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Efficient In-Service Railway Track Inspection and Fault Announcing System

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***Abstract*— Rail track condition surveillance is an evident system, which is being acquired and supported by many countries across the world. The proposed system detects the faults like crack, twists in the track routinely during in-service and intimates this fault to the responsible person through Wi-Fi module. This system provides service at the right time and prevents further maintenance at later date. The system also detects the obstacle in the track using ultrasonic sensor to avert from derailment and ensure the safety of the passengers. The proposed system have potential to deplete traffic jam at the level crossing with the help of self-operating gate by positioning sensors to recognize the entry and leaving of the train. It also reduces human intervention, increase the frequency of checking the track and mitigate human errors.**

***Index Terms*—Track inspection, irregularities, accelerometer sensors**

I. INTRODUCTION

Rail track is also known as the permanent way, which is a structure that allows the trains to pass through the track by providing a supporting surface for their wheels to roll upon. Track needs constant and continual maintenance to remain in good manner, especially for high speed trains. Inadequate maintenance may lead to dangle and curtailment of speed. In prior days track maintenance was tough and difficult since it requires team of labourers or trackmen, who used lining bars to repair the irregularities in the alignment of the track and tamping and jacks to rectify vertical irregularities. Quotidian maintenance jobs are greasing, revamping sleepers, fine-tune switches, reinforce wobbly track components and lining to keep straight sections unswerving and curves within maintenance limits.

There are two main methods for scrutinizing the condition of the track. One is portable devices which require handlers or operators to operate along the track line at the zero hours. It's a time depleting work and the quality can't be guaranteed since it relies on the ability of the workers. Another one is the Track Recording Vehicle (TRV) for scrutinizing the geometry condition of the track, which uses many acceleration sensors, optical sensors, and gyro sensors for measuring the different irregularities, such as vertical unevenness, gauge, lateral alignment, cross level, and twist.

Fig 1. Traditional track inspecting vehicles

However, such a system is expensive and the optical sensors are very much sensitive to the hard environment. The track will be inspected only once or less in a month. The dreadful track degradation cannot be detected appropriately and there is potential safety threat for the rail track.

The whole paper is divided into 5 parts. Sections II describes about the literature survey. Section III discusses about the current problems that exist in track monitoring and reporting. It also explains of how the proposed model will overcome the difficulties faced in the current scenario. Section IV gives the execution details of the proposed system and the results. Section V presents the conclusion and enhancement of this work.

II. LITERATURE SURVEY

The track examination system explained in [9] involves suspension system of the railway vehicle which uses sensor that can measure acceleration (both vertical and lateral) of the bogie frame. The sampling process is carried out by data acquisition device which outputs filtered data as a result of input taken from the sensors. Then the data is double integrated to obtain the both track alignments.

The method explained in [1], data can be collected more often time even during day-to-day activity, related to the ongoing condition of the track. In addition, the proper data management and interpretation can give a detailed description of the track line status, short-pitch corrugation. The vertical accelerometer mainly observes corrugation, while the lateral ones can notify about eventual lateral discontinuity like curve rail wear, or the presence of defects and damaged switches. This leads to the suggestion that only the first wheel-set is responsible for corrugation growth.

In paper [7], a method for the obtaining lateral and vertical track irregularity from acceleration measurements on using

multi-body dynamics code, SIMPACK is demonstrated. The entire vehicle is built as the exemplar of a subway train, which contains car-body, front bogie frame and rear bogie frame, primary suspension and secondary suspension, wheelsets and track. The observed study concludes that vertical irregularities have the most consequential effect on the bogie vertical vibration.

The paper [6] describes the use of sensors installed on the bogie of a vehicle to estimate the mean track orientation. According to this principle, either bogie lateral acceleration or yaw rate can be organized to give an estimate of mean lateral track irregularity, but a yaw rate gyro provides unfailing estimates down to lower vehicle speeds than does an accelerometer. In fact, a yaw rate gyro has advantage over a laterally sensing accelerometer.

The method proposed in [8] uses infrared sensors to detect the entry and exit of the train. While the train reaches within the range of the sensor the gate automatically closes with some indication to level crossers. When the train moves out of another sensors range the gate immediately gets unlocked.

The method explained in [3] detects the presence of hindrances like rock, timber in the track using Bayesian analysis technique. Here a locomotive was used along the track and the signal generated by barrier drop was filtered out from extremely high level of acoustic noise generated by locomotive motion using a novel Monte Carlo-based Bayesian analysis.

III. PROPOSED SYSTEM

Identifying and correcting of rail defects are crucial issues for all rail players across the world. Some of the defects include weld problems, worn out rails, corrugations, rolling contact fatigue problems (head checks, surface cracks, spalling, squats and shelling) and internal defects. If these are untreated, it leads to rail breaks and derailments. If these issues are properly addressed then inspection and rectification can reduce the potential risks and also reduces cost spent by railway on inspection and maintenance of rail tracks. The above problem can be avoided by implementing the system which be explained further. The list of components used in the experiment is MEMS SENSOR, IR SENSOR, ULTRASONIC SENSOR, BUZZER, DC MOTOR, LCD, and ARM MICROCONTROLLER.

A. MEMS SENSOR

Accelerometers sense and handle both static and dynamic acceleration. The accelerometers are widely utilized in tilt-sensing. Since they are altered by the acceleration of gravity, an accelerometer can notify how it's positioned with respect to the surface of the Earth. Analog, pulse-width modulated (PWM), or digital interface may be the interfaces. These both interfaces are very ease to work with.

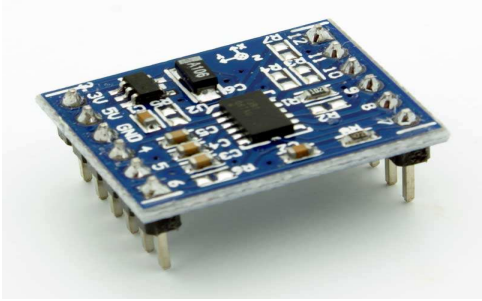

Fig 2. MEMS sensor

An accelerometer return value is a scalar with respect to the magnitude of the acceleration vector. The Earth's gravitational pull is the most habitual acceleration with reference value ~9.8m/s2

B. IFRARED SENSOR

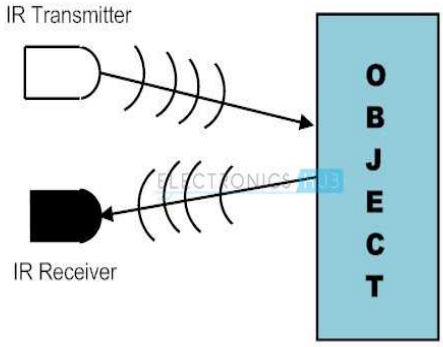

Fig 3. Infrared sensor

Every object possesses temperature significantly greater than absolute zero and act as an origin of IR radiation. These sensors make use of IR lasers & light emitting diodes with distinct wavelength which may act as a source. The transmission medium (vacuum, atmosphere, optical fibre) is necessitating factor for IR sensor. The thermal and quantum sensors are the major stratification with advantages like low power, simple circuiting and portable. IR sensors are applied in fields like IR tracking, climatology, anaesthesiology testing, meteorology etc. Certain type of sensors has to be cooled to achieve accurate evaluation.

C. ULTRASONIC SENSOR

Ultrasonic sensors measures sound waves having frequency exceeding human audible range. They follow three principles namely attenuation of sound waves, the Doppler shift and time of flight. Its quantifications are very delicate to temperature and targets angle. The pitfalls of this sensor are weather, dead-zone, angle, currents and material. Its application includes measurement of distance, depth, thickness etc.

Fig 4. Ultrasonic sensor

D. BUZZER

Buzzer is an electronic invention that produces sound. Due to its advantages it is utilized in variety of applications like call bells, vehicle indicator, computers etc.

Fig 5. Buzzer

Piezo buzzers create noises and can operate over vast temperature ranges varying form loud to hostile.

E. DC MOTOR

Three sorts of motors are customarily used: DC motors, RC servomotors, and stepper motors. Electrical principle of induction is the fundamental idea used in DC motors.

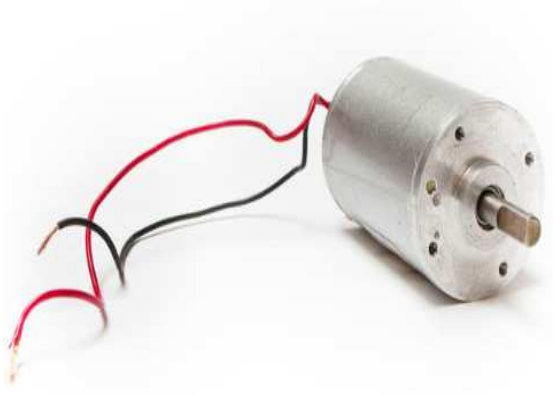

Fig 6. DC motor

Usually more load means more current. Every motor has a stall current, which is the current it draws when it's stopped by an opposing force. It draws more current even there is no load.

F. LCD

Alphanumeric displays are employed in palmtop computers, medical instruments, mobile phones, etc. The 16 x 2 intelligent alphanumeric dot matrix displays has the ability of displaying 224 different symbols and characters.

Fig 7. Liquid Crystal Display

The 8 data pin in LCD transmits only 8-bit ASCII code of character. 8-bit or 4-bit modes are the modes through which data can be sent. While using 4-bit mode, to complete whole 8 bit two nibbles of data is transmitted. 8-bit mode is perfect for the applications that require speed. The advantages of LCD are compact, low power consumption, little heat, any shape or size etc.

G. ARM MICROCNTROLLER

Advanced RISC Machine relies on RISC architecture. Optimised instruction set, low hardware cost, less heat production, power efficient are the merits of the microcontroller. The memory operation id performed with the help of general purpose registers. Nowadays, 98% of mobile phone makes use of atleast one ARM processor.

Fig 8. ARM microcontroller

IV. IMPLEMENTATION PHASE

The implementation of the track monitoring system consist of three modules namely irregularities detection, obstacle detection and automating gate operation. The architecture of the in-service rail track monitoring and fault announcing system is explained with figure 9.

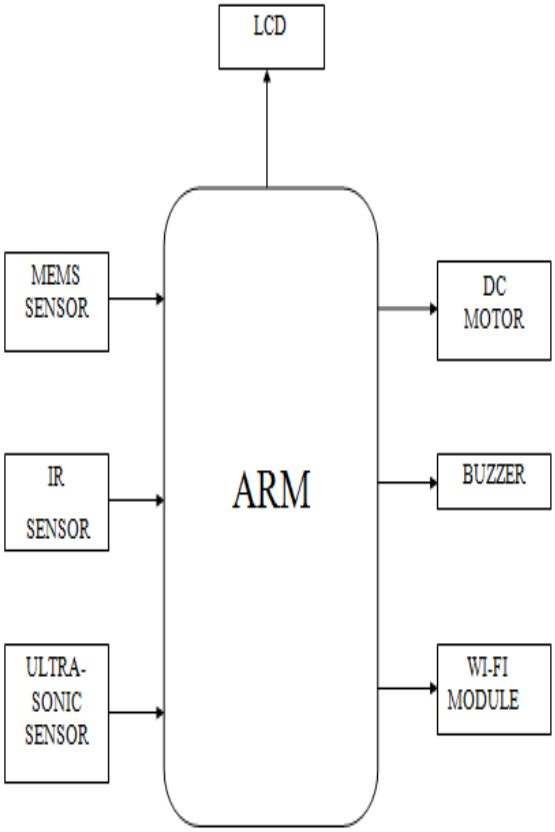

Fig 9. Architecture of the in-service rail track monitoring and fault announcing system

The components used in the architecture are explained in Section III. The overall prototype of the system is depicted in the figure 10.

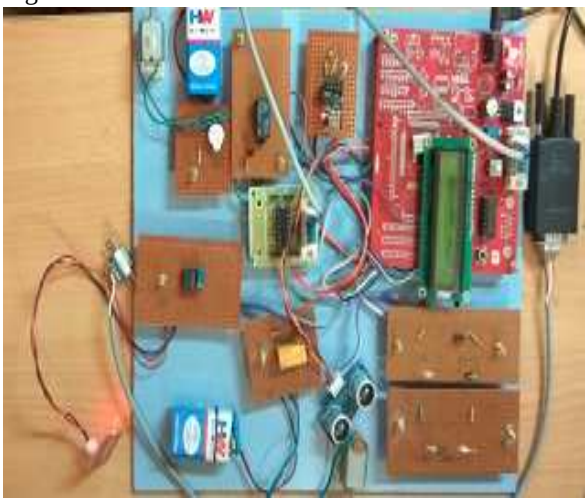

Fig 10. Prototype of the proposed system

A. *IRREGULARITIES DETECTION*

The prototype of the track is built and it is equipped with MEMS (acceleration) sensor. The Wi-Fi must be configured to get connected to the network. The prototype is connected to the Wi-Fi module which uploads the detected information to the webpage. The acceleration sensor is able to sense cracks and alignment changes of the train. Whenever there is a slight change in the movement of the train (shaking due to crack, change in X,Y and Z axis), the buzzer sound goes on and the irregularity is immediately displayed in LCD and also uploaded to the webpage. This functionality helps in providing service at the right time and prevents further maintenance at later date.

Fig 11. Alignment change in the track

Fig 12. Crack identified in the track

B. *OBSTACLE DETECTION*

The obstacle detection module is equipped with an ultrasonic sensor which operates with transmitting and receiving the sound waves. The ultrasonic sensor can be placed in the bogie of the train in the real time environment. This sensor in the prototype detects the obstacle on the track which can even cause severe damage (rock slides and timbers on the track in hilly areas) and this is indicated through LCD in the prototype and also updated in the webpage. The uploaded data can be further used to provide immediate service which avoids accidents and derailment.

Fig 13. Obstacle detected in the track

C. *AUTOMATING GATE OPERATION*

The proposed system is also capable of automating the gate operation at the level crossing. The IR sensor placed in the track senses the train entry and this initiates the DC motor to close the gate. The IR sensor identifies the arrival which also enables the buzzer to indicate the road users to avoid accidents at the level crossing. This module can greatly reduces the human interference and reduces traffic jam at the level crossing.

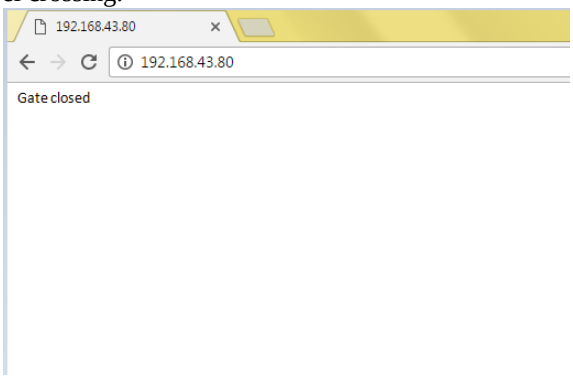

Fig 14. Automatic gate closing at the level crossing

V. RESULT

In order to maintain and monitor the condition of the railway track proper inspection is must. This is carried out through the acceleration sensors fitted in the bogie of the every time in a real time environment. To ensure the safety of the passengers in places like hilly regions where rock and timber slides are more frequent, the ultrasonic sensors are placed to detect those obstacles. If such an obstacle is identified the train stops immediately to prevent from derailment. The further analysis can be done over the data to prevent further maintenance at later date. Also the system is capable of automating the gate operation at level crossing to prevent accidents and traffic jam. The proposed system focuses on avoiding human interference, errors and hindrance. The reason behind avoiding human interference is to assure the safety of the workman, reduce human effort and to increase the accuracy of the result since the accuracy depends upon the ability of the workers.

Existing system	**Proposed system**
Less accurate	Accurate
Expensive	Economical
Threat to passengers and workers	Ensures safety of passengers and workers
High human interference	Reduced human interference

TABLE 1. COMPARISON OF EXISTING AND PROPOSED SYSTEM

VI. CONCLUSION

The proposed system aims at reducing the human hurdles of operation to obtain accuracy and thereby it reduces cost and time required for the operation. It also ensures the safety of the passengers by increasing the frequency of checking. The advantages of the proposed system are safe, economical and consistent.

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