A Real-Time Railway Fasteners Inspection using HAAR Segmentation

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Abstract— Railway inspection is a very critical task for ensuring the safety of railway traffic. Traditionally, this task is operated by trained human inspectors who periodically walk along railway lines to search for any damages of railway components. However, the manual inspection is slow, costly, and even dangerous. A Visual Inspection System can be used for fastener defects detection and also to find the location of the missing fastener. We focus on automatically finding and assessing the partially worn and missing fasteners based on computer vision technologies. The fasteners are used to hold the track on sleepers, if there is any fasteners may worn or missing may results in hazardous defects, which would cause the displacement of track and even threaten the safety of train operation. Generally, there are two kinds of fasteners: 1.hexagonal-headed bolts and 2.hook-shaped fasteners. The hook-shaped fasteners are widely used in current railway lines. Here we use the vehicle that runs on the track, which may hold the cameras on the both side of the vehicle. The vehicle can be run at the average speed on the track. The image captured by the vehicle can be send to the Real-Time Visual Inspection System to detect the defects on the fasteners.

Index Terms — Fastener, Frame Difference Algorithm (FDA), railway, visual inspection, localization.

1. INTRODUCTION

The detection of fastener defects is an important task in railway inspection systems, and it is frequently performed to ensure the safety of train traffic.With the extension of high-speed railway network, the inspection and maintenance face more challenges than ever before. Recently, the railway companies of all over the world are interested in developing automatic inspection systems.

An automatic railway inspection system is composed of a number of functions such as gauge measurement, track profile measurement, track-surface defects detection, and fastener defects detection. Our aim focuses on automatically finding and assessing the partially worn and missing fasteners based on computer vision technologies.

According to the United States Federal Railroad Administration Office of Safety Analysis, track defects are the second leading cause of accidents on railways in the United States. The leading cause of railway accidents is attributed to human error. Every year, North American railroads spend millions of dollars to inspect the rails for internal and external flaws. Non-destructive methods are used as a preventative measures against track failures and possible derailment.

A list of NDT methods that are used to detect flaws in rails:

- Ultrasound – The most popular method
- Eddy current inspection – great for surface flaws
- Magnetic Particle Inspection – used for detailed manual inspection
- Radiography – used on specific locations such as bolt holes and where thermite welding was used
- Magnetic induction – earliest method used to locate unseen flaws

Safety in Indian Railways becomes a subject of a discussion when there is an accident. The review of train accidents of the last 5 years (2009-10a to 2013-14) for which the data is available indicates that a large number of accidents happen because of derailments & at level crossing. It is also clear that more that 80% of the accidents are caused by Human Failure (Railway Staff or Otherwise).

Each time there is a train accident, the issue of safety in Indian Railways is discussed for a few days. Here is a review of the train accidents in the last 5 years including causes, types of accidents & casualities for each of those years.

There have been various causes for train accidents ranging from Human Failure to Equipment Failure to Sabotage etc.

- In the last 5 years, human failure has accounted for 86% of the total accidents. Out of this, 40% accidents are due to failure of railway staff and the rest by those other than the railway staff.
- Equipment failure has caused only 2.2% of the accidents, which is a welcome sign.

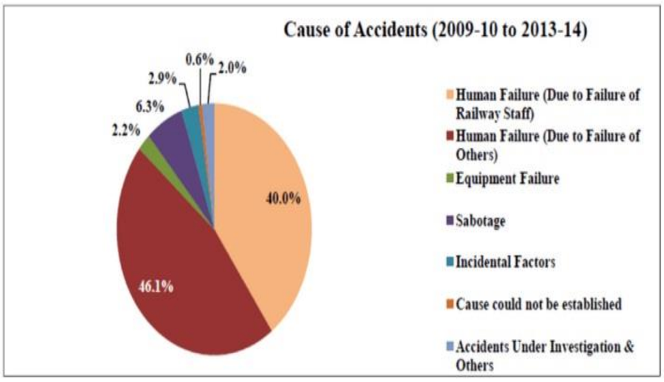

Figure 1. Cause of Accidents

The fasteners are used to hold the track on sleepers as shown in fig 2, if there is any fasteners my worn or missing may results in hazardous defects, which would cause the displacement of track and even threaten the safety of train operation. Generally, there are two kinds of fasteners: 1.hexagonal-headed bolts and 2.hook-shaped fasteners. The hook-shaped fasteners are widely used in current railway lines.

Figure 2. Image Captured by camera

2. SYSTEM OVERVIEW

A Real Time Visual Inspection System for Railway Fasteners Maintenance system consists of several modules. All modules work under the principle of specific Algorithm. This will mainly focus on automated Video Pre-processing, segmentation process, Extraction of features and to find Localization. The proposed system consists of five modules.

1. Video Pre-Processing
2. HAAR Segmentation
3. Feature Extraction
4. Localization

3. VIDEO PRE-PROCESSING

This module can be used to pre-process the input video and it may contain two sub-mobules such as:

1. Capture Video
2. Extract Frames

a. Capture Video

The Video can captured to detect the Missing Fasteners. Here we use the vehicle that runs on the track, which may hold the cameras on the both side of the vehicle. The Camera will focus on the Fasteners in the Railway Track. The vehicle can be run at the average speed on the track. The Video captured by the camera should be in the formats such as .mp4, .mov, .avi. The video captured by the vehicle can be send to the Real-Time Visual Inspection System to detect the defects on the fasteners.

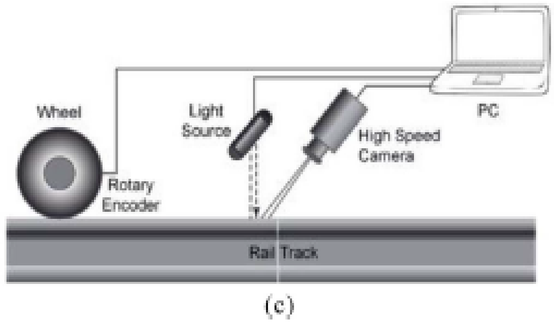

Figure 3. Configuration of the System

b. Extract Frames

This module can be defined as the process of extracting the frames from the video. The Motion pictures are nothing more than a series of rapidly changing still images or frames. It was determined that there are 24 frames per second was acceptable for motion. Then the image processing techniques can be applied to the resultant frames.

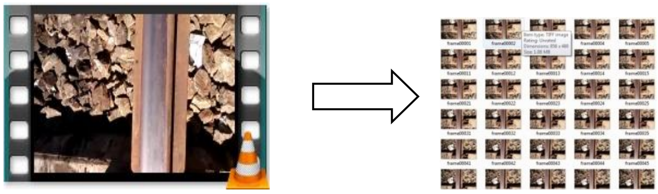

Figure 4. Frame Conversion

4. HAAR SEGMENTATION

In the images research and application, images are often only interested in certain parts. These parts are often referred to as goals or foreground (as other parts of the background). In order to identify and analyze the target in the image, we need to isolate them from the image. The image segmentation refers to the image is divided into regions, each with characteristics and to extract the target of interest in the process.

The image segmentation used in this paper is threshold segmentation. To put it simply, the threshold of the gray scale image segmentation is to identify a range in the image of the compared with the threshold and according to the results to the corresponding pixel is divided into two categories, The foreground and background. The simplest case the image after the single-threshold segmentation can be defined as

$$g(x,y)=\begin{cases}1 & f(x,y)>T\\ 0 & f(x,y)\le T\end{cases}$$

Threshold segmentation has two main steps:

1) Determine the threshold T
2) Pixel value will be compared with the threshold value T

In the above steps to determine the threshold value is the most critical step in partition. In the threshold selection, there is a best threshold based on different goals of image segmentation. If we can determine an appropriate threshold, we can correct the image for segmentation.

The Image Segmentation can be used for the purpose of detecting the Fasteners frames from all the frames.

a. Fastener Detection

The input video consists of several frames. Each frame may consist of a pixel count. The Frame that contains Fastener should have a High Pixel count in the range of 30,000-40,000. The Frame that doesn't contain Fastener should have a Low Pixel count in the range of 20,000-30,000.

Determine the Threshold value T as 30,000. The frame which contains the pixel count of >30,000 may holds the fasteners.

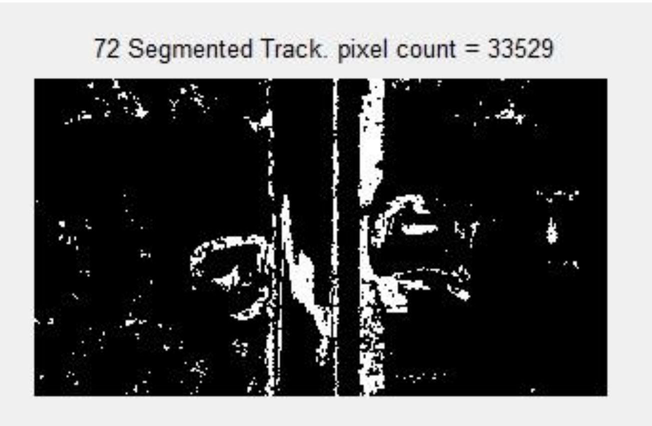

Figure 5. Fastener Detection

5. FEATURE EXTRACTION

This module can be used to find out the missing fastener from the frames. This can be done by using the Frame Difference Algorithm. It refers to a very small time intervals Δ_t of the two images before and after the pixel based on the time difference, and then thresholding to extract the image region of the movement, according to which changes in the difference of two frames, it can predict that the Fastener is missing or not.

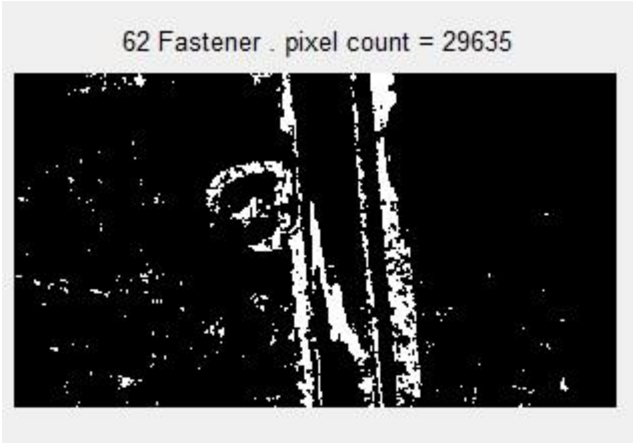

Figure 6. Fastener Missing

6. LOCALIZATION

This module can be used to find out the location of the missing fastener. The distance from the starting point can be calculated by using the Database that may contain KM traveled by the train and their time.

DISTANCE (KM) TRAVELLED BY TRAIN	TIME IN VIDEO (HR:MIN:SEC)
SOURCE	00:00:00
0.1 KM	00:01:00
0.2 KM	00:03:25
.	.
.	.
DESTINATION	10:15:23

Table 1. Location Database

For example, Time for the missing Fastener can be calculated by, In fig.3.5.1 the fastener was missing at the frame of 62. In the above input video, the frame rate should be 30 Frames per second. So the 62 frame will be occur at the time of 2.067seconds. By the time we can find the distance travelled by the train using database.

7. EXPERIMENTAL RESULTS

Images are collected from group photos and image size has been specified with minimum range of 512*512 to the maximum range of 1024*768. The pixel range for an image has a size of 375*281. In Face Recognition system, totally 25 images and 15 videos are collected and used in database for testing.

a. Frame Conversion

The Input Video can be converted to the Frames for the processing. For each second it contains 30frames. The number of frames should be depends upon the video length.

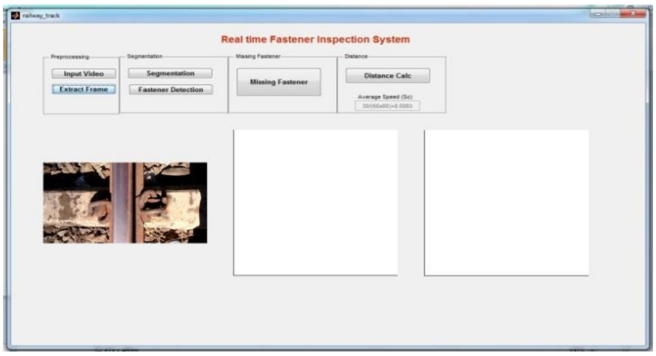

Figure 7. Frame Conversion

b. Image Segmentation

In the Image Segmentation, The pixel count value can be assigned for each frames. The frames that contain fasteners have high pixel count and the frames that doesn't contain fastener have low pixel count.

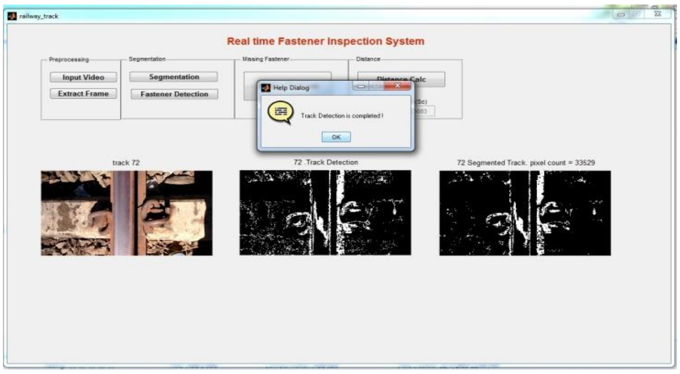

Figure 8. Image Segmentation

c. Fastener Detection

The frames that contain the fastener can be detected by their pixel count and placed them separately.

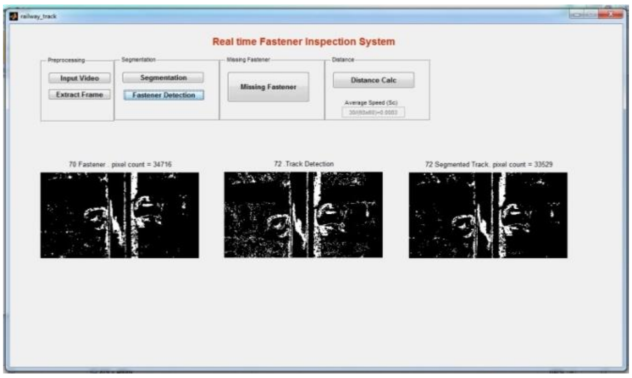

Figure 9. Fastener Detection

d. Missing Fastener

Out of all the frames, the frame in the fastener is missing can be detected and also displays the frame count of the missing fastener.

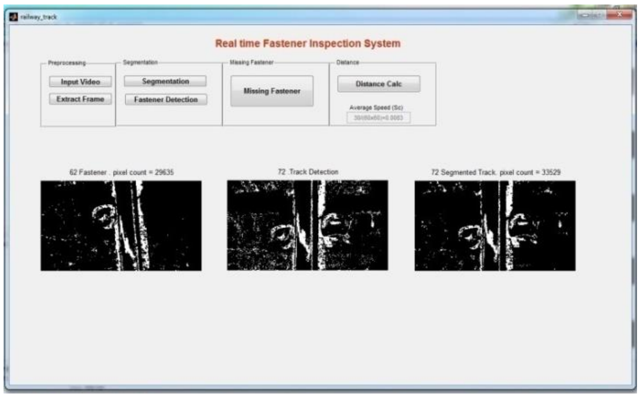

Figure 10. Missing Fastener

e. Fastener Location

The Missing Fastener Location can be calculated from the source point.

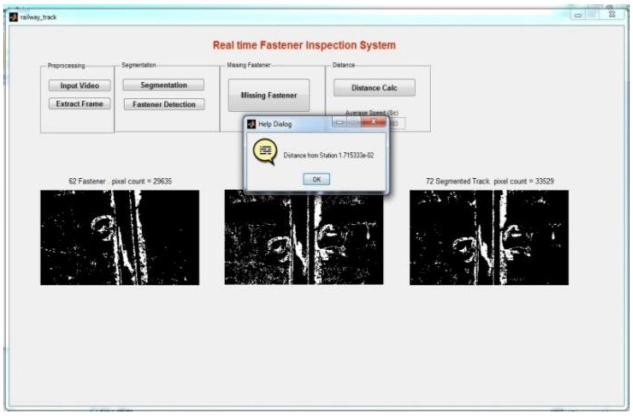

Figure 11. Fastener Location

8. CONCLUSION

The detection of fastener defects is an important task in railway inspection systems, and it is frequently performed to ensure the safety of train traffic. Generally, the inspection is performed manually, via a number of qualified personnel proficient in the structure of railway fasteners. However, as in all human-based inspections, this kind of inspection has a number of crucial disadvantages and sometimes is dangerous. First of all, manual inspection is very slow considering the average capability of a human. Furthermore, by increasing working hours, performance of a worker may degrade within a day and crucial mistakes could be made. The real-time railway inspection system is proposed, which is able to simultaneously assess the damage of fasteners and also to find the location of the fasteners.

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