A Vision Based Railway Track Crack Detection System

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Abstract: ***The inspection of railway tracks with each passing of trains is the most important as well as trivial task in the railway operation system. A number of inspectors are deployed to manually inspect the tracks time to time. But, still manual inspection has its limitations. This manual inspection is lengthy, laborious and subjective. In this paper, a novel automatic vision processing based system of track monitoring is presented. The methods can detect the presence of cracks in a railway track by analyzing the visuals of the track sections. The methods of image processing and morphological processing have been used in this research work to identify the presence of cracks. A number of track section images have been used to test the efficiency of the proposed system and it has found a good level of accuracy in finding the cracks.***

IndexTerms - Railway Track, Crack Detection, Morphological Operations, Image Processing.

I. Introduction

Computer vision provides many potential advantages to railway track inspection. Great levels of performance can be achieved through the automation of inspection using computer vision systems, as they allow scalable, quick, and cost-effective solutions to tasks otherwise unsuited to humans. At a minimum, railway track components can be objectively and quantitatively inspected, as the system does not suffer from fatigue or the subjectivity inherent with human inspectors. The reasons for track defects are manifold. As to the rail defects, most of them develop over time due to wear. They occur due to the stress rails undergo from bearing heavy loads. The loads that the rails support, now typically in excess of 100 tons per wagon, create an outward pushing force that spreads the rails apart. The fasteners supply an opposing force to keep the rails in their intended location at the specified distance apart. Aging and weather take their toll on rail components as well. Rails are constantly affected by forces of rail thermal expansion and contraction. Loose tie clips and/or defective crossties might lead to distortions in the track. In situations of extreme thermal variation, this can lead to a condition termed "sun kinks", in which the track becomes instantly inoperable, sometimes during the course of one day or night. A common cause of rail defects lies in the malfunctions of the wheels of a train. The segments of the rail on crossings and forks are especially prone to defects. Since the avoidance of defects is so important, the rails must be inspected periodically, and maintenance is to be performed in timely manner defects are discovered. All of the aforementioned defects can either lead to accidents or cause other problems which increase the likelihood of accidents. Therefore, track operators make routine inspections of the tracks. It is their job to continually inspect the tracks and make any necessary repairs. Loose or missing clips and fasteners, faulty rails, joints, crossties, bolts, or spikes need to be repaired or replaced.

In this research work, the key objective is to study the feasibility of an automatic vision based automatic railway tracks monitoring system. The monitoring system is implemented virtually using MATLAB Image Processing functions and algorithm for various operations like segmentation classification and matching. The images taken will be compared with the existing database of non-faulty track images on a continuous basis. If a fault arises in the track section, the system will automatically detect the fault and necessary actions can be taken, to avoid any mishappening.

The main research objectives are a) study the railway track monitoring systems and various kinds of faults appearing in the tracks b) to design and develop algorithm to capture the track images, c) to design suitable algorithm to detect the faults appearing in the railway track and accordingly raise an alarm in case of any misappropriation.

II. Literature Review

Security of railroad transportation can be upgraded by using wise frameworks that give extra data about the correct location of track section, its speed and up and coming snags. The rails confront increasingly danger of harm with the expansion of speed [8]. Along these lines, the rails ought to be intently assessed for inner and surface deficiencies. Rail profile investigation utilizing manual strategies the two harms the rail surface and incidentally upsets railroad. Consequently, rail profile investigation for railroad transportation has been finished utilizing contactless picture preparing procedures. Strategies, which distinguish the rail disappointments by methods for contactless picture handling procedures, are accessible in the writing.

Sambo et al. [9] exhibited a novel calculation that identify rail surface moving contact exhaustion harm and programmed consolidation in a split development show prescribed an essential commitment to the advancement of present day systems for non-ruinous rail examination.

Mao et al. [10] built up a sensor blame location conspire for rail vehicle latent suspension frameworks, utilizing a blame discovery spectator, within the sight of indeterminate track normality and vehicle clamors that are demonstrated as outer aggravations and stochastic process signals.

Faghih-Roohi et al. [11] have proposed a detailed convolutional neural system for the investigation of picture information for the location of rail surface deformities. They looked at the consequences of various system structures described by various sizes and actuation capacities.

Hu et al. [12] recognized uneven shine and clamor, the substantial rail surface deformities, as indicated by the qualities of overwhelming rail surface imperfections, in light of the numerical morphology of multi-scale and double structure components. Contrasted and the customary edge identification administrators, the outcomes demonstrate that their technique possesses solid hostile to commotion execution, can identify the little deformity edge precisely under clamor.

III. System Implementation

There are some general steps for any image based system. The various parts can be segmentation of the image to recover the region of interest, followed by preprocessing steps to minimize the pixel redundancy, noise etc. The detailed description of the vision based system is given in the below diagram:

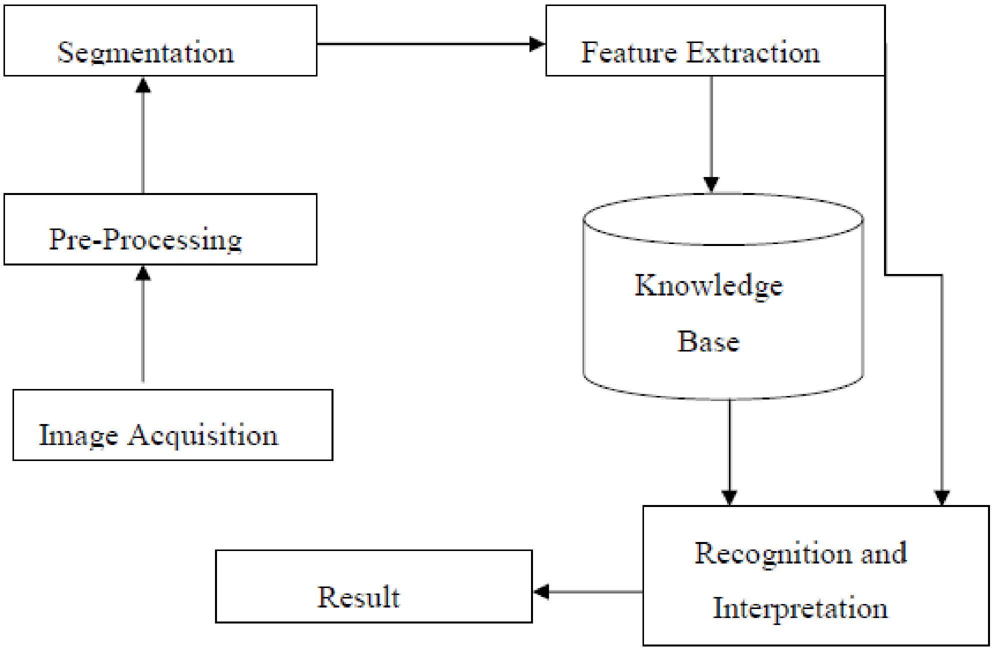


Figure 1.1: Vision based Recognition System

Algorithm:

Step 1: Read image from the database of the collected track images.

Step 2: Convert the input image to grayscale image.

Step 3: Enhance contrast using histogram equalization

Step 4: Convert to binary Image using gray level thresholding.

Step 5: Morphologically open binary image (remove small objects) removes from a binary image all connected components (objects) that have fewer than P pixels, producing another binary image.

Step 6: Display the binary image on the screen and defined the region to fill by selecting points interactively.

Step 7: Find connected components in binary image, using 8 connected neighbourhood.

Step 8: Count the number of values in binary image that fall between the elements in the edges vector.

Step 9: Counts the value in each connected neighbourhood x(i)

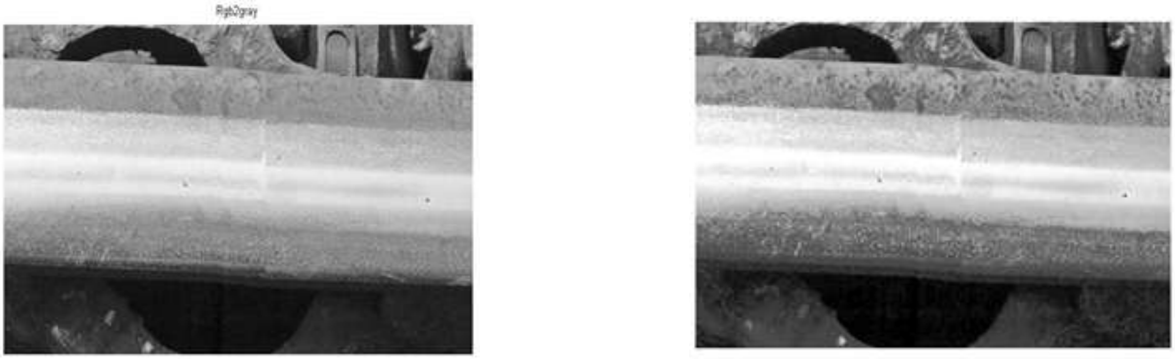
$$\text{if edges}(k) \le x(i) < \text{edges}(k+1). \quad (1)$$

The last bin counts any values of x that match edges(end). Values outside the values in edges are not counted.

Connected components are obtained from the complete area of the track image. If there is discontinuity then there is crack otherwise no crack.

IV. Simulation Results

The algorithm has been implemented in MATLAB 2014a using various built in functions related to Image Processing Toolbox. Images of track sections are collected from internet and are used to test the proposed algorithm. The figure 2 shows a) the track section converted to grayscale and b) histogram equalized image to enhance the contrast of the track image. The Figure 3a shows binary converted image and figure 3b shows the noise removed binary image.



a) b)

Figure 2: a) Track section b) Histogram equalized

After removing any noise present in the image, the holes(black spots) appearing in the image are removed to obtain the complete track image. The connected components are counted and based on a certain threshold the crack in the railway track is detected.

a) b)

Figure 3: a) Binary Image b) Noised Removed Binary

Morphological operations are performed on the noise removed binary image and finally morphological filling of holes is done. The morphologically filled image is shown in figure 4. If no holes detected post morphological filling there is no crack otherwise crack exists.

Figure 4: Morphological Filling

A second example of a cracked track section shows below simulation results.

a) b)

Figure 5: a) Binary Image b) Noise Removed Binary image

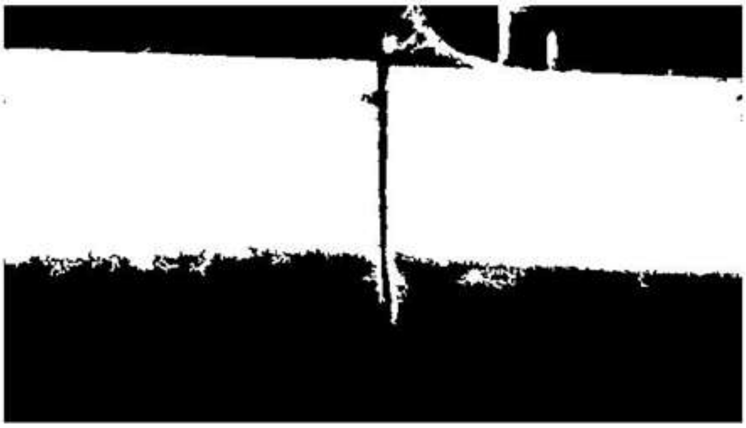


Figure 6: Morphological Filling

As can be seen from figure 6, after morphological filling a discontinuity is present which marks presence of crack in the track section being inspected.

V. Performance Evaluation:

The algorithm was tested on 14 different images obtained from the internet, having both cracks and without cracks in the tracks. The accuracy of the proposed system has been evaluated as below:

Accuracy:

TP= 7 TN= 3

FP=2 FN= 2

Accuracy= TP+TN/(TP+TN+FP+FN)
= 10/14*100 = 71.42 %

VI. Conclusion

A novel algorithm for automatic vision based system for the detection of cracks in railway faults is presented. The method uses morphological processing to find out connected components in image pixels. The subsystem performs well and achieves 71.42 % accuracy level. The current algorithm developed can be further tested by building a real-time version of the system. The realtime system can use a high definition camera so as to take live images of the track sections. Since, in India Railways is a government department it will ask for a number of clearances to allow to get real-time images of track sections. Efforts can be done in this regard and the inclusion of real-time standalone system which can itself take regular images from the track section and detect any mishappening in any part, will surely improve the surveillance and inspection system prevalent currently. In this research work, the main focus has been the cracks in the track. The investigation can be further extended to delve into other deformities in the railway track.

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