ROBOT FOR RAILWAY TRACK MONITORING WITH OBSTACLE DETECTION AND DATA SECURITY

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Abstract -*In India, rail transport occupies a prominent position in meeting the ever growing needs of a rapidly developing economy. However, in terms of the reliability and safety parameters, global standards have not yet been truly reached. The associated safety infrastructure facilities have not kept up with the continuous advancements. Our facilities are inadequate compared to the international standards and as a result, there have been frequent derailments that have resulted in severe loss of valuable human lives and property as well.*

The existing systems for railway track monitoring are manual. The person manually have to travel along the track using a 2 or 3 wheeler trolley and gadgets to detect the faults. Advanced Systems for track monitoring include the methods like Laser Proximity, IR method, LDR method etc. But these methods have certain drawbacks which affect their performance and accuracy. Existing robots occupy the track and thus themselves create an obstacle for train to pass. So, manual intervention is more in current systems which may induce errors. Our aim is to make this complete process automatic.

The proposed system is a robot that will work to find out the cracks and other anomalies of the railway track. The robot will run along the tracks automatically. It will detect the presence of humans on the track and if a train is approaching it will start a loud buzzer to warn them about the train. If some anomalies are detected then the latitude and longitude of that location will be send to the nearest railway station and there the exact location of the fault can be retrieved by using our android application. From this information necessary action can be taken. The data send by the robot should not be tampered by any adversary and for that purpose the data security is also provided.

Key Words: Track, Robot, Encryption, autonomous Arduino, Railway

1. Introduction

The major cause of the accidents is derailment which is mostly caused due to cracks or faults in the track or some obstacles which force driver to apply urgent brakes and the derailment occurs. The proposed product is an extension to the currently existing systems for monitoring the railway tracks in India. The current manual systems will be automated so that continuous monitoring can be done and accidents can be avoided. The product will add new features to current systems to make it more accurate and useful. The different subsystems of the product will be linear movement along the track, fault detection, folding the arms upon train detection and sending message about fault to officials.

2. Related Work

Most of the research papers followed a traditional literature survey for all modules. Some works proposed innovative ideas and some gave designing techniques.

1) The presented system helps to detect the flaws in the rail track using ultrasound testing method. When the crack is detected, respective coordinates are send to the nearest station [2]. This recording and sending of coordinates is done by GPS and GSM module. Ultrasonic technique is the most effective system it even detects minor cracks and also calculates the growth rate of the crack. The growth rate can be detected after several observations at regular intervals. The drawback of the system was that the security while sending the data was not considered [2].

2) The core of the proposed crack detection scheme consists of a Light Emitting Diode (LED)-Light Dependent Resistor (LDR) assembly that functions as the rail crack detector [5]. The principle involved in crack detection is the concept of LDR. In the proposed design, the LED will be attached to one side of the rails and the LDR to the opposite side. During normal operation, when there are no cracks, the LED light does not fall on the LDR and hence the LDR resistance is high. Subsequently, when the LED light falls on the LDR, the resistance of the LDR gets reduced and crack get detected. The drawback of the system is that track is occupied and also the result get affected due to sunlight [5].

3) In the given system, the robot is designed for finding cracks in the railway tracks [4]. The microcontroller is interfaced with Robot, ZigBee, GPS, LCD and Crack Sensor. The IR sensor senses the voltage variations from the crack sensor and then it gives the signal to the microcontroller. It checks the variations in the voltage of the measured value with the threshold value. If it detects the crack in the railway track, it immediately gets the exact location information using Global Positioning System (GPS) and Global System for mobile (GSM) and sends that location and crack information to the control section [4]. The main drawback is that the results of IR sensor are not accurate in light. The energy efficiency of the system is low.

4) This paper proposes a secure data transmission scheme based on digital watermarking technique [9]. The sensor node calculates the hash value of sensitive data, which collected at two different times. Then, the sensitive data are embedded into the hash value as watermark information according to the digital watermark algorithm. The target node extracts the watermark information from the hash sequence exactly. It calculates the hash value in the same way as source nodes did, and compares to the remaining part of hash sequence which not changed during the extraction operation to verify whether the data have been tampered with.

3. Methodology

The proposed system in fig.1 is a robotic vehicle and an android application. that will work to find out the cracks and other anomalies of the railway track. The robot will run along the tracks automatically. It will detect the presence of humans on the track if a train is approaching and will be start a loud buzzer to warn them about the train. When the train will be approaching the tracks will be cleared by the robot by folding it's arms automatically. After the train passes the arms will be automatically unfolded and working starts again. If some anomalies are detected then the Latitude and longitude of that location will be sent to the nearest railway station and there the exact location of the fault can be retrieved by using our android application. From this info and necessary action can be taken. The data about any fault that is send by the robot should not be tampered by any adversary and for that purpose the data security is also provided.

Fig.1 can give the clear idea about the flow of complete system.

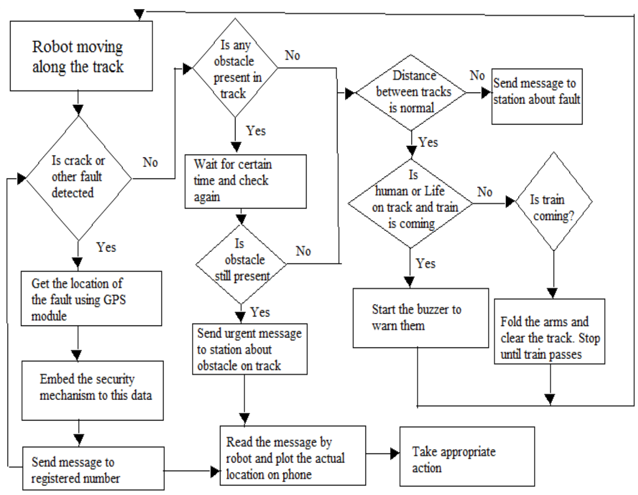


Fig -1: System Overview Diagram

The robot will be operated by Arduino (ATMEGA 328) microcontroller. The coding of the Arduino is done in Embedded C language and the Arduino IDE is used for the coding purpose. The code is written and compiled in Arduino IDE and is then uploaded in the memory of the microcontroller where it is executed. The operating System used is Windows. The proposed system consists of hardware part which is a robot and the software part which is an android application. It will receive the latitude and longitude of fault location from the robot and will plot them against the Map so that exact location of fault can be found. The user interface is at the software part only. The application will show the Map of the location where the fault is detected by the robot.

3.1. Flow of Working

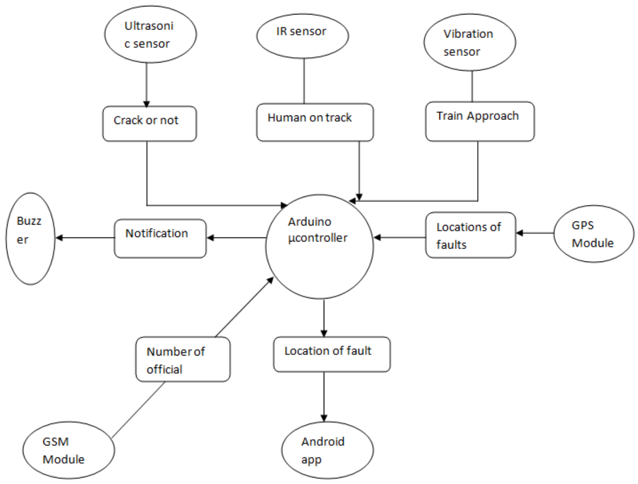


Fig -2: Data Flow Diagram

The above figure shows how different modules of the system works with co-ordination. Arduino controller is at the center of the system. Sensor continuously sense the environment and gives input to Arduino such as crack is detected or not ,whether there is obstacle on the track or train is coming etc., in turn Arduino controller sends the location of crack to administrator using GPS And GSM modules or it starts the buzzer if obstacle is detected on the track. Arduino controller commands robot to fold its arms if train is coming.

5. Implementation

This chapter deals with the role of all the 5 modules of the railway track monitoring system discussing the implementation of the major functionalities.

5.1 Crack Detection:

This module uses Ultrasonic sensors to measure the distance between track and the sensors using ultrasonic waves. Those waves reaches the receiver in specific time. If waves does not reaches receiver in specific time it shows distance between track and sensor got varied and which in turn shows crack in track. This module also starts GSM module to send massage to administrator. GPS module will help in plotting the location of the crack on the google map.

"Analog_Read(sensor)" function is used to read the sensor data.

A. Algorithm Crack Detection

```
Start:
{//Record time for normal track to receive transmitted
UT signal
While (true)
{//Collect readings from sensor continuously.
        if(readings are within normal range)
        //continue;
        else
        {
        //crack or fault has been detected
        //report the fault
        }}}
```

5.2 Obstacle and human Detection

This module also uses ultrasonic sensors to sense the obstacle present in front of robot. Robot will stop after detecting obstacle and runs backward for small distance.

5.3 Track Clearance

This module uses vibration sensor to sense the vibration of approaching train. As soon as vibrations get sensed, Arduino will start servo motors to fold the arms of robot. Servo motors are interfaced with robot using Arduino. Here, "attach()" function is used to configure servo motor object with the Arduino pins. "Analog_Read(sensor)" function is used to read the sensor data.

Interfacing of vibration sensor with Arduino:

The vibration sensors have 3 pins namely: Vcc, Gnd, Analog Output. The analog output is fetched from the sensor onto the Arduino using the analog input pins available on it. The intensity of vibrations is checked and subsequent action will be taken.

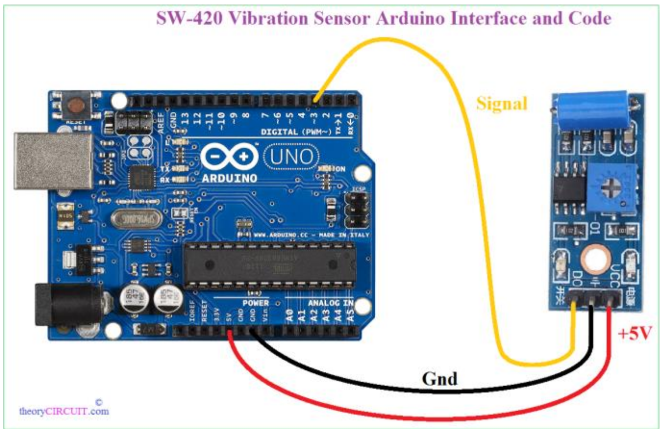


Fig-3. Interfacing of Vibration sensor with Arduino

5.4 Data Security

AES and DES algorithms are used to secure the data transmission. Location of the crack is sent to administrator after embedding it with some encryption. The more popular and widely adopted symmetric encryption algorithm likely to be encountered nowadays is the Advanced Encryption Standard (AES). It is found at least six time faster than triple DES.

The features of AES are as follows:

- Symmetric key symmetric block cipher
- 128-bit data, 128/192/256-bit keys
- Stronger and faster than Triple-DES
- Provide full specification and design details
- Software implementable in C and Java

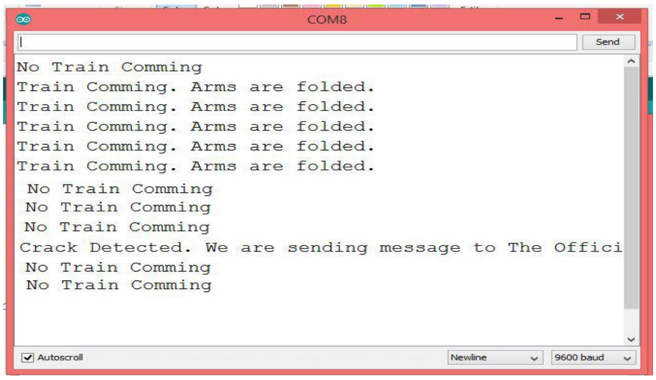
AES is an iterative rather than Feistel cipher. It is based on 'substitution–permutation network'. It comprises of a series of linked operations, some of which involve replacing inputs by specific outputs (substitutions) and others involve shuffling bits around (permutations).

The code snippet below depicts the Data security module :

```
public static String encrypt(String plainText, int shiftKey)
{plainText = plainText.toLowerCase();
String cipherText = "";
for (int i = 0; i ¡ plainText.length(); i++){
int charPosition = ALPHABET.indexOf(plainText.charAt(i));
int keyVal = (shiftKey + charPosition) char replaceVal =
ALPHABET.
charAt(keyVal);
cipherText += replaceVal;
}return cipherText;}
public static String decrypt(String cipherText, int shiftKey)
{cipherText = cipherText.toLowerCase();
String plainText = ""; for (int i = 0; i ¡ cipherText.length(); i++)
{ int charPosition =
ALPHABET.indexOf(cipherText.charAt(i));
int keyVal = (charPosition - shiftKey) if (keyVal ¡ 0)
{ keyVal = ALPHABET.length() + keyVal; }
char replaceVal = ALPHABET.charAt(keyVal); plainText +=
replaceVal; }return
plainText; }
```

6. Results and Discussion

Following screenshots gives idea about how system is executing and how we are getting proper results. Robot continuously monitors the track, w hen train is coming it fold its arm as shown in the figure below:



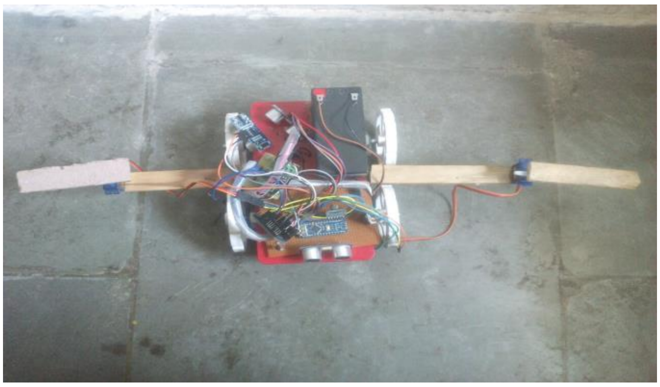


Fig -4: Robot without folded arms

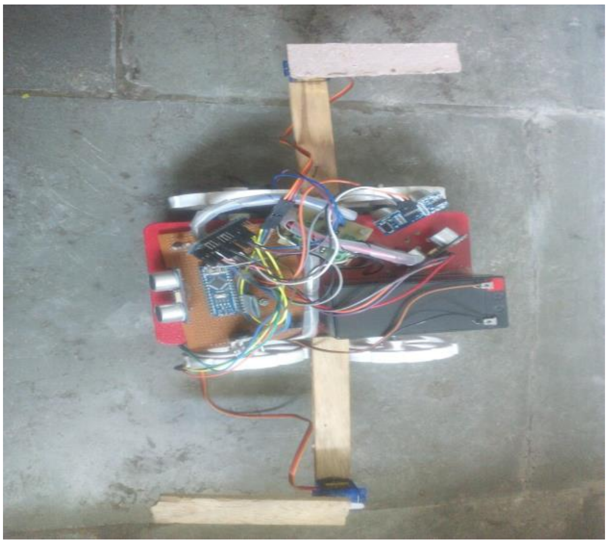


Fig -5: Robot with folded arms

From the execution of this system and after analyzing the results we came to know that following are some of the key factors over which the systems functionality depends.

1. Accuracy of Sensors: Sensors used for crack detection, obstacle detection and to sense the vibration should be more accurate to get correct result. Ultrasonic sensors used are more accurate than IR sensors in daylight as well as it gives us actual value rather than giving only Boolean value.

2. Internet connection: Faster Internet connection would help in sending massage to administrator more fast and to plot it on google map more efficiently.

3. Battery life: Battery life of robot should be longer so that it will be more durable.

7. Conclusion

This proposed system makes railway track monitoring more autonomous. Ultrasonic sensor used in the robot gives more accuracy to detect the faults compared to other available sensor. Also encryption techniques used prevents data tampering while transmission. So overall system is more accurate, robust and secured and helps in reducing railway accidents with high margin.

8. Future Scope

The system has a varied implication on railway track monitoring. This system can be integrated with various other track monitoring modules such as cleaning, detection of other anomalies etc. Autonomy of the robot can be increased which helps in reducing manual errors. The system can effectively lessen human labor in adverse conditions, maximizing the profit margin and minimizing the labour cost.

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