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Robust Automatic Railway Track Crack Detection using Unsupervised Multi-Scale CNN

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Abstract: *The identification of faults or cracks in rail tracks is critical in railway management, as it helps to avoid train accidents during summer and rainy times. During summer due to the heat cracks are formed in the tracks, which eventually leads to the slipping of the train wheel affects rail tracks even in rainy environments, causing cracks. In the current system cracks are detected by using vibrations which takes longer. In this proposed method, we show how CNN is used to identify cracks on railway track surfaces and obtain their corresponding masks, which can then be used to extract other inspection-relevant properties. By using machine learning for crack detection, we minimize time spent performing this job, decreasing costs, and increasing employee protection, such a method can help remove the disadvantages of manual inspection. We get a dataset from open-source contributors such as Kaggle or use web-crawlers on copyright free site to get our dataset and train on them.*

Keywords: Computer Vision, Data Labelling, TensorFlow Deep Learning Algorithm.

I. INTRODUCTION

By using a defect inspector to improve inspection by taking into account specific track characteristics such as gaps and no gaps (0 or 1). The premises of this paper is around the concept of a convolutional neural network and building a model which is capable of identifying if cracks are pre-sent on the tracks or not. The data is managed by OpenCV module in python. For the ease of training the data is split into test, validation and training dataset. The images are later resized and the colours are changed to black and white, since we have abundant of images to train to the machine, we process the images in batches, and is sent to the hidden layers which is used in training the data. Since the release of TensorFlow 2.0 the images can be optimized easily and we can get results much faster than what we used to have. We can use latest more improvised algorithms such as ResNets can be added to a convolutional neural network to get a more accurate predictions of the railway crack track detection, this has units for our need of having complex systems and modules such as physical hardware and make it completely cost-effective and have easy to use modules. In this paper we use a combination of ideas which helps in making a better and faster method of detecting cracks on the railway tracks one such method is called Otsu segmentation method which helps in optimizing our images by extracting all the unnecessary details and color correction one of its major part which helps in building a better convolutional neural network. Since noise plays a great role in image processing and computer vision the more the noise the image has the less accurate our neural net becomes so this method helps us in getting an optimized image without any noise data and it also enhances the image. Use the help of open-source railway track images to get a data and train them. The aim of our project is to completely use modern techniques of computer vision and deep learning to produce a more effective solution.

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II. Related Works

2.1 Otsu Segmentation Method

The rail surface is observed by capturing photographs of the rail surface from the railway. The signal is obtained by calculating the mass deference (variance) of the obtained rail surface image. An image acquisition system with LED peripheral illumination and shade device has been developed based on basic concept of machine vision, and a compact experimental model has now been made to handle out the experimental study. This paper uses the method of capturing the data for the project where is the means of using open-source images. They use the method of H value curve which helps in getting the data for the statistical analysis of the railway tracks each value has different views such as the difference between a scanned rock or railway track or even the key links. They also use defect detection system plays upon the railway track the data is later analyzed and goes through pre-processing post processing call image optimization.

2.2 Segmentation

Data compression and invariance are two important functions of this extraction. An over-sampled set of measurements is typically used to extract the feature vector, which contains a carefully chosen set of features. The purpose of the feature selection step is to remove redundancy from the representation. A well-chosen feature vector would contain the majority of the discriminatory information while being significantly smaller in size than the original signal vector. As a result, the classification accuracy improves while the overall computational effort decreases. In this method they use dimensionality reduction techniques to get a better segmentation of the data which is images such as railway tracks rocks, railway links, couplers the method goes as such there are two sides of this dimensional reduction system which is feature selection and feature extraction. In the feature selection we have new methods such as filters wrappers and embedded systems which uses the method of Bayes weighted vector of an SVM and variable threshold and the use of feature extraction as a matter of non-linear and linear which is based on linear discriminant analysis (LDA) and linear PCA.

Predictive Algorithms

Here we use Machine Learning algorithms to create our model, using TensorFlow to create our Hidden Layers along with the Activation Function ReLU (Rectifier) and for the loss function we use Cross-entropy loss function. Here we use rectified linear activation function because when we trained in the images, we need the output to be either positive or zero because we only have two classes, this is also the same reason why we use binary cross entropy method these two methods gel well with each other to give us a better output.

III. Existing System

3.1 BODI

This defect inspector method is used to detect defect during inspection by taking into account specific track characteristics. This uses an image testing stage to get a base layer for training of data without any previous data. This method uses random selections to produce and determine where the current pixel is and a background upgrade mechanism is used to find and extract the necessary data giving us with a better consistency and continuity in the data and helps and helps it in analysing giving us a proper histogram of the data and a well formed manner which can be used in find in the cracks**.**

3.2 Differential Images

The system uses the technique of spectral image differentiation. This method is used to find minor details in the image such as scratches or even cracks. How this happens is that two light sources line scan camera is kept apart from each other. The light sources may be of RG light source. Flat surfaces will reflect the same amount of light, and reported back to the machine if there is no changes or the output is consistent then it means that there is no crack in the railway track if there is any inconsistency then the machine detects and reports it back to the user.

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3.3 Temperature Rise Detection

This method uses a temperature capturing device to get the data of the railway tracks. The data shows the temperature along with the photo to find where most of the erosion has happened. This method uses the process of a heat gun and which is run across the railway tracks and when the heat is continuous and has no difference it does not detect but when there is a difference in heat the heat gun immediately notifies the program and tells them that there is an inconsistency in the data. This is this also helps in tracking the cracks during summer time because during the summer the tracks usually tend to expand which can be easily detected by this machine.

PROPOSED MODEL

3.4 Neural Network Description

We use CNN with hidden layers to build our model

- 64 Hidden Layers (Conv2D Layers)
- Epochs: 100 + 25
- Activation: ReLU / Sigmoid activation
- Loss: Binary Cross-Entropy

We use TensorFlow to define these Neural Networks. Since there are only two possible outcomes (cracked or not cracked), we could even use binary classifier instead of multi-class classification. To give a better sense of how this work a neural network is like our brain and the more we train the neural network the better it gets at detecting what it is. Since there are only two methods of detecting classes, such as cracked or not cracked

We go to a method called as max pooling which is basically to reduce the dimensionality of the image for example if you have 64x64 images we reduce the images to 62x62, since we take four pixels in a square manner and we take measures of the color with respect to each other and take the one which has more value for the pixel data that is which has more significant data on net this uses this helps us in getting a better image for the training of our neural net.

The image we get now is much smaller and more efficient for the training of the neural network. While training our neural network we found a problem known as gradient exploding which basically means that when a neural network works efficiently and goes to the next neuron it has a sudden increase in in the bias which makes our neural network completely different. Hence, we use ResNets to use like a mean of the previous or old data just to make sense of our data.

3.5 Data Collection

A Web-Crawler is used to get the images, we train our model by using transfer learning. Transfer learning is getting the output from other trained models and adding our own layers of models and training them. Some of our datasets are collected from Kaggle. Reducing data size is part of furthering the data throughout the login acquisition process. Various studies have shown that not only are there serious gaps between the size of the network data feature but also high interactions are present between the data for each size. Redistribution and merging between feature sizes not only reduces the response time of the internal access system but also affects the effectiveness of the training process. Therefore, reducing the size of the top data is especially necessary. Reducing the size of the database can not only improve the learning performance of the acquisition program; can also reduce data depletion. A crawler's primary aim is to create an index. Crawlers are therefore the foundation of search engine operation. They search for content on the Internet first, and make the findings accessible to consumers. When indexing, focused crawlers, for example, rely on existing, content-relevant websites. Railway is one of our country's most important modes of transportation so it is vulnerable to damage. As a result, a large number of accidents occur each year as a result of these primitive types of train lines, and as a result of such accidents, we lose a large number of lives each year.

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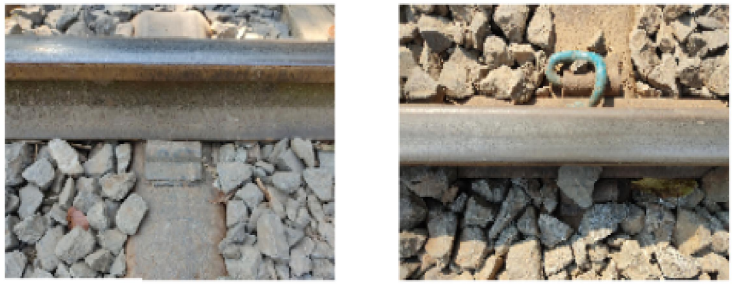

Figure 1: Non-defective railway tracks

Figure 2: Defective railway tracks

Figure 3: Non-defective Railway Links

Figure 4: Defective Railway Links

IV. ADVANTAGES

- Automatically detects the important features
- Computationally efficient
- Captures the spatial features from an image
- It is effective cheaper to apply this Model than any other device.

V. SYSTEM ARCHITECTURE

5.1 Load Dataset

For the dataset we use open-source contributions such as Kaggle and Web crawlers, image enhancement methods such as ports of segmentation methods to optimize our image and get a better result from our convolution neural network goes from multiple filters phases the image is reduced dimensional which is more sensible.

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5.2 Image Preprocessing

The image goes through multiple phases of filtering and de noising and the dimensions are reduced because the move the resolution of the picture the more time and work load it puts on the graphical processing units (GPU) or tensor processing unit (TPU). Once the image is properly optimized to go to neural net we can go ahead and start training the data since we use open-source data, we already have some amount of training and validation data and using this we can compare the loss. The label data goes through our neural network as well when the data is passed through the neural net the image is flattened which basically turns an image into a single line which makes it easier for the computer to read the data because multidimensional data is much harder to read that a single dimensional data. This image is later turned into color scale which is lessened because color doesn't matter over here and it's turned into black-and-white what is this case which makes the laws function even less and made our model even more accurate. And then our image dataset goes through the Neural Network.

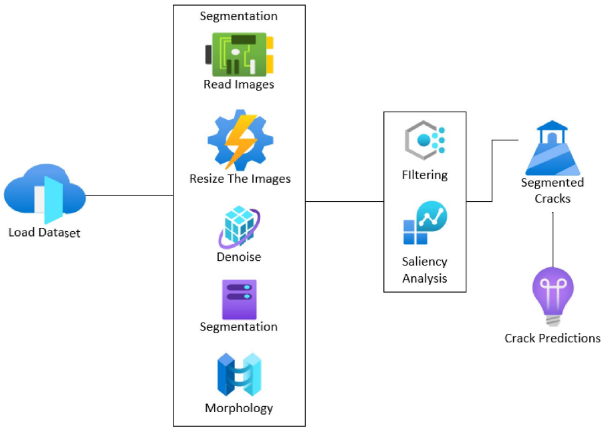

Figure 5: System Architecture

5.3 Saliency and Segmentation

This approach is based on the principle of picture saliency. In the sense of optical analysis, saliency correspond to the item's characteristics (pixels, resolution, etc.). These distinct characteristics reflect the image's visually appealing places. A spatial depiction of them has been a saliency map.

VI. Future Works

In the future applications of railway crack detection can be done using augmented reality and mixed reality techniques to find the cracks in real time to save us both time and computational resources. The future looks more promising as there are more and more applications of mixed reality applications along with more phones out there having LIDAR sensors, which help in the accurate measuring of the objects, both the sides of the smartphone companies are continually developing their technologies both on AR-Core and AR-Kit side to have more smartphones without any sensors such as LIDAR to make sure they have these features to get the basic Augment Reality functionality on those phones, this can be harnessed and be used in application which is open source and people can upload their Augment reality scanned files to contribute to the open source database to build the future of Mixed reality.

VII. Conclusion

Through this method of using Deep Learning for the detection of cracks in railway tracks we are able to eliminate the cost of using expensive audio based or physical method of finding cracks. We were able to achieve an accuracy of 0.89 after testing it with the validation dataset. By using the machine learning algorithm, we are able to reduce cost of not only the equipment also eliminating a lot of the physical human work.

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