Road Crack Detection And Segmentation For Autonomous Driving

A) Problem Statement

Definition:

In the existing world, all the geographical areas, continents, countries states, cities and villages etc. are connected by several means of transportation such as air, trains, metros and roads. The road transportation is one of the busiest and cheapest way to connect one source point to its destination point. Failure of the road or surface due to traffic loading causes Crack. A heavy snow fall, poor drainage and movement of heavy weighted vehicles etc, are the frequent cause of the degradation of the road surfaces and possible causes of cracks in roads.

Crack detection is the process of detecting the crack in the structures using any of the processing techniques. By incorporating the visual examination and surveying tools, surface condition deficiencies are evaluated [Lee,2012]. Instead of having a manual inspection, it's better to do automatic detection of cracks in the roads.

Challenges:

1. low level image processing techniques are not immune to the contrast change and cannot detect cracks when illumination is low, or cracks are rapidly varying objects.
2. a very few algorithms are available for detection of cracks in the images or videos of roads
3. Currently this project will deal with the captured videos of roads or surfaces. But if this project wants to use this crack detection in real-time for Autonomous Driving, it will have to create a mobile application, or it will need a Hardware device.
4. **Small size datasets:** If this project will not be able to find an enough large dataset for crack detection then this project will need to create its own dataset of images of roads or surfaces.

Scope:

Road Crack Detection has its immense utilization in many areas which are related to find the variations in normal patterns of roads and surfaces, so that appropriate actions in against can take place on time. Following are some of the important areas where road crack detection can be utilized:

1. Road Inspection
2. Status of roads in Unfavourable weather conditions
3. To estimate the amount of damage of roads when natural calamities occurs such as earthquake, Tsunami.
4. Length, width and direction of the cracks on the roads
5. Crack detection for Autonomous Driving Cars
6. Lane Detection, Traffic Light Pole Detection, Buildings, number of Adjacent moving cars and distance between adjacent moving vehicles etc. for Autonomous Driving Cars

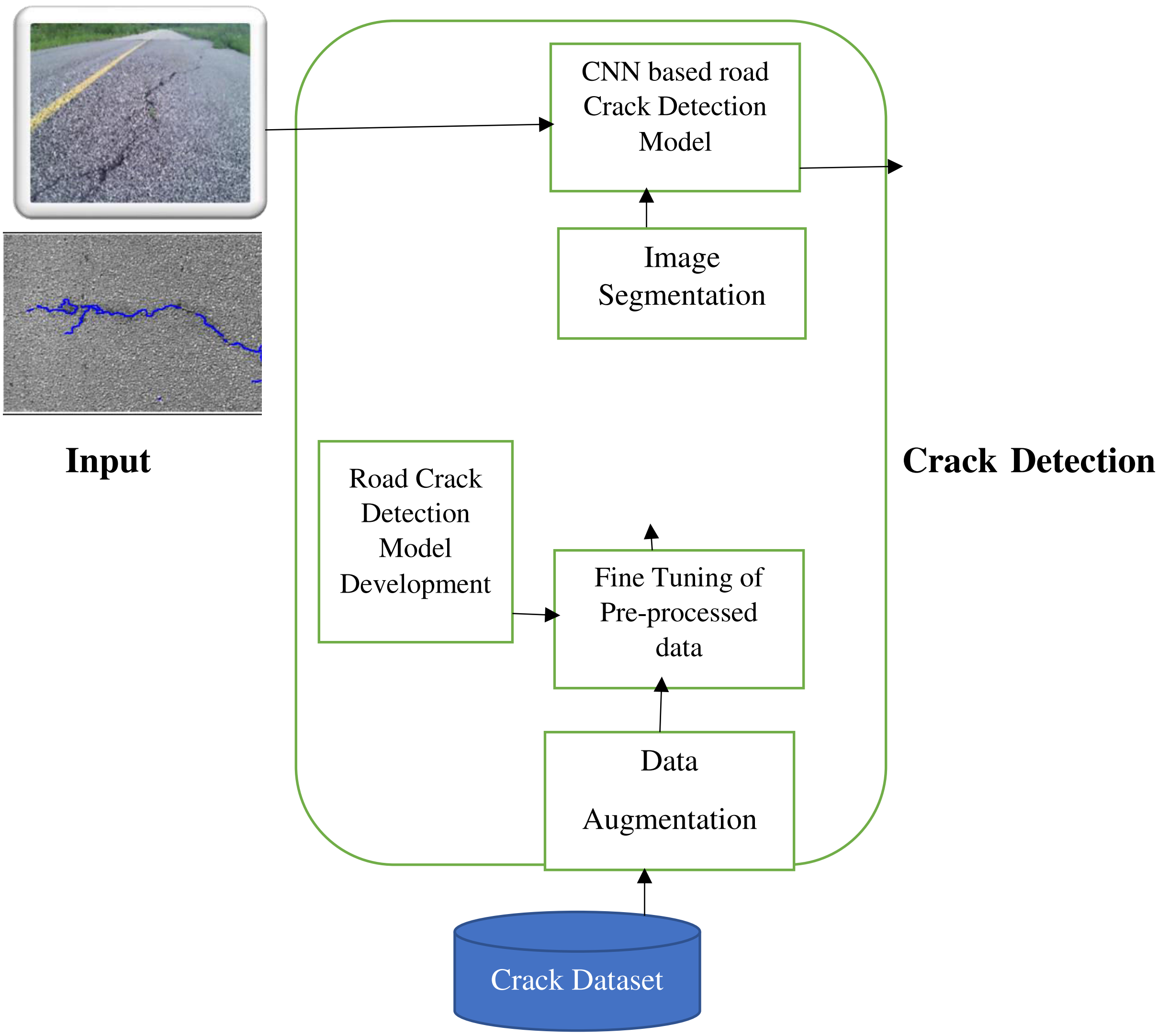
B) Background

Road Crack detection has emerged from a widely researched area of Crack Detection. Previously, several methodologies or approaches have been proposed for detection of cracks such as, an automatic crack detection based on the tree structure, also referred as CrackTree has been introduced [Balcones, 2011]. A local binary pattern-based algorithm(LBP) for pavement crack detection has been developed [Zhao,2010], whereas one more crack detection method has been proposed based on Gabor Filter [Salman,2013]. A comprehensive set of image processing algorithms for detection and characterization of road pavement surface crack distresses have been introduced in [Correia,2014].

the impressive performances for several medical imaging and computer vision tasks have been showcased the activeness of deep features learned by deep neural networks [LeCun,2015] which can be used to replace the conventional hand-crafted features [Hinton, 2012]. Restricted Boltzmann machine (RBM), autoencoder and their variants are popular for unsupervised deep learning when the number of labelled examples is small, while deep convolutional neural networks (ConvNets) are popular for feature learning and supervised classification [Zhang,2016].

C) Methodology

The architecture diagram for Road Crack Detection and Segmentation for Autonomous Driving is shown in Figure 1.



Imagery Pre-processing

Figure 1: Architecture Diagram for Road Crack Detection & Segmentation for Autonomous Driving Cars

The above architecture diagram consists of 6 stages for crack detection ang segmentation for autonomous driving which are listed below:

- **Data Collection:** First images will be collected from open source datasets of images to train Convolutional Neural Network (CNN). These image datasets consist of several types of images such as Camera Images, IR Images, Ultrasonic Images, Laser Images etc.
- **Data Augmentation:** To achieve good performance results**,** for each sample image, patch will be generated by using some sampling strategies such as rotation by a random angle in between 0o to 360o, low level of overlap between two positive patches etc [10]. In the labelling process of images, an image with crack will indicate a True (1) and similarly an image without crack will indicate a False (0).
- **Fine Tuning:** The existing databases are not big enough to train a CNN model from scratch. So, this project will fine-tune the previously trained models such as ResNet-50, ResNet-101, VGG-16, PlaceNet or ImageNet via the transfer learning.
- **Feature Map Generation:** These fine-tuned models will generate a feature map which will be pooled using a soft-max layer of convolutional neural network to generate the classification results.
- **Classification:** This project will use supervised learning-based classification technique to classify the images into two categories as images with Crack and images without Crack. To apply proposed method on the real-time videos of Autonomous Self Driving Cars to identify the cracks on road for testing phase, with this view, this project will use ffmpeg to extract frame from the videos.
- **Crack Segmentation:** Afterwards, using available image segmentation techniques, we will try to segment the image into regions and will find the region which has crack. The current image segmentation techniques include region-based segmentation, edge detection segmentation, segmentation based on clustering, segmentation based on weakly-supervised learning in Convolutional neural network, compression-based methods and histogram-based methods etc.

D) Experimental Design

Datasets:

The solution depends on the datasets obtained from different data sources listed below:

1. Concrete Crack Images for Classification (https://data.mendeley.com/datasets/5y9wdsg2zt/1)
2. Crack Forest Dataset (https://github.com/cuilimeng/CrackForest-dataset)
3. German Asphalt Pavement Distress Dataset (GAPs) (https://www.tu-ilmenau.de/en/neurob/data-sets-code/gaps/)
4. CFD and AigleRN dataset (http://telerobot.cs.tamu.edu/bridge/Datasets.html)

Evaluation Measures:

Measures such as Accuracy, Cross Validation Accuracy with varying number of epochs and batch size in the trained model, Dropout, Data augmentation etc. will be computed by comparing the detected crack images and the ground truth images of roads from the datasets.

Software and Hardware Requirements:

Python based Computer Vision and Deep Learning libraries will be exploited for the development and experimentation of the project. Tools such as Anaconda Python, and libraries such as OpenCV, Tensorflow, and Keras will be utilized for this process. Training will be conducted on NVIDIA GPUs for training the end-to-end version of CNN based crack detection model.