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Detection Of Squats In Railways Infrastructure With High Hit Ratio

Harshvardhan Saraogi[1], Asst.Prof (S.G).A.Ruhan Bevi[2]

[1]*Electronics and Communication Department / SRM University, Kattankulathur, Chennai, India*
[1] *harshvardhansaraogi007@gmail.com*
[2]*Electronics and Communication Department / SRM University, Kattankulathur, Chennai, India*
[2]*ruhan.b@ktr.srmuniv.ac.in*

ABSTRACT

In this paper, the focus is on the early detection of short surface defects called squats. Different classes of squats are classified based on the response in surface characteristics of the rails and with the voltage variation in the surface of rails, using the infrared sensor and 3 axis accelerometer .The robot is designed to find the crack in the railway track with the help of IR sensor and accelerometer with exact location of the railway crack information is send to the control section using GSM and GPS technology. The hit rate of the system for light squats is higher than 88%, with a false alarm rate of 2% which is higher than previous techniques. In the case of severe squats the hit rate was 100% without False alarm.

Keywords/ Index Term—Squats, Axle box acceleration (ABA), Infrared sensor, 3 axis accelerometer, GSM, GPS

1. INTRODUCTION

A squat is a Rolling Contact Fatigue (RCF) defect in rails which is widely studied during mid-1970s, primarily in Europe and Japan. [1] Squats are particularly dangerous because if they are allowed to remain in track, the commonly develop into rail breaks. For this reason railway systems are concerned about the presence of squats and ensure either that rails are ground routinely to prevent small surface breaking cracks propagating and to manage rail-wheel contact stresses, or that rails containing cracks which have developed too deeply to be ground out are removed. In this project, robot model is designed which contains in-built microcontroller with IR sensor and 3-axis accelerometer, that detects the squats as early as possible with high

hit ratio even in the light squats. A robot is designed in such a way that it can move freely without external support or dependency which can detect different types of squats and send them to the nearest railway management through GSM and GPS module.

2. DIFFERENT SQUATS DETECTION MECHANISM

There are different types of mechanism for detection the squats:

2.1. Frequency analysis using Wavelet Transform:

The ABA measurements in the time domain are not enough to detect small defects. The usage of the proper frequency content of ABA is necessary for the improvement of the detection of moderate and light squats. There are several techniques available for the investigation of frequency content of the signal, like Short-Time (or Windowed) Fourier Transform (STFT), which has the drawbacks of window size. When the window is narrow it can provide a good time resolution with poor frequency resolution; while when the window is wide it can provide good frequency resolution and poor time resolution. Therefore, it is necessary to analyse several window sizes to determine an appropriate one [2] to be used for the application.

2.2. Lock-in thermography Experiment:

An infra-red camera is placed 0.57 m above the surface of the rail sample. Four 750 W stage lights controlled by an agilent 3320A (20 MHz) function/arbitrary waveform generator provided the sinusoidal heat flux at 0.2 Hz. According to the survey result, lock-in thermography works best if multiple periods are captured, as the phase angle data is effectively averaged, thus reducing noise and error from the results. This frequency (0.2 Hz) was used as it is low enough to detect defects up to 8 mm deep [3], yet high enough to allow multiple periods to be measured in a reasonable time frame. Accumulation time was 30 seconds, thus allowing six periods to be captured. Thermal images are recorded at alternate phases and we used three locations, I1, I2 and I3, over a particular thermal cycle [3].

3. HARDWARE DESIGN FOR AUTOMATIC SQUAT DETECTION WITH HIGH HIT RATIO:

3.1. The hardware architecture:

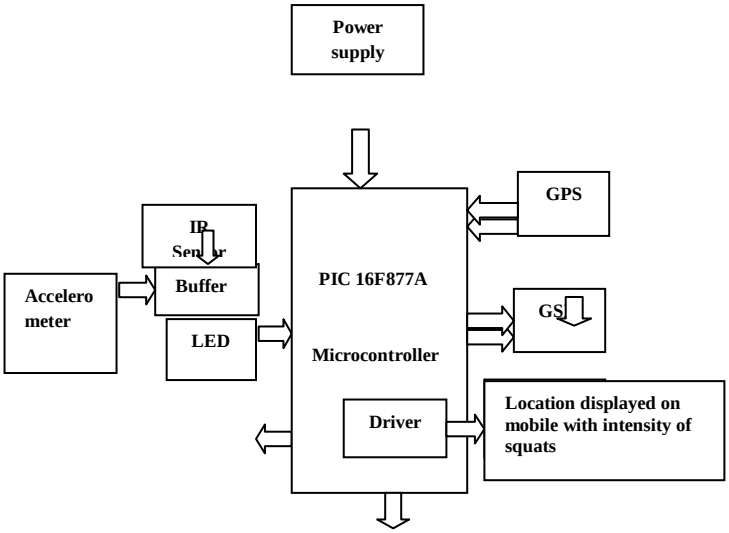

Fig.1: Block diagram of hardware architecture

In the proposed architecture, automatic detection of squats mainly consisting of 3 types of modules: 1) sensor module, 2) control module and 3) motor driver as in fig 1. The sensors will sense the change in surface variation of the rail track and change in acceleration in z-axis of the accelerometer and send the values to control module. Control module is used to take a decision about whether there is a squat or not and categories the type of squat as light, moderate or severe squat according to that it will intimate the nearest control section of railway station using GSM and GPS module .GPS module will detect the exact location of squats with respect to latitude and longitude and it also sends the message about what type of squat it is by using GSM module. Control module converts analog data into digital and send the values to pc motor driver.

3.2 Working of Automatic Squat Detection

PIC16887A Microcontroller:

In this proposed model, the master controller is PIC16887A. It is high-performance enhanced flash microcontroller with 10-bit analog to digital converter and microcontrollers with 10-bit analog to digital converter and also 32k of flash memory. PIC16887A is belongs to PIC16f series.

Squat detection using sensor (Infrared sensor):
Infrared sensor is connected to voltage follower circuit and voltage follower circuit is connected to ADC pin of master controller. When robot is initiated, infrared sensor will read current analog value of surface in terms of voltage which is send to ADC pin of microcontroller to convert analog value to digital value.Based on variation in the surface of the rail track Infrared sensor will sense the voltage variation in the surface and compare with previous value, result will again compare with cut-off voltage which is set according to the squat. If the criterion match as a squat then it will sends the reading to the master controller where controller will decide about the type of the squat according to the length of squats in millimetres. If it is a squat then LED which is connected to the port D of microcontroller will start glowing. For accurate readings whether it is squat of not, we are using 3-axis accelerometer.

3-axis Accelerometer:
The 3-axis accelerometer used in the proposed system will detect the acceleration in z direction of the axis. The principle that we are using behind proposed system is if there is squat, then there will be acceleration in z axis .A 3-axis accelerometer is capable of detecting acceleration in x, y and z axis but according to our need only z-axis is needed so we programmed master controller like that it will only detect in z-axis. It send analogue values to ADC port of microcontroller, the microcontroller have inbuilt A to D converter it converts analogue values into digital. It measures static acceleration of tilt sensing and dynamic acceleration resulting from motion, shack or vibration. If squat is there then acceleration will be developed in z-axis, accelerometer will detect the intensity of squat and compare it to cut-off. If it is more than a cut-off value then according to the value (infrared sensor) which is stored in the buffer and current value of accelerometer, decision is made according to the intensity of voltage variation. The master controller will decide which type of squat like light, moderate and severe as per intensity of voltage and sends its location using GPS, GSM module to nearest control section.

GPS module
A GPS working principle is that, it measures the time interval between the transmission and the reception of a satellite signal, and then it calculates the distance between the user and each satellite. Through the distance measurements of at least three satellites in an algorithm computation, the GPS receiver arrives at an accurate position fix. To obtain a 2-D fix (latitude and longitude), information must be received from three satellites and for a 3-D fix (latitude, longitude and altitude), four satellites are required [4].GPS transmission pin is connected to the receiver pin of master controller. When squat is detected, GPS will send the location of squat to the nearest control section.

GSM module:
GSM SIM300 receiver pin is interfaced with transmitter pin of master controller. When squat is detected then it will send a message to the nearest control section

which will contain the longitude, latitude with the intensity of infrared sensor and 3-axis accelerometer.

4. WORKING OF AUTOMATIC SQUAT DETECTION ROBOT

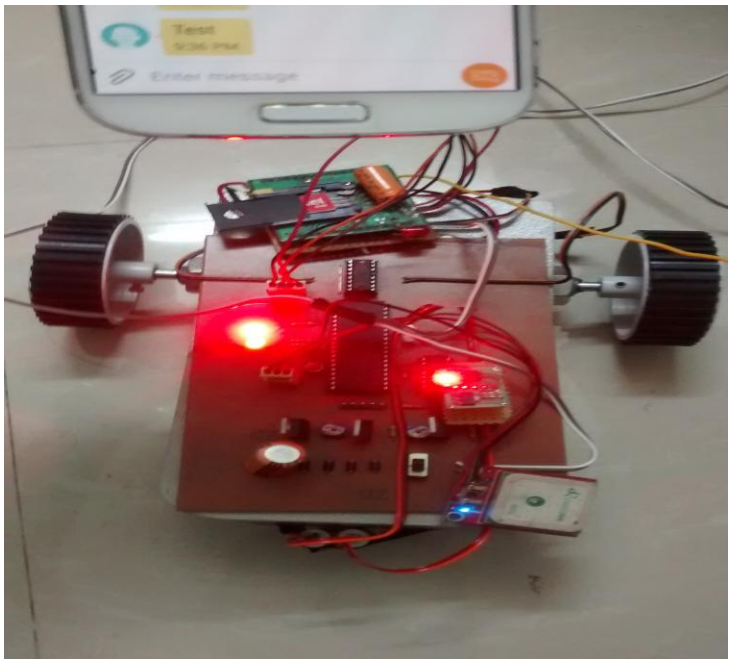

Fig-2: Prototype model when initialized.

When the proposed system is initiated, it will send the "TEST" message to the control section .This will indicate that our model is ready to use and saves the current value of infrared sensor and accelerometer into buffer. The proposed system starts with the detection of squat with robot running in the track which is having infrared sensor, 3-axis accelerometer, GPS and GSM module interfaced with PIC16887A master controller. In order to detect the squats in the track, robot as in fig 2 will search for the squat with the help of infrared sensor and 3-axis accelerometer. The IR transducers which are embedded in the prototype model will act as squat detection sensor that sense the voltage variation in the surface. If there is squat present in the track then there will be different voltage variation rather than normal railway in metal strip voltage which is already stored in the buffer. Simultaneously 3-axis accelerometer will also sense the variation in the z-axis if there is variation in acceleration above certain cut-off point then it will be taken as squats. After getting reading from IR transducer and 3-axis accelerometer, it is send to the master controller into its ADC pin because readings are analog values and it need to be converted into digital. The master controller is having inbuilt analog to digital converter which is programmed like it has to take decision according to the readings

which we got from squat detection sensor and 3 axis accelerometer whether it is squat or not? If there is squat than in which category it is? If squat is detected then LED will glow. According to the reading of infrared sensor and 3-axis accelerometer ,the master controller will decide the type of squat and send its location with the type of squats i.e. light squats (0-0.5mm), moderate squats(0.5-2mm),severe squats(>2mm) to the nearest control section of railways with the use of GPS and GSM module.

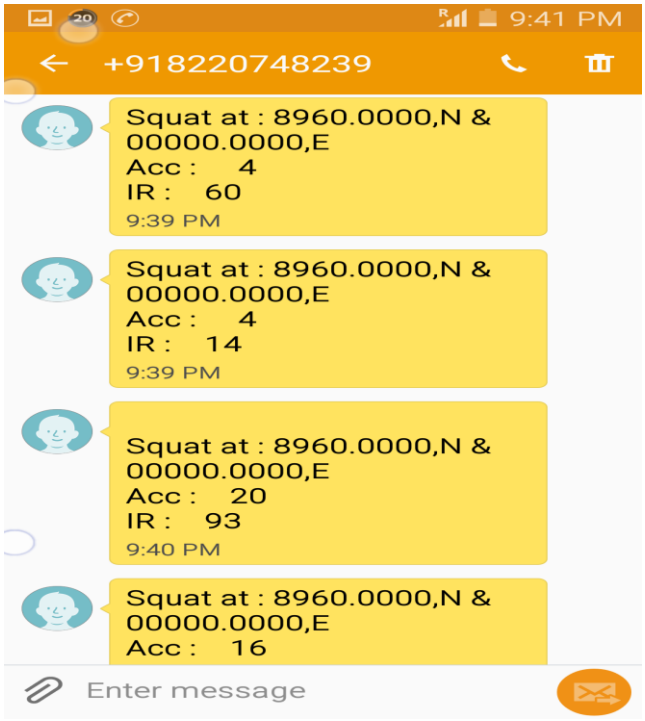

Fig-3: Squat detected

The automatic squat detection robot will detect the squat in the following manner shown in fig 3.Using 3 axis accelerometer and IR sensor ,it will send the intensity of squat i.e. more the intensity of squat, more severe damage can be happen. The following prototype model can detect location of squat as well as intensity of squat as shown in fig 3.

5. RESULTS AND CONCLUSION

The existing squat detection methods are based on wavelet transform and lock-in thermography techniques thus it is not only tedious to work with thermographs but also it is very costly. The main disadvantage of these techniques is it will not have higher hit ratio in light squats. But our system uses IR sensors and 3-axis accelerometer which is having high hit ratio and very cost efficient also. Today, Robots play a vey major role in industrial applications. In future these may come in every field, they could change the way the people live. Even though robots are the

creation of human, they are more efficient and accurate. However, the only drawback with this project is it is not having 100% hit ratio in light squats. It is having about 88% hit ratio for detecting light squats which is higher than any technique which was implemented earlier. To make the system more accurate with 100% hit ratio for all the type of squats we need to add more sensors with high speed robot rolling on the track.

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