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A Robust Rail Surface Defect Analysis And Monitoring System

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ABSTRACT

Railways are helpful in developing a country's economy and national integration. Discrete rail surface defects have adverse effect on the safety of railway system. It is important to frequently monitor the quality of rail heads. Human inspection is slow and dangerous. Modern inspection system makes use of visual cameras. Visual inspection system employs a high speed camera to capture rail surface images. The sub image of rail track is extracted and contrast can be enhanced using local normalization method. Local normalization does not depend on illumination. This paper puts forward a method to identify location of defect ,which may be helpful to rectify the defect.

.***Keywords: visual inspection system, local normalization, defect localization***

1. INTRODUCTION

Railways are helpful in developing a country's economy and national integration. It is a pre-indication for economic development of every country. This paper deals with surface defects that have adverse effect on rail tracks. Man has become aware about various calamities that might befall him and has in turn tried his level best to tackle them on such a manner that there is less vulnerability. This is best illustrated by considering the case of surface rail defects. Rail inspection is the practice of examining rail tracks for flaws that could lead to catastrophic failures According to U S Federal Rail road Administration Office of safety analysis track defects are second leading cause of accident in rails. Leading cause is attributed to human error. The contribution of poor management decision to rail accidents caused by infrequent or inadequate rail inspection is significant. Non destructive testing methods are used as

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preventive measure against track failure and possible derailment. First rail inspection was done visually. Many sources site that the need for better rail inspection came after a derailment in Manchester Newyork in 1911, which resulted in death of 29 people. Investigation in accidents revealed that cause was a transverse fissure .There are many effects that influence rail defects failure .They include bending and shear stresses ,wheel or rail contact stresses ,thermal stresses, residual stress and dynamic effects.

II. VISUAL SENSOR

Rail defect detection is of great concern to railway operators, and related techniques have been improved greatly in last decades. Often rail defects were inspected manually by a trained technician who views rails visually. Human inspection, however takes relatively long time and may be inaccurate. The limitation of human inspection led to many advanced testing techniques, which acquire the present status of a rail by some sensors (such as visual and ultrasonic sensors) and then detect defects with advanced software. Nowadays, NDT techniques for rail inspection make use of visual cameras, ultrasonics, eddy current, etc. Ultrasonic inspection has proved to be the best technique for detecting internal cracks. However, its inspection speed is slow, furthermore, it cannot detect surface defects. Several improved ultrasonic techniques were proposed to increase the inspection speed, such as electromagnetic acoustic transducers, lasers, and air-coupled ultrasonics, but they did not achieve enough progress to detect surface defects. Eddy current testing utilizes magnetic field generated by eddy currents to detect the surface defect. It has relatively high inspection speed and is able to detect surface defects, so it is widely combined with ultrasonics for rail inspection. However, the sensor of eddy current is so sensitive to the lift-off variation that the probe should be positioned at a constant distance (not more than 2 mm) from the surface of the rail head. As a result, the operation of eddy current testing is complex and sensitive.

As eddy current and ultrasonic rail inspections have its own disadvantages a more robust method of rail flaw detection has to be introduced. With advanced computer vision techniques, a visual inspection system has been developed. In a visual inspection system (VIS), a high-speed digital camera, which is installed under a test train, is used to capture images of a rail track as the train moves over the track, and then, the captured images are analysed automatically using a modified image processing software. Typical applications include corrugation inspection, and crack detection. Visual inspection has the advantages of high speed, low cost, and attractive performance and is regarded as the best technique for surface defect detection. VIS basically comprises three parts namely image acquisition system, contrast enhancement system and a defect localization system. With the help of these subsystems a VIS can effectively detect a surface defect. Image acquisition system acquires the rail image which is further enhanced using a contrast enhancement method and finally the defect is localized by a defect localization method. These are the basic operations performed in defect identification and localization.

III. IMAGE CAPTURING SYSTEM

Rail images are captured by using a high speed camera mounted under the test vehicle. The camera is focussed in such a

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way that the obtained image contains the focussed image of a rail surface. Usually a high speed camera is employed for capturing the images. The high speed camera must be able to capture the rail surface throughout its length.

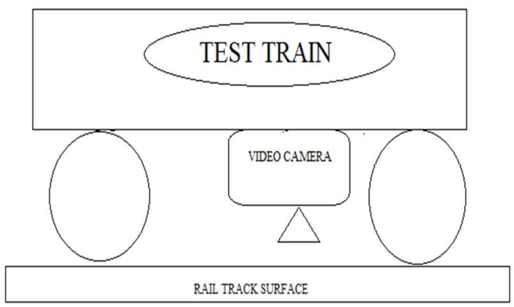

Figure 1: Set up of image capturing system

The image acquired by the video camera may be affected by natural light and shake of the train. This factor has to be taken into consideration while doing further manipulations.

IV. ANALYSIS SYSTEM

After a rail image is generated by the image acquisition system, it is processed by the image analysis subsystem, which aims to efficiently detect possible defects in the image. This subsystem includes three main modules: rail track extraction, contrast enhancement, and defect localization.

A. Rail Track Extraction

The image obtained from the high speed camera may contain extra fields other than the desired track image. These unwanted fields have to be removed for the further analysis. The main aim is to extract the rail head devoid of other fields. This is done by taking mean of each row and comparing it with all other raw mean. This is performed under the assumption that rail track has fixed width. Once the beginning of the track is identified then the assumption of fixed track width is used to extract the track from the background. The track extraction based on projection profile (TEBP) [1] is used for track extraction. TEBP is based on the assumption that rail tracks have fixed width, and rail tracks have more average intensity as compared with extra fields. According to the characteristics of defect regions of interest, the following features are considered for defect identification:

1) The length of defect region in pixels.

2) Gray scaled version of the image.

3) Gray scale comparison showing differences.

4) The area of suspect defect region in pixels.

A. Contrast Enhancement

Defects are easily distorted by illumination inequality and the differences in reflection property of rail surfaces, so contrast enhancement is a necessary step to classify defects from their background. Local normalization method is used to classify the defects from their background. In this method, a rail image is divided into a number of non overlapped $w \times h$ windows, and each pixel is normalized by the mean and standard deviation of the window. The normalized image is further improved by using a filter.

The LN method has the following advantages:

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1) Normalized images are independent of illumination

2) It obtains a background of same kind or nature and highlights defects Local normalization technique is used for contrast enhancement. Local normalization technique is applied to an image thereby all the uneven illumination effects can be eliminated. Each rail track image have different lighting conditions, hence an illumination independent algorithm became necessary .Local normalization method is non linear and illumination independent. A contrast enhancement algorithm for rail images should take into account following facts such as

1) The background often has a large intensity range because of the variation in illumination and reflection property of the rail surface. For example, natural light may change the local lighting condition. Smooth parts of a rail surface reflect more light.

2) In a local window, the illumination and reflection property is stable, so the local window tends to have small differences.

3) Differences in gray level between defects and background.

The selection of local window W is very important for an LNI, as it affects quality and cost. We can use either sliding window or fixed window. In case of sliding window, each pixel has its own window. In the case of fixed window, multiple pixels share a fixed window. More clearly, a rail image is divided into non overlapped windows, and a window W is assigned to all pixels located in it. The next important step is the defect localization, this is done to localize the defect .As defects does not have a fixed shape, it is important to localize the defect.

B. Defect Position Identification

The position of the defect or the distance at which the defect has occurred has to be identified for rectifying the defect. As the image capturing system takes the image of rail surface throughout the distance the test train travels, the number of frames will be related to the distance covered, hence it will be possible to identify the distance at which the defect is present. A proper recording system can then be used for detecting the defects throughout the distance covered.

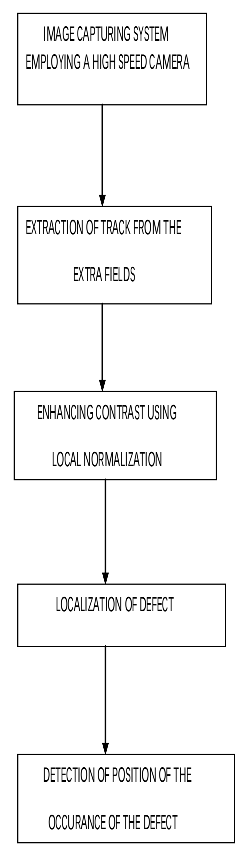

Figure2: System setup

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D. Coding Algorithm

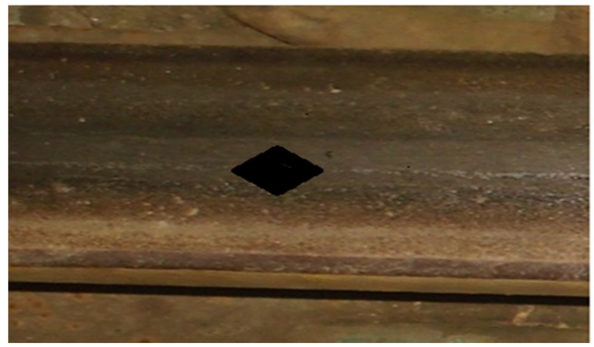
Algorithm 1 Track extraction

procedure TEXTRA($imgex$, $track\ width$)
$row \leftarrow size(imgex, 1)$
$column \leftarrow size(imgex, 2)$
$M(1) \leftarrow mean\ of\ imgex(\cdot\ , 1)$
for $i \leftarrow 2, column$ **do**
$M(i) \leftarrow mean\ of\ imgex(\cdot\ , i)$
$M(i) \leftarrow M(i) + M(i-1)$
end for
$cumulatmax \leftarrow -1$
$dbeg \leftarrow 0$
for $i \leftarrow 1, column - trackwidth + 1$ **do**
$currentc \leftarrow M(i + trackwidth - 1) - M(i)$
if $currentcum > cumulatmax$ **then**
$maximumCumlt \leftarrow currentcum$
$dbeg \leftarrow i$
end if
end for
return $dbeg$
end procedure

VI . SIMULATION STUDY AND RESULTS

Experiments are performed on an image as shown below. The image shows a rail track surface with a crack.

From this image the track has to be extracted from the extra fields in the background.Thus the extracted track from the original image will be as shown below.



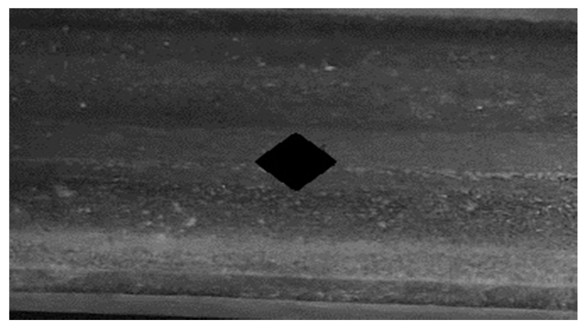


Figure3: Original image

Figure4: Extracted track from the original image.

From this image the track has to be extracted from the extra fields in the background.Thus the extracted track from the original image will be as shown below.

If local normalization is performed on the extracted track then the new enhanced image will be as below. Normalization is performed with a block size of two.

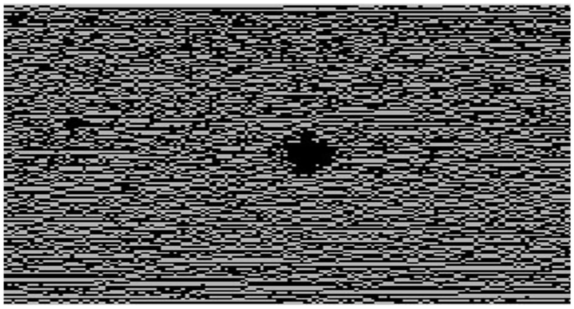


Figure 5: Normalized image with a block size of 2

Filtering the image provides a more clear view of the defect, the filtered output will be as shown below.

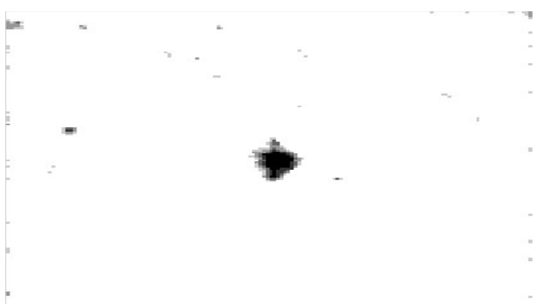


Figure6: Filtered output with a block size of 2

The filtered output is then given to a defect localization algorithm .The localized defect is shown below.

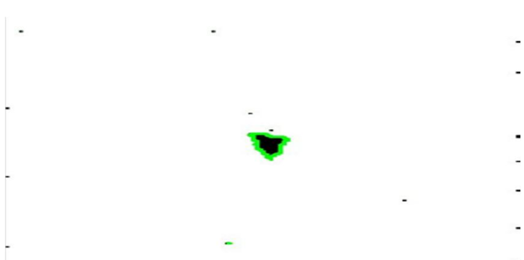


Figure7:Localized defect

VIII . CONCLUSION AND FUTURE WORK

In this paper, we have proposed an effective system to detect and locate a defect in railheads. To do this, we developed an algorithm to extract the track from the extra fields. In future this work can be extended by classifying the defect on the basis of depth and severity of the defect. The defect identification system can be further improved by adding a GSM module. This paper put forwards an effective way of localizing the defect, which is an illumination independent system.

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