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Demonstration of an Intelligent and Efficient Smart Monitoring System for Train Track By using Arduino

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ABSTRACT- In Indian railway, the smart monitoring system for the train also train track is a significant aspect to prevent accidents. Indian railway system is underdeveloped in terms of smart monitoring of the train when compared with the other developed countries. Using the smart monitoring system for train, the deterioration of the railway track could be identified and secondly, accident between two trains could be prevented, thirdly any obstacle present in railway track, could be find and removed, two coaches of the train getting disconnected during the movement of the train due to manufacturing mistakes could also be detected. It helps to detect fire in the particular coach of train. Smart monitoring of the train can be achieved by the help of some semiconductor devices such as laser, laser camera and photodiode is used. Smart monitoring system of the railway could help to monitor the train and its track in an efficient way it could be implemented in Indian railway to avoid accident and extricate people's life.

General Terms: Intelligent Systems, Security, Sensor Networks et. al.

Keywords: Arduino, Sensors IR &Ultrasonic sensor, LCD, Atmega328, GPS & GSM Module.

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1. INTRODUCTION

One of the greatest inventions by the human mankind is the transportation vehicles. Railway transportation is one among the important vehicle since it is economical, secured and fast-moving mode of transportation to the customers. In 16 April 1853, the India's first train ran from Bori Bonder to thane on stream engine it was the first passenger train in India. There are many developments have taken place from this time. During this period there is no AC coach available in the train but now a days both AC and sleeper coaches are available for the use of passengers. Besides all these improvements, many more developments are required to be done by the railways. Railways is the important mode of transportation for people also for transporting goods from one place to another. Hence, to meet the requirements implementation of smart monitoring system of train is especially important which will reduce the number of train accidents.

In this project Arduino is central and most important thing. By connecting laser, photodiode, fire sensor with Arduino the smart monitoring system of the trainis achieved effectively. Arduino works as theheart of the smart monitoring of the train. In this project some semiconductor devices have been used such as laser used to find any obstacle inthe railway line. Laser camera is used for the 3D photography of an obstacle. Sometimes particular it may get fire, so to prevent the fire from reaching the passenger compartment fire sensor and camera module is being used. Whenever fire accident happens driver get notification of fire with the help of camera module and fire sensor. Strong electromagnet is used to mitigate the problem of the coach separation, to achieve this very strong electromagnet is needed that can attract the tons of weight when the coach of the train gets separated.

The article is organized in the following manner. The *section 1* discusses the introduction, Secondly, the *section 2* describes the literature survey, *section 3* is the methodology of the proposed design, *section 4* describes the demonstration of the proposed design, *section 5* explains the results and discussion and finally section briefs the conclusion with references.

2. PRINCIPLES

In their research paper different IR sensor mainly four sensors are used to open and close the gate of the railway gate. The important idea of this work is to reduce man power to opening and closing of the railway gate and preventaccident due to human errors in closing and opening the railway gate. Previously, IEEE 802.15.4 and ZigBee are used to sense the high speed and vibration of train. But there is a delay in the transfer of information in these techniques [1]. In this paper the authors utilized seismic sensor to identify the vibration. The level of vibrationmay be high or low which depend upon the

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directionof acceleration. If the value of vibration is not normal, It is predicted that, there is a defect in the trial [2]. The obstacles and the cracks in the tracks are detected by the proposed method. This uses the ultrasonic sensor at 100cm and switches off at 30cm also when the train travel in slow phase while the train is at a distance of 20cm. The sensor automatically stops at distance less than 20cm [3]. The researchpaper explains the railway crack detection using IR sensor and blue tooth technology. If crack is identified sensors immediately transmits the location of the crack through Bluetooth to the registered mobile phone. The sensors automatically prevent the accidents with low-cost investigation [4].

The proposed method provides GSM (Global System for Mobile communication) along with gas/smoke sensors integrated with LM35 to prevent the fire accidents. The Arduino enables the buzzer and gives the alert signal to GSM network, If the temperature is greater than 80 then motor will rotate and open the knob of the fire extinguisher when the heat sensor senses the temperature, thus preventing fire [5]. To fault is identified and fault location is also determined with the help of proposed design of IR (Infrared Radiation) sensor and GPS (Global Positioning System) with the control of longitude and latitude coordinates which is sent to predefine a mobile number [6].

The work describes the prevention of accident of train. Also, they constructed a device which can find the crack in railway track using IR sensors and charge the battery of the Arduino with the help solar panel cell [7]. This paper aims to solve the problem of railway crack by the proposed IR sensors for detecting the crack by implementing 2560 Microcontroller using GSM based. GPS Manual detection of crack is not so effective, and it consumes time [8]. It uses a ultrasonic sensor, bump sensor, infrared sensorto detect any obstacle present in the railway It utilizes a vibration sensor to find the level of vibration in the train to alert the people who are near to the track [9].

The Ultrasonic sensor is applied to sense the obstacle and relay is implemented to apply brake track.in this paper, automobile is fully controlledby the microcontroller by taking signal from Arduino [10]. A proposed model of GPS tracking system with WIFI module used to detect railway crack and an alert message are sent. A Raspberry Pi3 is used to coordinate and control the performance of these devices which stops train derailment [11]. In the project theyuse IR sensor to detect obstacle and send messages to the right authority using Bluetooth module. They design a detection of track using an Infrared sensor which is operated with GSM and GPS. The detected obstacles alert message is sent to the operator and automatic braking is applied by activating the relay [12].

Two ultrasonic sensors to detect crack and integrated with Arduino for displaying message to the maintenance team. Communication with the end users is realized by the GUI in this system of crack detection. In order to reduce railway crack in railway track, a railway crack detector device installed into an essential.[13]. The natural or artificial presence of crack in the railway track, is detected by the IR and Ultrasonic sensor network. The GPS module and GSM modem used to find and send the geometric parameters of crack detection to the nearest railway station. If installed the fault can be prevented using, low power consumption and less cost [14]. Accelerometers and gyro sensors are implemented to detect with good accuracy of the railway crack deformation. The Direct-Cosine-Matrix (DCM) has been utilized to get the data from the Inertia Measurement Unit (IMU) sensor for both acceleration and prevent the tilt movement of the train [15].

Sensors implemented for continuous monitoring of railway tracks. Computational analysis is carried out by the data collect and gathered by the sensors by which the faults in the railway tracks are identified and catastrophic accidents are prevented [16]. Implementation of Microcontroller does the inspection of parallelism, levelling, etc. based on principles of sensing and data acquisition. By using this it will overcome the challenges in existing system faced by the Railway non-synchronization between sensors and motor for switching timing of sensor and motor of mechanical system [17]. They experimented a fast-track quality calibration system using gyro sensor.In their work they built a system that consist of very minute railway lineto raise the level of actual train on railway line scenario. In their proposed system, they built a project that can keep the track of the train by placing a sensor in motor driven unit. This project also helps to find the missalignment in a railway track [18].

3. PROPOSED METHODOLOGY

3.1 System Design

This section discusses the proposed method of system design under four different cases situations. They are first case detection of crack and second case detection of obstacle, third case to detect the separation of two coaches and last case collision between two train. All the sections are clearly explained with the description, algorithm of detection and with necessary flowchart.

3.1.1. Case I: Detection of Crack

One of the factors which cause the rail accidents are due to derailments because of the cracks on the rails which happens because of natural disasters. Hence this paper suggests a low-priced, novel structure with adequate potential also convenient to the Indian scenario. The *fig. 1* shows the flow chart for crack detection. The algorithm for finding the crack in railway track is explained below. Hence this paper suggests a low-priced, novel structure with adequate potential also convenient to the Indian scenario. The *fig. 1* shows the flow chart for crack detection. The algorithm for finding the crack in railway track is explained below.

The algorithm for the detection of crack in railway track
Step1: Start the module.
Step2: Register the sim in the module.
Step3: If crack detected mobile will be on and it will receive the message.
Step 4: End the module.

In this proposed design we use a sensor to detect the crack, once if crack identified it is sent to mobile which is already connected

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with the GSM. So, it gives an alert signal, so accident is prevented.

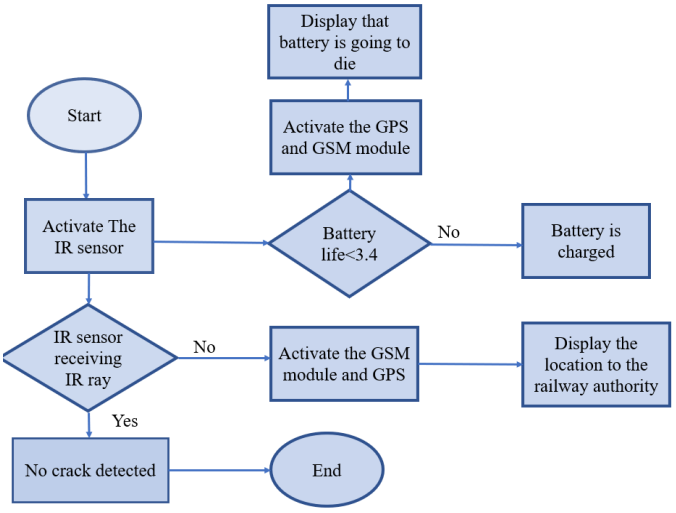

Fig. 1: Flow Chart for Crack Detection

3.1.2. Case II: Detection of Obstacle

In railways another problem is the obstacle present in track, it is important to detect the foreign objects on railways for transportation safety. In practical, unnecessary objects can appear anywhere and anytime on the railway tracks. In this proposed framework, the problem of crack detecting to prevent the accidents.

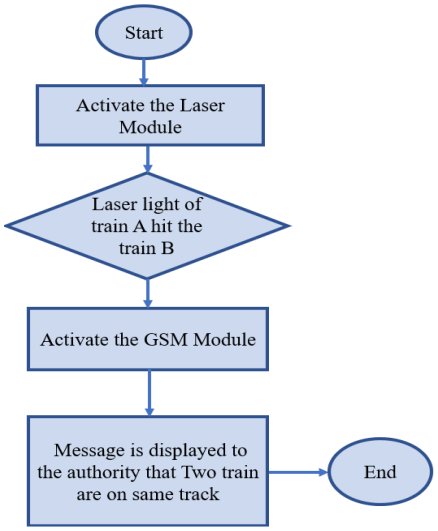

Fig. 2: Flow Chart for the Object Detection

The algorithm for the detection of obstacle
Step 1: Start the module
Step 2: Register the sim in the module
Step 3: If crack detected mobile will be on and it will receive the message
Step 4: End the module.

In this proposed design we use a sensor to detect the object, once if foreign object is identified it is sent to mobile which is already connected with the GSM. So, it gives an alert signal, so accident is prevented.

3.1.3. Case III: Detect the separation of two coaches

The next primary most important damage that occurs are the separation of coaches under unfavourable situations.

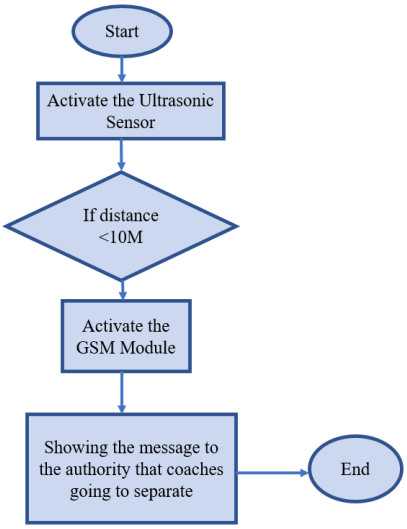

Fig. 3: Flow Chart for the Detection of Separation of Trains

This must be taken care in the at most cases. In railways another problem is the separation of two coaches in the track. It is important to detect the separation of bogie on railways for transportation safety. In practical, unnecessary separation of bogies can appear anywhere and anytime on the railway tracks. In this proposed framework, the problem of bogie separation will prevent the accidents. The *fig. 3* shows the flow chart description for the detection of separation of trains. The algorithms for the detection of separation of two coaches are explained below.

The algorithm for the detection of separation of two coaches
Step 1: Start the module.
Step 2: Activate the Ultrasonic laser
Step 3: Activate the laser to calculate the distance
Step 4: Activate the photo detector to reflect the laser
Step 5: Activate the electromagnet if distance less than 200m
Step 4: End the module.

3.1.4. Case IV: Detection of Collision Between two Trains

Collisions of train are the most disastrous accidents. It is difficult to stop train collisions because, the speed of moving trains is very high. This requires a lead distance to stop the train. Collisions of train can arise due to human errors or equipment faults. The reason for train collisions with the running trains in tracks because of the negligence of safety guards and harsh weather conditions. The proposed design supports to protect the human life from collision-based train accidents by implement this work in railway transport. *Fig. 4* shows flow chart for the collision between two trains. The algorithm for the detection of separation of two coaches are explained below.

The algorithm for the detection of separation of two coaches
Step 1: Start the module.
Step 2: Activate the laser to reflect from front end.
Step 3: Activate the photo detector to reflect the laser.
Step 4: Activate the LED module.

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Step 5: Display train is detected.
Step 6: End the module.

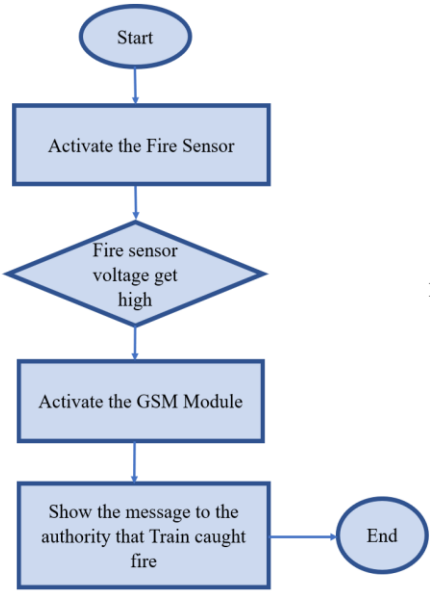

Fig. 4: Flow Chart for the Detection of Collision between two Trains

4. RESULTS AND DISCUSSION

4.1 Demonstration of the proposed design

IR sensor is utilized in finding the breakage andcracks in railway line by pumping and collecting IR signal at a particular distance. This DCgenerator is used to power the Arduino DC motor which is connected to the back wheel. Whenpushing force is applied to the wheel thenmechanical energy of the backside tyre startrotating and convert mechanical energy into electrical energy. This gives power to the Arduino andrun the front two motor as front tyre is rotating itpulls the back tyres. Because of this it rotatesthe motor and Arduino get constant 5V.

If crack is found in railway track, then byusing GPS latitude and longitude coordinateswill be sent to railway authority by using GSM Module. The specification of components and the list of components are given in the *table 1*.

Table 1: The specification of components and the list of components used in the proposed method.

S.NO	COMPONENTS	SPECIFICATION	VALUES
1	DC Motor	Operating max voltage Motor torque Max Power dissipation Size of Frame Operating max current Motor Speed	10 mV 0.36 to 160 nm 10 mW 8 to 35 mm 10 mA 5,000 to 14,000 rpm
2	IR Sensor	Range of Distance Weight IR Dimensions Voltage operating rang	2 cm to 30 cm 15 gm 48 x 14 x 8 mm 3.3 DC to 5 DC
3	GSM module	Min power consumption GPRS multi-slot GSM Compliant Max Supply voltage Dimensions Weight AT Control commands Dual-Band	1.5 mA Class-B- 10/8 GPRS mobile station phase 2/2+ 5 V 24*24*3 mm 3.4 gm GSM 07.07, 07.05 and SIMCOM enhanced Commands 900 / 1800 MHz
4	GPS module	GPS antenna Update rate. Support SBAS Start cold time GPS track sensitivity Start hot time Baud rates	18x18 mm 5Hz WAAS, EGNOS, MSAS, GAGAN 38 s 162 dBm 1 s 4800 to 115200 Baud
5	Arduino	Microcontroller Clock Speed Max Operating Voltage EEPROM Input Voltage Range Input Voltage (min to max) DC current for 3.3V I/O PWM Digital Flash Memory Digital PWM I/O SRAM Input analog Pin DC Current per I/O Pin	ATmega328P 16 MHz 5 V 1 KB 7-12 V 6-20 V Pin 14 50 mA 32 KB Pin 6 2 KB Pin 6 20 mA
6	Laser proximity	Max Current Voltage Temperature range Driver Transmit power Line length	40 mA 3.0 V to 5 V 36◦C to 65◦C APC 58 mW 135 mm
7	LCD Display	operate current Operate power Operate Voltage	10 mA 10 mW 5V DC
8	Ultrasonic sensor	Resolution Sensor output voltage range Ultrasonic sensor weight Ambient temperature Max target distance Sensing range Response time Beam angle Voltage range Preciseness Ultrasound operating frequency	1 mm 0 VDC to 10 VDC 150 gm -250 C to +700 C 5 cm x 5 cm 40 cm to 300 cm 50 ms to 200 ms 50 20V DC to 30V DC +5% 120 kHz
9	Photodiode	Light Resistance Diameter Rated Power	50-100 KΩ 3 mm to 20 mm 200 W

4.2 Detection of various flaw analysis

This section discussed about the operation and detection of crack. Set up of getting the detail of the location of a crack in the railway track using GPS module and send it to railway authority using GSM module.

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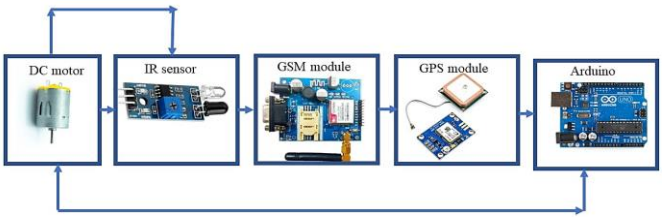

Fig. 5a: Prototype of crack detection robot

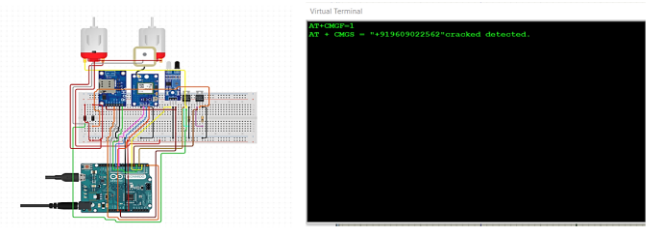

Fig. 5b: Prototype of crack detection robot hardware model

4.2.1 Obstacle Detection

Laser proximity is used to detect the obstacle present in the path by sending the laser light and analysing the reflected ray.

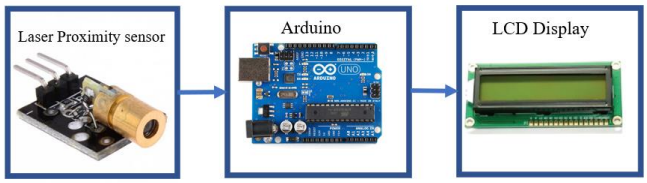

Fig. 6a: Prototype of laser proximity sensor and LCD

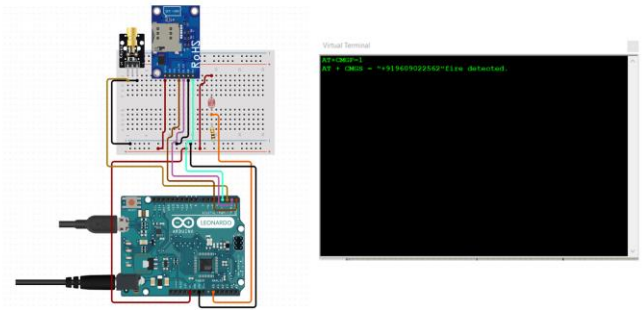

Fig. 6b: Hardware module to detect fire

Set up of Proximity laser which is used to find the hindrance or obstacle in the railway track during its motion.

Fig. 7a: Prototype of ultra-sonic sensor and Arduino set-up

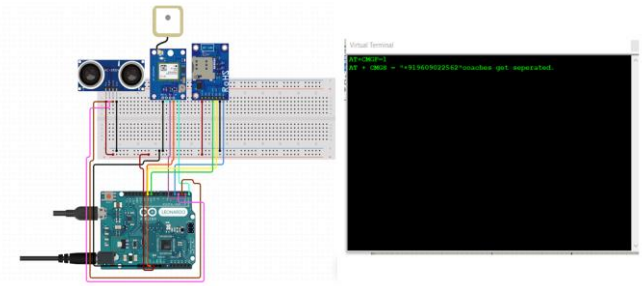

Fig. 7b: Module to detect separation of two coaches

Connecting ultrasonic sensor in between two coaches will maintain a continual distance length between them. If the distance is developed then using the attached camera calculation of the distance or attach sonar is performed to the Arduino and switch it on when coaches get separate to measure the distance. Laser has to connect at the backside of the coach and connect one polished surface to the adjacent coach and calculate the time it takes to get reflect back from the adjacent boggy and calculate the distance between the two separated coaches and at suitable distance switch on the electromagnet that is present between the coaches.

Setup to detect the separation of two coaches in the train during its motion as per the law of reflection it will reflect back to the photodiode of the train *B* after getting a signal through photodiode train *B* will stop and data can be sent to the police authority *via* GSM module.

In *Case 2* the train track is a little bit curved When two *train A* and *train B* will approach each other at curve point then vibration sensor on thetrack of the *A* vibration sensor send the signalArduino to lit the red light which is facingtowards a train *B* similarly vibration sensor onthe track of the *B* then vibration sensor sends thesignal Arduino to lit the red light which is facingtowards a train *A* so in this way two trains will stop at the junction.

4.2.2 Crack detection

In the part of crack detection system, if the crack is figured out in the railway track, then the message would be sent, along with the information of longitude and latitude of that location to the railway authority. In obstacle detection, if obstacle is observed in track during the motion of the train, then it will show message in LCD. In Laser obstacle detection/counter if obstacle in track is not detected then it will show **FREE**. In coaches' separation, in case the ultrasonic sensor shows a distance greater than 6cm then message will show on serial monitor that coaches get separated and also indicate to switch on the electromagnet between them. To avoid the collision between the two trains if there are two trains travel on the same track, the train which is behind the first train will get reflected laser from the first train in its photodetector and show a message to an operatorthat one train in front of him in the same track.

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5. CONCLUSION

This paper is presented a smart train and its track monitoring system. This work is splitted as four sections the first part is to figure out the crack in a railway line by utilizing an infrared sensor. Secondly, The Arduino is used for this work and the mechanicalenergy of the wheel is to be converted into electrical energy which provides power to an Arduino. The third part of the work is to reduce the problem of coaches' separation which occurs because of manufacturing fault. This can be achieved by ultrasonic sensor which shows a constant separation length between the coaches. If the length of distance calibrated by the ultrasonic sensor is increases then coach of the train gets separated. Further, we calculated the distance between the separated coach and the rest of the train using Arduino. The final part of the project solves the problem of train collision between the train units which are travelling on the same track this work on the law ofreflection.

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