through a Convolutional Neural Network (CNN) to extract features, which represent different patterns in the image (e.g., cracks, potholes).

3. Regions

The regions proposed by the RPN are filtered and refined to eliminate overlapping and irrelevant regions.

4. Roi Pooling

The Regions of Interest (ROIs) are pooled into a fixed size so they can be processed by the next layers regardless of their original size.

5. Classifier

A classifier determines whether each region is an object (like road damage) or part of the background.

6. Object Or Background?

Based on the classification, the final decision is made about whether the region contains an object or is just background. This process is common in road damage detection systems, where the model identifies and classifies different types of road surface defects using a combination of RPN and CNN.

Modules:

1. Image Processing Modules

-OpenCV (cv2): Provides a wide range of image processing functions like filtering, edge detection, contour detection, etc.

-Pillow (PIL): Useful for basic image manipulation like resizing and format conversion.

2. Scientific Computing & Data Handling Modules

-NumPy: For numerical operations and handling image arrays.

-Pandas: Useful for handling tabular data like damage reports.

3. Machine Learning Modules

-scikit-learn: For traditional ML models like SVM, Random Forest, KNN

-XGBoost: For gradient boosting models

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IV. IMPLEMENTATION

1.Tensor Flow Object-Detection API
Tensor flow's object detection API is a very powerful tool that can quickly enable anyone to build and deploy a powerful image recognition system. It provides many pre-trained models (trained on different datasets) which can be used to build customized classifiers/detector/recognizer after finetuning. We've selected the model named "F-RCNN inception v2".

2. Transfer Learning
Transfer Learning makes use of knowledge gained while solving one problem and apply it to a different but related problem. With this technique, we can save a lot of time. In this technique below first, we select any pre-trained model (In which all the parameters are trained), then we perform finetuning. We fetch the new dataset to fine-tune the pre-trained CNN. If the new dataset is similar to the original dataset (with which the model has been trained), the same weights can be used for extracting the features from the new dataset. In our case, the dataset is very different from the original dataset. The Earlier layers of CNN contain more generic features (edge detector, colour blob detectors), but the later layers of CNN become progressively more specific to the details of the classes contained in the original dataset. So, earlier layers can help to extract the features of the new data. We fixed the earlier layers and Re-train the rest of the layers (because of the small amount of data).

3. F-RCNN (Faster Region-Based Convolutional Neural Network)
It stands for Faster Region-based Convolutional Neural Network. Before talking about Faster RCNN we should know about Fast R-CNN. Fast RCNN is a detector that uses an external proposal or external selective search. It consists of External selective search, CNN with max pooling, ROI (Region of Interest) pooling layer, fully connected layers, and output layers. Fast R-CNN takes an input image and then with the help of CNN & maxpooling layers, a convolutional feature map is extracted from the image. The ROI pooling layer performs a very important task here. We know that fully connected layers can accept only certain sizes, So ROI pooling layers converts the output of the CNN into certain fixed sizes. When we put Fast RCNN with the RPN (Region proposal network), it becomes Faster R-CNN. So, basically, the difference between Fast R-CNN and Faster R-CNN is the Region proposal. In Fast R-CNN, there is an external selective search whereas in Faster R-CNN RPN is combined with the Architecture. RPN is the Architecture that makes Fast R-CNN a Faster R-CNN. In order to reduce the computational complexity and requirement, RPN decides where to look in the image. It scans the image and gives k output boxes each with 2 scores indicating the probability of availability of an object. Different size and different aspect ratio of boxes are selected in order to accommodate different types of objects.

V. EXPERIMENTAL RESULTS

Home Page

Explaination: We have the option to select the image we have to detect the pathholes.

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Final Result Detection Page

Explaination: After selecting the image, we click the 'Submit' button to detect and highlight the potholes.".

VI. CONCLUSION

Road damage detection using image processing in Python is a reliable and efficient method for identifying and classifying road damages such as cracks, potholes, and fading. By utilizing basic techniques like thresholding, image filtering, and color space conversion, and advanced techniques like feature extraction, classification, texture analysis, and morphological operations, we can automate the process of road damage detection.

This approach can help transportation authorities and maintenance teams to prioritize repairs, reduce maintenance costs, and enhance public safety. With the help of Python libraries like OpenCV, Scikit-image, and Scikit-learn, we can develop a robust and accurate road damage detection system that can be integrated into existing road maintenance management systems.

VII. FUTURE ENHANCEMENT

Our system successfully detects pothole in images/images but there are some works yet to be done.Those are our future works regarding pothole detection. We'll try another good CNN architectures like the latest versions of inception (inception v3 and inception ResNet) for improving the speed and accuracy. Additionally, a GPS system has to be created for updating the location of potholes on the map for all users. In near future, we'll create a GPS enabled system and an android app (with GPS and google map enabled) with which we will update the location of the pothole to the map when a user finds it on the road so that other users get the location of potholes earlier without any detection. We also have to deploy our system to raspberry pi or Android so that common people can use that.

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