MULTI - SENSOR RAILWAY TRACK DETECTION USING FUZZY LOGIC CONTROLLER

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Abstract
This paper deals with the efficient use of fuzzy logic controller which is a vigorous solution to the problem of railway track detection. Track irregularities are the main causes of vibration and thus carefully monitor the parameter to improve the ride quality. Bridge damage status is monitored by the sensor and wireless modules, when the sensor not getting signal immediately nearby wireless system notifies and alert or informs to the current train on the track.

Keywords: Fuzzy logic, MEMS, Ultrasonic, Railway track circuit, Track detection

I. Introduction

As railway networks are becoming busier, they are required to operate with increasing levels of availability and reliability. To enable the safe operation of a railway network, it is crucial to detect the presence of trains in the sections of a railway track. The railway track circuit is worldwide the most commonly used component for train detection. To ensure a good maintenance of the rails, frequent measurements are needed in order to avoid railway distortion or unsafe situations.

II. GENERAL DESCRIPTION

In each and every transport systems, particularly in the case of railways, safety and reliability are highly considered. Accurate geospatial data about railway infrastructures like tracks, wires, towers, signs, and stations in railway environment are of vital importance in the public transportation departments. The updating of existing data sets and the digital implementation of objects has become crucial importance. One of the main focuses has been on the rail tracks. Rail tracks have a large effect on various aspects of railway operation, system safety, train speed optimization, movement behaviour, and passenger comfort. To ensure a good maintenance of the rails, frequent measurements are needed in order to avoid railway distortion or unsafe situations.

A comparatively high amount of dedicated sensory systems has been installed in areas at or near level crossings to prevent collisions between trains and vehicles. There is recent analysis about the phenomena that may cause collisions at level crossings. On high-speed lines, there are no level crossings, but zones close to bridges or tunnels are considered to be quite critical since objects can fall on to the tracks. Currently, operational rails safety inspections and maintenance are carried out either by time consuming on-site inspections or semi-automatically by visually analyzing imagery and video data.

To avoid the generation of false alarms, it has become necessary to increase the reliability of the detection system. Reliability is highly influenced by the design of the sensor used, the conditions in which the sensor is working, and the signal processing that is carried out by the system. This paper focuses on one of such systems to detect obstacles and vibration on railway lines in a reliable way.

Due to the fact that the ideal sensor does not exist, in this paper, a multi sensory system is proposed so that the drawbacks of using any particular type of sensor are compensated by the performance characteristics of the other types of sensors.

It simultaneously provides multiple emissions and multiple receptions, avoids interference among the emissions, and can function with a low signal-to-noise ratio. Second, the use of fuzzy logic to combine the information given by the two sensors (MEMS and Ultrasonic) is proposed

III. DESIGNED MULTI SENSORY SYSTEM

The designed sensory system is composed of two multisensory system, i.e., MEMS and Ultrasonic, which are placed at both sides of the railway.

A. DETECTION SECTION

In this paper, a different detection is proposed, based on the use of fuzzy logic controller. Therefore, they are Robot Section, Train Section and Signal Section.

B. ROBOT SECTION

First, a robot codification section measures theoretically whether, obstacle or any vibration is present in the track. The minimum dimensions of the object to be detected by the MEMS and Ultrasonic sensors are are 50 × 50 × 50cm. As a result if an object with minimum dimensions is present in the scanned area the two sensor links are interrupted.

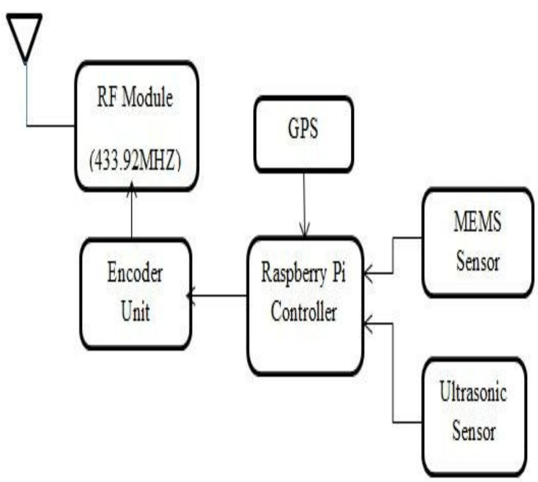

Fig. 1. Robot Section for the detection of objects and vibration.

The required scan time is 500ms and if an obstacle is inside the detection area for more than three seconds an alarm will be generated. The GPS in the robot section is used for finding the latitude and longitude position to detect the presence of faults. Fig. 1. shows a proposal for an obstacle-detection system.

The location of faults in the track is sent through GSM. RF module is used to transmit and receive signals

B. TRAIN SECTION

The designed system is composed of RF module, Display unit, Decoder unit, Driver circuit, Alarm unit. The RF receiver is used to receive the signals from the RF module and sends the corresponding signals to the decoder unit.

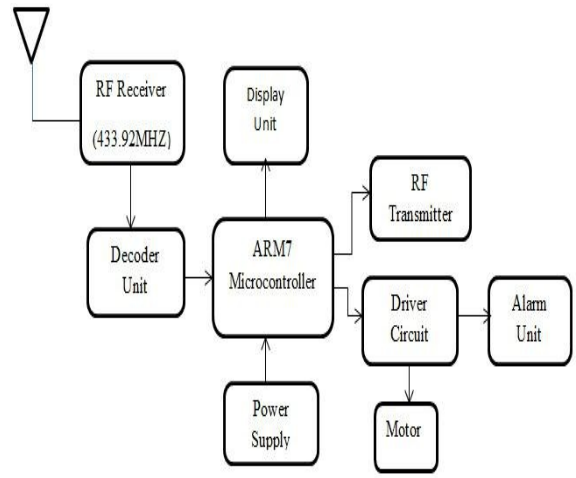

Fig. 2. Train section in which the information is received from robot section by RF receiver.

The Decoder unit is a circuit which changes the code into a set of signals. It does the reverse process of encoding for receiving the signals from the robot section. Fig. 2. shows a Train section in which the information is received from robot section by RF receiver. The display unit is used for displaying the latitude and longitude position of the faults in the track circuit.

The driver circuit is used to control another circuit or component and the alarm is generated if fault is present in the circuit.

C. SIGNAL SECTION

The RF receiver receives the information from the train section and it is given to the driver circuit. The alarm is generated in the signal section which is received from the train section. Fig. 3. shows a Signal Section is used to alert railway authority. The alarm produced is very useful for the railway authority people so that the latitude and longitude positions of the fault can be easily identified by the railway authority people and they will detect the faults in the track circuit. By the implementation of this method the faults in the track can be eliminated and the accidents can be prevented

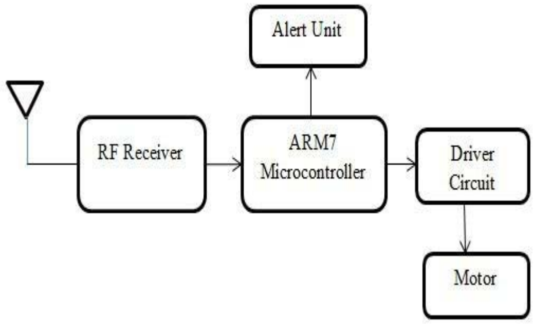

Fig. 3. Signal Section is used to alert railway authority.

IV. REVIEW ON SENSORS

A. MEMS SENSOR

Micro Electro Mechanical Systems is the technology in which the microscopic devices, particularly those with moving MEMS are made up of components between 1 and 100 micrometers in size. The vision of MEMS whereby micro sensors, micro actuators and microelectronics and other technologies can be integrated onto a single microchip.

MEMS sensors combine electrical and mechanical components into or on top of a single chip. Poly silicon springs suspend the MEMS structure above the substrate such that the body of the sensor can move in the X and Y axis. MEMS sensor in which the sensing method has the ability of sensing both dynamic acceleration which is a shock or vibration and static acceleration which is inclination or gravity.

B. ULTRASONIC SENSOR

Ultrasonic sensors are based on measuring the properties of sound waves with frequency above the human audible range. They are based on three physical principles: time of flight, the Doppler effect, and the attenuation of sound waves. Ultrasonic sensors are non-intrusive in that they do not require physical contact with their target, and can detect certain clear or shiny targets otherwise obscured to some vision-based sensors. On the other hand, their measurements are very sensitive to temperature and to the angle of the target. Ultrasonic sensors are based on the measurement of the properties of acoustic waves with frequencies above the human audible range often at roughly 40 kHz . They typically operate by generating a high-frequency pulse of sound, and then receiving and evaluating the properties of the echo pulse. They generate high frequency sound waves and evaluate the echo which is received back by the sensor.

1) OPERATION: A special ultrasonic transducer is used for the ultrasonic proximity sensors, which allows for alternate transmission and reception of sound waves. The ultrasonic waves emitted by the transducer are reflected by an object and received back in the transducer. After having emitted the sound waves, the ultrasonic sensor will switch to receive mode. The time elapsed between emitting and receiving is proportional to the distance of the object from the sensor.

V. SIMULATION AND EXPERIMENTS

In order to validate the proposed detection method, this paper reports the results of numerical analyses using python language and experimental results using sensors and micro controllers

A. EXPERIMENTAL RESULTS

1) Vibration Detection

The detection of vibration in the track circuit is obtained by slightly tilting the MEMS sensor. If the vibration in the track is found the sensor generates the code as sensor is detected. If the vibration in the track is not found the sensor generates the code as sensor is not detected. The vibration of the sensor is shown in Fig. 4.

Fig. 4. Prototype for Vibration of the sensor in the railway track.

2) Obstacle Detection

The ultrasonic sensor is detected only when the objects are more than 3s. The ultrasonic sensor detects the sound waves of the object to the human audible range. The Fig. 5. shows the detection of objects in the track circuit

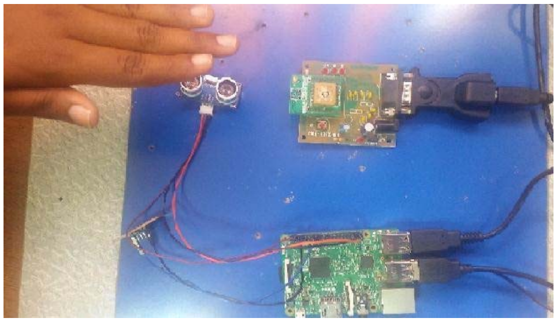

Fig. 5. Prototype for detection of objects in the railway track.

3) MEMS AND ULTRASONIC Sensor Detection

Initially when Robot section starts, the Robot detects any vibrations in the track and the any objects in the track. If there are any vibrations or any objects in the track then the information is given to the train section. The detection of MEMS and Ultrasonic sensor is displayed on the LCD.

4) Location of faults using way2sms

The location of faults in the track circuit is sent through the way2sms to the gate section. The location of faults is the latitude and longitude position of faults in the track. The way2sms is shown in Fig. 6.

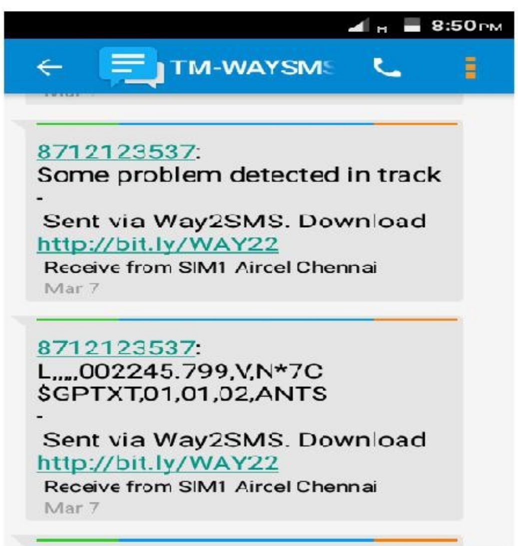

Fig. 6. shows a location of faults through way2sms.

B. SIMULATION RESULTS

The proposed simulation results for the detection of faults using fuzzy logic controller is simulated by using python language.

1) GPS and Sensors Output

The GPS execution shows the latitude and longitude positions of faults in the track. The sensors shows the distance at which the obstacle is found and data transmission to train section.

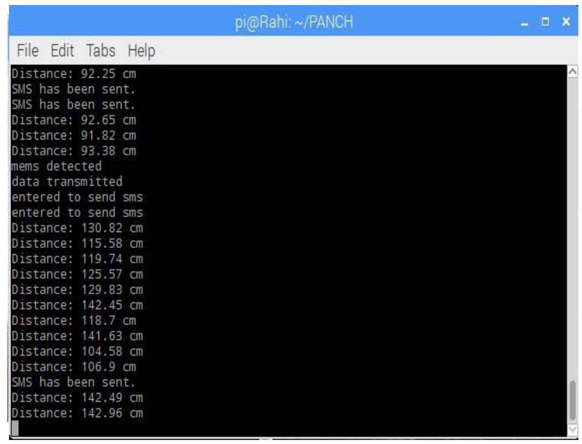

Fig. 7. GPS and Sensors Output

VI. CONCLUSION AND FUTURE RESEARCH AREAS

Initially a Robot section is sent to detect the fault in the railway track. Railway Regulations required a scan time of 500 ms, and if an obstacle is inside the detection area for more than 3 s, an alarm must be generated. The information is sent as Short Message Service as an indication by using GPS. In that time, this system can give almost 30 measurements about the state of the tracks using two different technologies.

This method achieves mile point measurement data improvement on a specified-track-length basis. It automatically divides track condition measurement data from an inspection run of a track geometry car into pieces, each of which corresponds to a track segment.

Further the railway track faults can be accomplished by track condition measurement. For condition monitoring of high-speed railway track, a new device for measuring vertical track irregularity using double integration of the axle-box acceleration is introduced. The model takes into account the effects of routine maintenance and noticeable measurement noises on the alignment and is able to capture nonlinear mile point shifts.

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