Automatic Wireless Sensor Network Based Railway Safety System


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ABSTRACT

In the present state of railway transportation, the presence of railway monitoring system in railway networks ensures that the train control system becomes a much easier and safer system. In the modern day railway system, there are many problems such as derailments, fire accidents and etc. These problems are still happening in spite of the technological advancements made. Derailments may occur due to the primary mechanical failure of a track component, wheel breakage, excessive speed and signal error. Other disaster may occur due to the various reasons such as collision with other trains, road vehicles, or other obstructions like level crossing. Moreover, train derailment could also happen because of sudden traction or braking forces. In this paper, a new monitoring system for railway network based on wireless sensor devices has been proposed. This framework helps the railway system to detect the damage in the track, level of corrosion on wheels, bearing faults, object detection on tracks, and fire accidents in compartments.

INTRODUCTION

A safety measure for railways becomes a major concern in current state of the system (SatheeshKumar, 2010). In the existing system of railway transportation, the presence of railway monitoring system in railway networks ensures that the train control system becomes a much easier and safer system. But, still there are many problems, namely derailments, fire accidents and etc. (Selvamraj et al., 2012). This paper aims in improving the safety measures for above mentioned issues. For example, stopping the train at the initial stage of fire accidents reduces 80% of harms, since spread and flow of the fire is stopped at the initiated place. To bring down these issues, sensors with quick response time are used along with web portal which uniquely monitors and controls the various activities of the train operation (Robert et al., 2001). The activities include temperature, smoke, track and object monitoring. In this paper, an effective monitoring and control system for railway network based on wireless sensor devices has been proposed. This proposed framework will enable to detect the damages in the track, and fire accidents in the compartments and objects or living beings on the track.

Related Work:

There are quantitative works carried based on railway safety system, among which few of the works related to fire accidents, train crack detection and object identification in the tracks are discussed as follows. In (Antonio-Javier et al., 2010) the authors illustrate that Wireless Sensor Networks (WSNs) are being deployed in very diverse application scenarios, including rural and forest environments. In these particular contexts, specimen protection and conservation is a challenge, especially in natural reserves, dangerous locations or hot spots of these reserves (i.e., roads, railways, and other civil infrastructures). This paper provides the conceptual information of how sensors can be used for identifying generic target (animal) tracking in the surrounding area of wildlife passages built to establish safe ways for animals to cross transportation infrastructures. Authors have illustrated by building an efficient Wireless Sensor Network (WSN) with appropriate scheduling thereby improving the network lifetime and receiving the information at the server. This deployment is designed on the basis of the IEEE 802.15.4 standard. The system has been evaluated for the particular scenario of wildlife monitoring in passages across roads.

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The authors, (M.Pradeep et al, 2013) discuss that ultrasonic distance measuring sensors are widely used in many industrial establishments and particularly in the metrology area. These sensors are used in many engineering disciplines because of their high-precision characteristics of different methods. In addition, Global Positioning System (GPS) receivers and total stations are widely used in geodesy. Using the GPS receivers is very popular, particularly for navigational purposes different techniques. In this paper, a new railway track geometry surveying system is introduced which is designed by integrating the ultrasonic sensor, fire sensor, GPS receiver, and total station. This new surveying system is an alternative to classical geodetic measurement methods that are often used for Advanced RISC Machine (ARM) controlling the railway track geometry. To identify the location of damage detection of track gauge, and track axis coordinates, which are railway geometrical parameters, can be instantly determined while making measurements by using the new surveying system (Navaraja et al, 2014).

In (Ch. Muneendra Rao, 2014) & (V. Pedda Obulesu, 2014), the train crack detection using the Light Emitting Diode - Light Dependent Resistor (LED-LDR) sensors are illustrated. The work proposed by M. Praveen Kumar et al (2013) mainly targets on the fire accidents in train. The fire may occur in any form of activities such as short circuit in the electrical wires, prohibited activities of carrying diesel, petrol, gas stoves and smoking nearby them will cause fire accidents. To overcome this, a system of having automatic sensor monitoring, fire alarm warning and fire extinguishing are based on ZigBee wireless sensor network technology. This system can monitor real-time related parameters such as temperature and humidity in each coach. From the information collected by the system, decisions for fire fighting, alarming, and automatic operation of the train braking system can be made more quickly by the system or engine driver. The engine driver will get the warning light and he stops the engine.

**railway safety system model:**

A system is designed modally, which will sense the heat, smoke, clear distance and the rails condition (L. Beales, 2003) (Charan, 2013) and sends the data to the main system using the RF433 MHz transmitter and receiver. In the receiver, the data’s are validated and sends an alert to server if the sensor values reach the specific threshold respectively. In this proposed model, the system has two parts whereas the first one is the transmitter placed in each rail cars and receiver as the second which placed at the rail engine cabin.

### A. Transmitter side:

**Fig. 1:** Transmitter Block Diagram.

The sensors and the transmitter are connected as shown in Fig 1. The sensor module i.e., Arduino Uno processor at the transmitter side, reads the sensor data and stores them as an array of strings. It gets transmitted to the receiver. The entire model is connected with the non-replenishable power supply. It doesn’t need any monitoring. All the data’s are collected and transmitted via the transmitter (J. A. Stankovic et al, 2003).

### B. Receiver side:

**Fig. 2:** Receiver Block Diagram.

**Implementation of railway safety system:**

**A. Transmitter system:**

The transmitter system is placed in all the rail cars of the train. The transmitter system is equipped with Arduino embedded ATMEGA 328 chip (http://www.arduino.cc/). It is connected with RF433MHZ transmitter, LM35, smoke sensor, ultrasonic sensor and LDR - LED sensor. The transmitter module is shown in Fig. 3 necessitates only the need of power supply to handle its activities.
The transmitter is preloaded with transmitter programming module inside the Arduino module using embedded C. It is programmed to continuously monitor the activities of train using the sensors attached and transfers data regularly to the receiver. These data’s are arranged in an array and made as single string and transmitted via the RF 433 MHz transmitters. In this circuit design, 3 analog pins and 3 digital pins are used to connect the components with the Arduino microcontroller board, so that data gets transmitted to the receiver.

**B. RECEIVER SYSTEM**

The receiver system is placed in the rail engine of the train as shown in Fig. 4 equipped with Arduino embedded ATMEGA 328 chip. This system is connected with RF433MHz for receiving the data from transmitter. In addition, the receiver module is also connected to a control system which enables the engine driver to monitor. The driver is also notified about the critical situation based on the data, provided that the necessary preventive or precautionary measures can be carried out such as manually stopping the train, notifying the near control rooms and etc. Here, the receiver system plays the major role for ensuring the safety of the railway passenger by initiating, monitoring and controlling the railway system.

As like transmitter, the receiver side also gets the data as a single string, which is split into ‘n’ number of arrays of data. Using this array the data can be separated and used according to the sensors and threshold. In the receiver side the motors and buzzer are connected, if the threshold reaches a specified value the motors will stopped and the buzzer will start to alarm.

**Results:**

In this system a user interface is provided where the driver can manually control the train at any situation. But, this system will also work automatically when the sensor values reach its respective higher threshold.

**Fig. 5:** User Interface (UI).

Fig. 5 shows the user interface designed using Visual Basic (VB), which is interfaced with the serial port of the Arduino receiver. When a button is clicked, it sends a character through the serial port and then Arduino reads the value and prints the required data to serial port again. This data is read at the server and displayed in the user interface.

**A. Get temperature:**

**Fig. 6:** Get Temperature using UI.

The above Fig. 6 shows the temperature of the passenger car when Get Temperature button is clicked. Using this interface, the temperature can be viewed, and if the data reached the user defined threshold it automatically generates the alert and the train can be stopped manually. The value read by the Arduino will be in the form of Volts, which is then converted to Celsius. The interface displays the converted Celsius value as shown in Fig. 6. Similarly by clicking the Get Smoke Value button, the user can view the smoke value in each rail car. The value is read in the form of Volts, which is then converted to
ppm (Parts per Million) and if the data reached the user defined threshold it will automatically give the alert so that the train can be stopped.

B. Check track:

The user interface also provides the facility for the user to verify the status of the track as shown in Fig. 7. It verifies and displays whether the track is in good condition or the track has any crack or disjoint. This can be verified by clicking the Check Track button.

Fig. 7: Check Track Status (Normal) using UI.

The above Fig. 7 shows that the track is normal at that time. Which means the LED is not fall on the LDR. Because of this, the value will be low and informs that there is no damage in the track.

Fig. 8: Check Track Status (with crack) using UI.

The above Fig. 8 shows that a crack or disjoint has been detected on the track. This is done by the LDR, which reads a high value when the LED falls on it. Using this information, the train can be stopped automatically and start to alert. It can also be done manually. The train will stop automatically when the value received by the LDR is high for 2 seconds. This is done when the driver doesn’t monitor the status.

Conclusion:

Wireless Sensor Networks are increasingly applied in the field of safety monitoring and control. Especially in METRO railways that are victim to fire accidents and derail. In addition, wireless sensor technology has a broad application background in the field of real time monitoring. This system has not been applied in practical train for monitoring and control. To monitor temperature and humidity in the rail cars in a more timely and precise way, a unique way of achieving safety in signal transmission, flexibility in set up and low cost has been pointed out in this work. This system has been proposed as a first attempt and compliment to Indian railways to monitor and control the system which includes object detection, fire and derails all together. By extending the potential of current system, the safety of the Indian railways can be improved by avoiding train accidents of all aspects in future.

As a part of the future work, interfacing with an Ethernet shield, the current system extends to replace the software driven control into web based monitoring and control of train. Implementation of web based architecture for safety of train also be enabled to automatically alert the recently crossed control station and the next control station of the railway system. It can also be extended to possibly to alert the nearest hospitals and police stations in case of emergencies if web portal based control is implemented.

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