Concrete Surface Crack Detection with Convolutional Neural Network

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Abstract- This paper presents utilizing machine learning to detecting cracks on concrete surfaces. The purpose of this system is to help detect the cracks in concrete infrastructure, specifically in places like bridges and tunnels, where there are fewer human workers. Using deep learning algorithms, we were able to create a robust crack and occlusion detector that can look at images of different resolutions and photos taken under different light conditions. To determine the best outcome in each experiment, the model's accuracy was noted. The most effective experiment for the dataset utilized in this study produced a model with accuracy of 98.12%, demonstrating the promise of deep learning for concrete crack identification. The developed CNN is trained on images at a resolution of 227x227 pixels and, as a result, records with an accuracy of roughly 98%.

Indexed Terms- Concrete surface crack detection, crack detection, deep learning, Image Processing, Convolutional Neural Network, CNN

I. INTRODUCTION

Cracks in concrete can affect the surface in a number of ways. For example, they can cause the surface to become rough or uneven, which can make it difficult to walk on or use for certain purposes. Cracks can also allow water to seep into the concrete, which can lead to further damage over time. Additionally, if the cracks are large enough, they can cause the concrete to become structurally unsound, which can be a safety hazard. Concrete is a very durable material, but it is not immune to cracking. There are many factors that can cause concrete to crack, such as excessive loads, changes in temperature, and ground movement. When concrete cracks, it can affect the surface in a number of ways. For example, if the cracks are small, they may only cause the surface to become rough or uneven, which can make it difficult to walk on or use for certain purposes. However, if the cracks are larger, they can allow water to seep into the concrete, which can cause further damage over time. Concrete buildings frequently develop cracks due to corrosion, chemical deterioration, and applying unfavorable loads. As cracks grow larger, greater risks come along with them. The quality of our concrete structure is a direct reflection of its structural integrity. Monitoring cracks in a concrete surface is important because it can help identify potential problems early on, before they become more serious. If cracks are detected early, they can often be repaired before they cause further damage to the concrete. Monitoring cracks in concrete can also help prevent safety hazards, as large cracks can cause the concrete to become structurally unsound. Additionally, monitoring cracks in concrete can help identify the underlying cause of the cracking, which can be important for preventing future cracking. Monitoring those cracks is one way that engineers can assess the risk to these structures and help ensure they're structurally sound. Visual inspections are not an effective means of crack detection. This form of an inspection is time-consuming, labor-intensive, subjective - and it may not detect cracks as they form near the unfixable area. And even if contemporary techniques can hasten that process by eliminating manual procedures and substituting automated ones such as deep learning or computer vision techniques, there are still challenges remaining in this area that need to be addressed for the full benefits to take place. Further research into how effective these new methods may be is needed for us to understand where automated crack detection using images can bring value. There have been researches done before but none of them uses CNN to detects cracks and even if they used CNN they did not got a very high accuracy.[1][2]

II. LITERATURE REVIEW

A. Review and Analysis of Crack Detection and Classification Techniques based on Crack Types[20]

Sheerin Sitara. N. , Kavitha. S. , Raghuraman. G. investigated the problem of crack detection and worked on the problem. They used various machine learning algorithms to detect cracks in surfaces. They were able to detect cracks at the accuracy of 82%

III. PROPOSED METHOD

In order to detect cracks in concrete surfaces , the suggested system uses the CNN algorithm because, given the right data, it may offer the maximum level of accuracy.[3]

A particular class of neural network called a convolutional neural network (CNN)[4] is made to cope with data that has a grid-like structure, like an image. They process the data using a mathematical procedure called convolution, hence the term "convolutional".[5] In a convolutional neural network, the neurons in the network are arranged in three-dimensional grids, with each neuron connected to a set of local inputs from a subset of the overall input data.[6] This arrangement allows CNNs to effectively learn spatial hierarchies of features, which makes them well-suited for tasks such as image classification and object detection.[7]

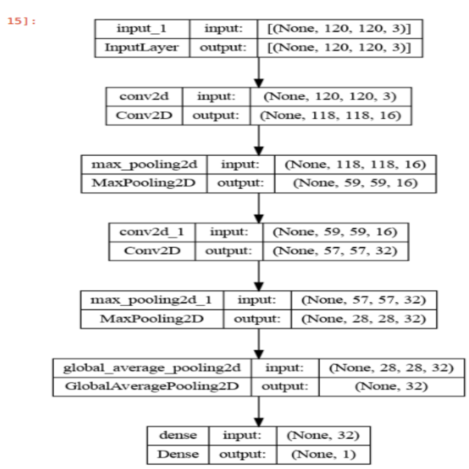

Fig1.CNN Model

A. Dataset

Images of diverse concrete surfaces, both with and without cracks, can be found in the datasets. The picture data are separated into two as negative (without crack) and positive (with crack) in a separate folder for image classification. There are 40000 227 x 227 RGB-channeled images total, with 20,000 photos each class. Using the method suggested by Zhang et al., the dataset is created from 458 high-resolution photos (4032x3024 pixels) (2016). In terms of surface quality and lighting, high resolution photos were found to show significant variation. No random rotation, flipping, tilting, or other form of data augmentation is used.[8]

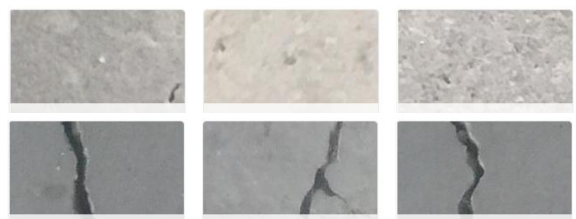

Fig2.Image Dataset

B. Processing

Image augmentation is a necessary component of a strong image classifier. Even while datasets may contain hundreds to thousands of training examples, the variety may not be enough to build a trustworthy model. Resizing the image, rotating it at various angles, and flipping it vertically or horizontally are just a few of the numerous picture enhancing options.[9]

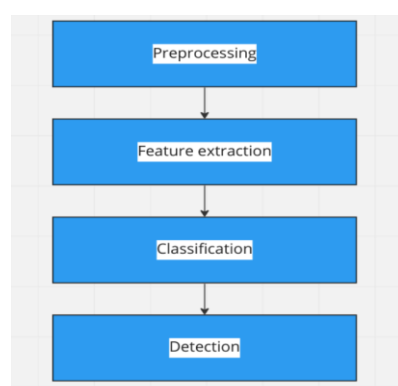

Fig 3. Data Flow Diagram

C. System Overview

Input images will be clicked by the user. Then the images will be uploaded via web applications which will then call the api where the pre-trained model will compute the output to give results at the maximum accuracy[17][18]

IV. EXPERIMENTATION

Each image is first turned into an array. The input file is scaled to the range [0, 1] from [0, 255] (the image's least and most prevalent RGB values).[10]

The dataset was then divided into 20% for testing photos and 80% for training images. Objects that conduct random rotations, motions, inversions, civilizations, and sections of our picture library are formed as image generators.

We have used different convolutional layers to get the output at the utmost accuracy.

We have utilized a 2D convolution layer, which produces a tensor of outputs by winding a convolution kernel with layers of input. Then we have used a Max pooling operation for 2D spatial data. A pooling procedure known as "max pooling" selects the largest element from the feature map area that the filter covers. Therefore, the max-pooling layer's output would be a feature map that featured the standout elements from the previous feature map.[19]

```
Model: "model"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 input_1 (InputLayer)        [(None, 120, 120, 3)]     0

 conv2d (Conv2D)             (None, 118, 118, 16)      448

 max_pooling2d (MaxPooling2D  (None, 59, 59, 16)       0
 )

 conv2d_1 (Conv2D)           (None, 57, 57, 32)        4640

 max_pooling2d_1 (MaxPooling  (None, 28, 28, 32)       0
 2D)

 global_average_pooling2d (G  (None, 32)               0
 lobalAveragePooling2D)

 dense (Dense)               (None, 1)                 33

=================================================================
Total params: 5,121
Trainable params: 5,121
Non-trainable params: 0
```

Fig 4.Model Summary Output

The Primary Step is to add data, train, validate and test data.

We have tried to keep the accuracy to the maximum.

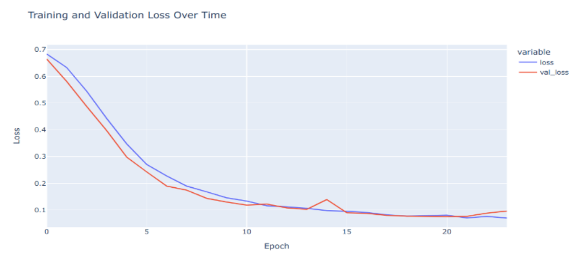

Fig 5.Training and Validation Loss

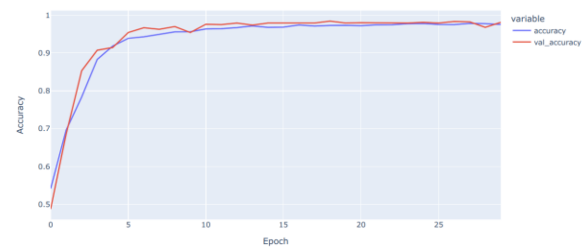

Fig 6. Training and validation accuracy

We have also built a web app to support our model. The backend of our application is made using FastApi and python[12][13][14] and the frontend user interface is made using javascript and ReactJs.[15][16]

V. RESULT AND ANALYSIS

The results above show that CNN performs effectively and can precisely identify Concrete surface cracks despite the fact that we lacked a huge dataset and access to powerful processors. We were able to predict the cracks in the images with an accuracy of 98.12% .

It has been repeatedly demonstrated via various studies and trials on large populations that any form of visual aid, whether an image, a video, or even an animation clip, tends to be more easily recalled by people.

We have created our web application user interface as simple as possible to allow everyone irrespective of age and mindfulness to use the feature.

Our project may easily be integrated with our educational system while encouraging alternatives to the conventional blackboard method of instruction because all we need to use the application is a website on the internet.

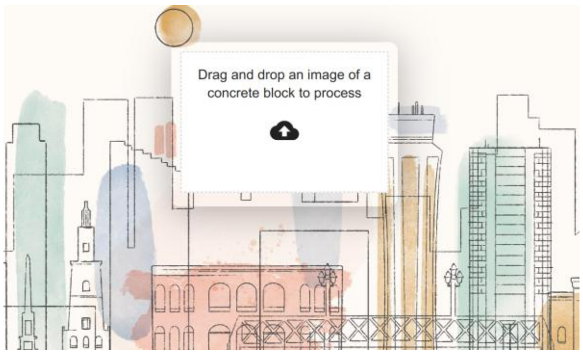

Fig 7. Web app home page

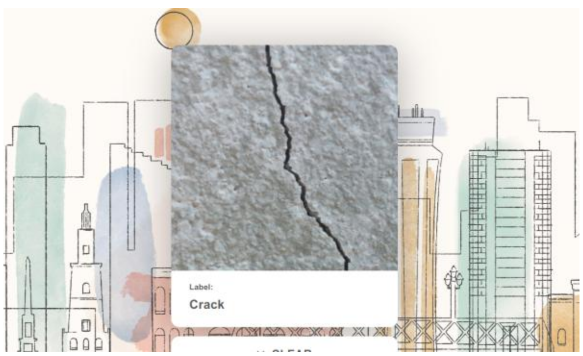

Fig 8. Web App detects cracks

Fig 9.Web App Preview

CONCLUSION

Concrete constructions frequently develop cracks as a result of corrosion, chemical deterioration, and the application of unfavorable loading. Our method uses photos of Cracked and non cracked concrete surfaces using a specific deep learning model built on a particular architectural convolution network.

Our method uses photos of Cracked and non cracked concrete surfaces using a specific deep learning model built on a particular architectural convolution network. The trained model is supplemented with the technologically advanced web application which allows crack detection in a user friendly way. The web application is built in a way that everyone irrespective of their age can use the system.

FUTURE WORK

We want to add a lot more features. The Web Application only has a few features at the moment. We will be including several Cracked surfaces Dataset Variations of CNN, and collecting more data can be used in the future to attain greater accuracy.

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