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Railway Track Failure Detection System

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ABSTRACT: Indian railway is one of the largest networks in the country. Its motto is "the life line of the country", and the main transport is completed by the railways of the country. Railroad is one of the cheapest and safest means of transport, but there are also certain accidents on the railroad. 60% of accidents are caused by road failures or the formation of cracks in the road. Today's rail systems involve manual track inspection, which is cumbersome and not entirely effective. However, the detection and correction of track defects is a problem for all railway companies in the world. The objective of this research work is to detect railroad track failures with the help of ultrasonic sensor and show the exact location of the crack on web app by using GPS module.

KEYWORDS: Detection, GPS Module, Node-MCU, Ultrasonic Sensor, WPVC

INTRODUCTION

Railways are substantial infrastructures and are the main mode of transportation in many countries. After United State, Russia and China ranking four in its place .The Indian railway network stretches across the globe with a length of 113,617 kilometers .over a route of 63,974 kilometers covering 7,083 stations [1]. In India, it is found that rail transport occupies a prominent position in providing the necessary transport infrastructure to sustain and quench the ever-burgeoning needs of a rapidly growing economy [2]. Transport is very important to carry the passengers and goods from one place to another [5]. As it is closely associated with passenger and cargo transportation, it is risky in terms of human lives and the cost of assets. Better safety standards and new technologies are constantly introduced but still, accidents do occur. Detection and rectification of rail failures are major issues for all rail men around the world .If this failure remains without inspection these defects can lead to rail breaks and derailments. Hence to prevent rail accident it is very necessary to improve the quality of railway tracks by doing regular inspection [3]. Detection and corrective decisions can reduce the potential risk of derailments and rail breaks. This research work is aimed towards addressing the issue by developing a railway track failure detection system. The advantages include less cost, low power consumption and less analysis time.

When a certain amount of repeated stress is applied to the upper I section of the track, cracks will occur after a certain number of repeated cycles. If the stress is applied continuously, the cracks will continue to propagate [8]. The point of crack propagation depends on the crack initiation point, the track material, and the type of metallurgical processing or heat treatment method used for that specific part of the track. The crack development process includes three phases as shown in figure 1: crack initiation, crack propagation, fracture, or road rest. Track failure is the result of the crack development process. The first two stages of crack development are critical for railway engineers because at this stage cracks must be detected by inspection techniques, and then maintenance or track replacement must be properly implemented. It is important to analyze the frequency of these cracks. Cracks will start as a result of degradation.

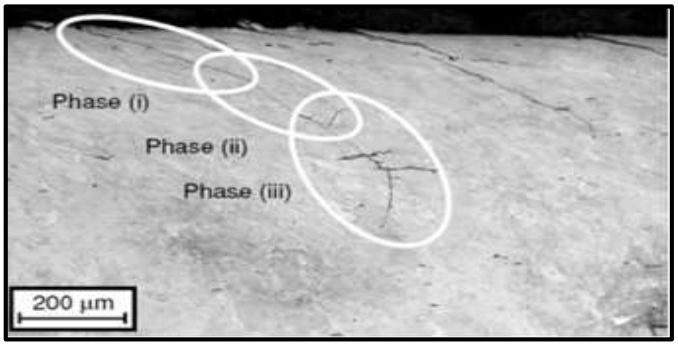

Figure 1: Phases of Crack Development Process

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A. EXISTING SYSTEM

Current rail track crack detection is done manually; it is hand handled and man powered. It also requires assistance of 3 to 4 rail men. This procedure is time consuming due to manual inspection. It reduces the accuracy too. This procedure has limited intelligence and time consuming.

B. PROPOSED SYSTEM

The proposed crack detection scheme consists of ultrasonic sensor which is the core component of the detection system. Node-MCU microcontroller is used as interface between the ultrasonic sensor and GPS Module. In order to detect the current location of the device in case of detection of a crack, a GPS receiver is capable of storing and sending geographical coordinates of the area of interest (where the crack is detected) which will help the repair team to each site as early as possible. Also the proposed vehicle will be powered by a battery and driven by a motor and will need only one rail man to assist the vehicle.

C. FLOWCHART

The flowchart shown in the figure 3 describes step by step procedure involved in in working of the prototype vehicle. The flowchart begins with locking of GPS Module, where the current location of the vehicle is recorded. After this the vehicle starts moving forward. During this process there can be two possibilities that can occur. Either a crack is detected by the ultrasonic sensor or there is no crack detected. If the crack is detected the vehicle stops moving and the current latitude and longitudinal coordinates are recorded with the help of GPS Module and is display on web app. If there is no crack detected the vehicle continues to move forward.

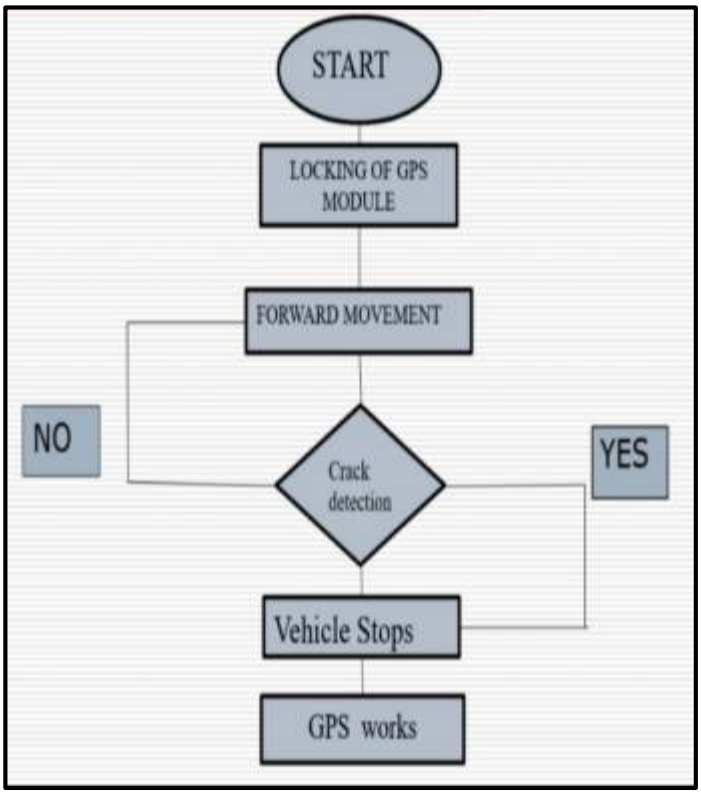

Figure 3: Flowchart

D. SYSTEM ARCHITETURE

Construction of system architecture

- A 12 V DC/AC supply is given to motor driver.
- Motor driver is connected to two motors.
- Motor driver is connected to microcontroller as shown in figure 2 which provides power to microcontroller and also microcontroller provides necessary data to motor for starting or stopping.

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- Microcontroller is connected to GPS module. GPS module provides the necessary longitudinal and lateral information to microcontroller.
- Microcontroller is connected to ultrasonic sensor as shown in figure 2 which provides signal to microcontroller if defects are detected.
- Microcontroller gives real time longitudinal and lateral coordinates to database .database provides with the number of cracks detected.

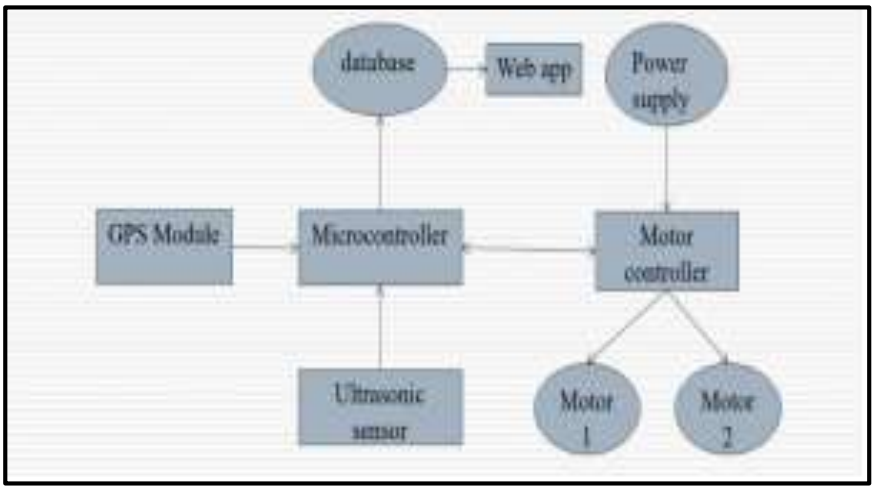

Figure 2: System Architecture

E. CIRCUIT DIAGRAM

Components used in the circuit are as follows

1) NODE MCU (Micro Controller Unit)
2) GPS module (neo 6m)
3) Ultrasonic Sensor
4) Motor driver L298N
5) Motors 2nos (200 rpm)

Given below is explanation on connection of Individual Components with Node-MCU Microcontroller as shown in figure 4.

1) GPS module connection with microcontroller
   - VCC pin of GPS module is connected to VIN of Node-MCU
   - Tx pin of GPS module is connected to D0 pin of Node-MCU
   - Rx pin of GPS module is connected to SD3 of Node-MCU

2) Ultrasonic Sensor connection with Node-MCU
   - VCC pin of ultrasonic sensor is connected to VIN pin of Node-MCU
   - GND pin of ultrasonic sensor is connected to GND pin of Node-MCU
   - ECHO pin and trigger pin of ultrasonic sensor connected to D3 and D2 pin of Node-MCU respectively.

3) Motor driver connection with NODE MCU
- AC or DC supply is given to motor driven which in turn supplies current to Node-MCU.
- EN1 and EN2 pins of motor driven which are connected internally also connected to VIN of NODE MCU
- GND pin of motor driver connected to GND pin of microcontroller
- IN1 and IN2 pin of motor driver connects to D4 and D5 pins of node MCU respectively

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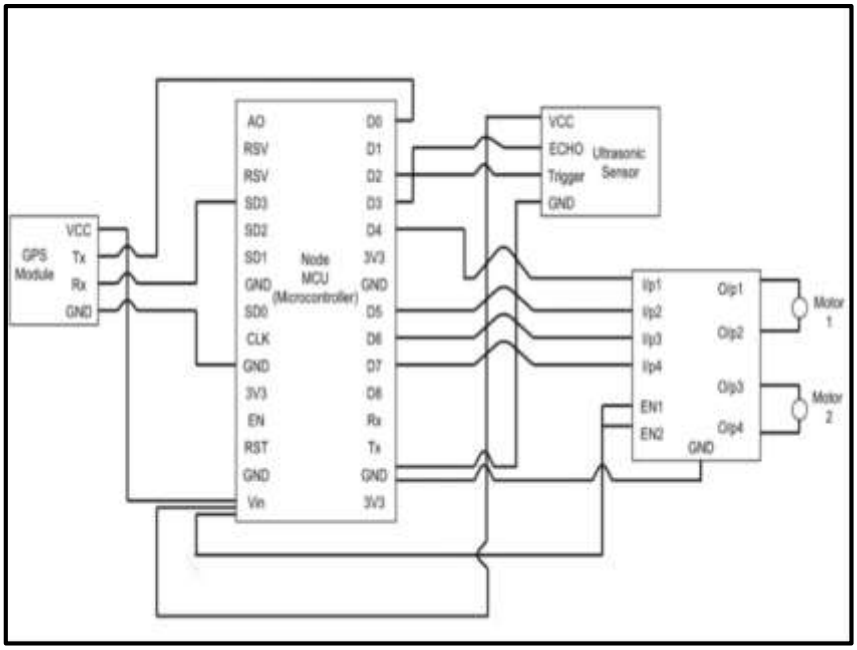

Figure 4: Circuit diagram

F. ELECTRONIC AND MECHANCAL COMPONENTS

The materials used are Wood Plastic Composites (WPC). These are composite materials made of wood floor and thermoplastics. WPC is more environmental friendly and requires less maintenance than other available alternatives. It is produced by mixing wood particles and highly heated Thermo plastic resin. WPVC do not corrode and is highly resistant to decay.it does not absorb water. Aluminium C-channel is used as, rails on which crack detection vehicle runs Aluminium C-channels is used as it is lightweight. Crack detection vehicle consists of 1 base plate all electronic components are mounted on baseplate which is made up of WPVC material Electronics and electrical components such as Node-MCU, GPS module, motor driver and battery mounted on top of base plate. The two DC motors are clamped at the bottom side of the baseplate next length the motors are connected to the wheels which drives the vehicle forward.

1) Ultrasonic Sensor

The ultrasonic sensor basically works on distance measurement which is used for crack detection. These sensors transmit a short burst of ultrasonic sound toward a rail track, which reflects the sound back to the sensor. The system then measures the time duration for the echo to return to the sensor and computes the distance to the track using the speed of sound in the medium. The ultrasonic sensor is placed between wheels of the prototype vehicle. The prototype vehicle is made to move in-between the tracks. Distance between the tracks is measured and in case of change in distance system identifies it as a crack and an alert message is sent to microcontroller and the vehicle is stops.

2) Node-MCU

Node-MCU ESP8266 in small sizes module that encapsulates Ten silica L106 integrates low power 32-bit MCU micro, with the 16-bit short mode, Clock speed support 80 MHz, 160 MHz, supports the RTOS, integrated Wi-Fi, on-board antenna. ESP8266 is high integration wireless SOCs, designed for space and power constrained mobile platform designers. It provides unsurpassed ability to embed Wi-Fi capabilities within other systems, or to function as a standalone application, with the lowest cost, and minimal space requirement.

3) GPS Module

The GPS (Global Positioning System is used to receive the position data from the vehicles and display on a digital map. It too will have the interface to the communication link. Enhanced features include video features, trace mode, history track, vehicle database, network support. A GPS module can be used to feed start and destination latitude and longitude and the vehicle moves from start point to destination point following the track to maintain equal distance from both the sides of the track [4].

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4) Wheels

The wheels are made of WPVC material. The Crack Detection system consists of four wheels, two at the front and two at the rear. Battery supply is provided to the front end, and the motor shaft is connected to the two wheels. Motor located at the front drives two tires, so the vehicle moves forward. It uses an idler at the rear end, in the direction in which front wheels are moving .The idler is clamped to the bottom side of the base and is connect to the wheels.

5) Rail Track

The prototype rail tracks are made up of aluminium C-channel. This track represents the actual rail track that is being used by railway. Rail track provides a base for crack detection vehicle for moving forward.

6) Slippers

All rectangular blocks resembling sleeper of the railway track is used to hold two rails intact. Number of rectangular blocks are used both rails are screwed on either side of the rectangular blocks in such a fashion which resembles actual railway track and sleepers in between two tracks.

Figure 3: Railway crack detecting system

G. WORKING

Whenever the power is given to the motor driver, two motors connected to motor driver starts to rotate .This motor drive two wheels made of WPVC. The crack detecting vehicle moves forward. Whenever a defect is detected in rails, the ultrasonic sensor senses the cracks and gives information to microcontroller. At this instance the microcontroller signals the motor driver to stop the motor. The GPS module provides the lateral and lo ngitudinal coordinates to microcontroller. Microcontroller then gives the location of defects on web page. Once all the process of detection of crack along with the submitting of exact location of crack is done microcontroller signals motor driver to start the motors and move forward. The motors continue to move forward and detect any cracks or defects. The same process is continued in cycle.

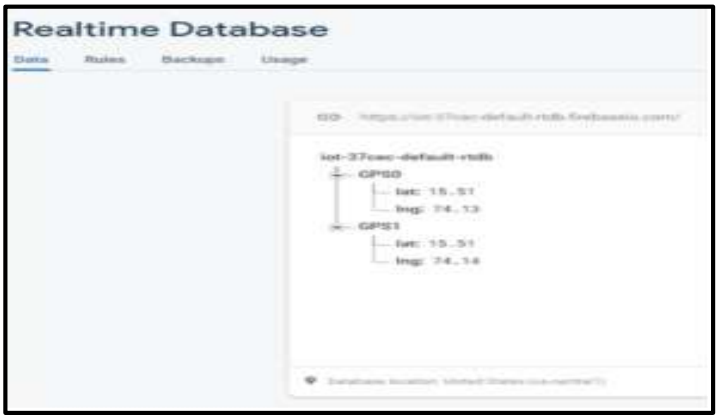

Figure 4: Real time coordinates location

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Figure 5: Live map location of crack

H. RESULT

The Prototype vehicle shown in figure 3 is kept on the aluminium rail track. Whenever the power is given to the motor driver, the driver gives signals to the two motors connected to motor driver and motor starts to rotate .This motor drive two front wheels made of WPVC. The crack detecting vehicle moves forward. Whenever a defect is detected in rails, the ultrasonic sensor senses the cracks and gives information to microcontroller. At this instance the microcontroller signals the motor driver to stop the motor. The GPS module provides the lateral and longitudinal coordinates to microcontroller. Microcontroller then gives the location of defects on web page shown in figure 4 and the live map location is shown in figure 5. The table 1 shows coordinates of crack location once all the process of detection of crack along with the submitting of exact location of crack is done microcontroller signals motor driver to start the motors and move forward. The motors continue to move forward and detect any cracks or defects. The same process is followed thereafter.

Table 1: Coordinates of Crack Location

CRACK	LATITUDE	LONGITUDE
1	15.51	74.13
2	15.51	74.14

I. CONCLUSION

The prototype of railway track failure detection system is successfully designed and is represented by figure.3. The latitudinal and longitudinal coordinates are shown in real time database in figure 4 and live map location is shown on figure 5. The main aim of the prototype is to detect the cracks on rail track by use of ultrasonic sensor and display the exact location of the crack on the web app with the help of GPS module. This system can be implemented on a large scale in order to have safe and sound infrastructural facilities for better results.

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