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IoT: Automatic Broken Railway Track Detection with Live Video Streaming

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Abstract: *The Indian railway is the seventh largest railway system in the world. The maintenance of the gargantuan transport system can be problematic and human error can cause a crisis. Economic level is mainly depends on increasing the capacity and level is mainly depends on increasing the capacity and level of transport. Till date there are cases of rail derailment due to track fracture. The proposed system is a solution to automatically detect a crack in the railway track along with live video streaming. Internet of Things is the most researched field and its applications are limitless. Internet of Things (IoT) is implemented to give an up to date update on the railway system. In this model ultrasonic is used for surveillance and GPS receiver is used to track the location of the crack. A GSM module is used to send messages to notify the authorities about the fracture. A camera is fixed to provide the live video data to analyse the rupture from the base stations.*

1. Introduction

Railway is one of the most conventional methods of travelling and is the most commonly used means of transport. India has the world's seventh largest railway system. The detection of fractures in such extensive system of 115,000 km of track around the country increases the probability of error rate. Many derailment cases due to track fracture have been cited even to this date. A few cases are cited below

a) On November 2016, a tragic derailment of the Indore- Patna train claimed the lives of 147 passengers and 180 passengers were injured. The train derailed due to rail fracture near Kanpur.[3]
b) On 28th December 2016, Sealdah-Ajmer Express derailed near Kanpur, which reportedly has many rail fractures, and 22 passengers were severely wounded.[4]
c) On August 2016, 12 coaches of Thiruvananthapuram-Mangalore Express derailed due to broken rails. Though there weren't any casualties, it caused a lot of traffic issues and property loss.[5]
d) Jagdalpur-Bhubaneswar Express derailed on its way to Bhubaneswar claiming the lives of 27 passengers and 36 passengers were injured.[6]
e) On January 2017, the Hirakhand express derailed near kuneru in Andhra Pradesh killing 41 people and inflicting injuries on 68 people in an accident whose cause is suspected to be due to rail fracture.[7]

The above cited scenarios are tragic events due to rail fracture. The previously mentioned misfortunate incidents happened just within the past seven month duration at four different places. The railways extend all throughout the country and accidents have been recorded since 1890. Countless lives were lost due to improper crack detection. The rupture may happen due to temperature changes, aging of the rails or by using defective rails during the construction. If a crack is detected at an early stage, the derailment and loss of lives can be prevented.

The GSM (Global System for Mobile Communications), GPS (Global Positioning System) and microcontroller based broken railway track detection when implemented is an efficient method of detection of cracks which is present in the tracks and thus avoiding derailment of the trains. The implementation of Internet of Things (IoT), which is a fast growing technology in the present times, is used for smart surveillance system. This system is used in-between two stations which will detect the cracks present on the track using ultrasonic sensors which transmit sine waves for an ideal track. If a crack is detected the ultrasonic sensor will send a signal to the Arduino Uno board which will activate the GPS receiver. The GPS receiver will pin point the exact location which will then be messaged to the authorities. Once the ultrasonic sensor sends a signal to the controller, the controller will initiate the webcam. The webcam will provide the live feed of the track. The live feed and the data from the GPS will be updated in the website. This smart technology will be a part of the brave new digitalized world which will be able to prevent the loss of precious life or property as the above mentioned cases.

2. Existing System

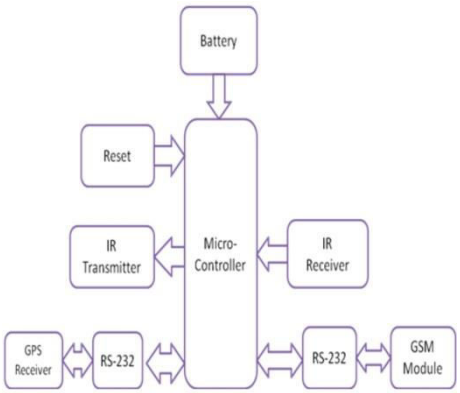

Figure 1: Crack detection using IR.

The existing system portrayed in Figure 1 uses a microcontroller for the manipulation of the other peripherals attached to the system. The sensing system used in this technique is an IR transmitter and receiver. If light is incident on the IR transmitter, the intensity of light is directly proportional to the intensity of the crack present in the tracks. The IR receiver will then give a signal to the GPS receiver which will pin point the latitude and the longitude coordinates and sends them to the GSM module which will send a message to authorities. [4]

3. Proposed System

The embedded system depicted in Figure 2 utilizes Raspberry pi 3 and Arduino Uno microcontrollers which acts as the processing unit for the other peripherals interfaced with the controller. [1][2][3].

An arduino board is incorporated in the model which acts as an interface between the ultrasonic sensors and the GPS, GSM, and the Raspberry pi board which controls the bot and the video camera. The Raspberry pi is also used for synchronising the data received into the website.

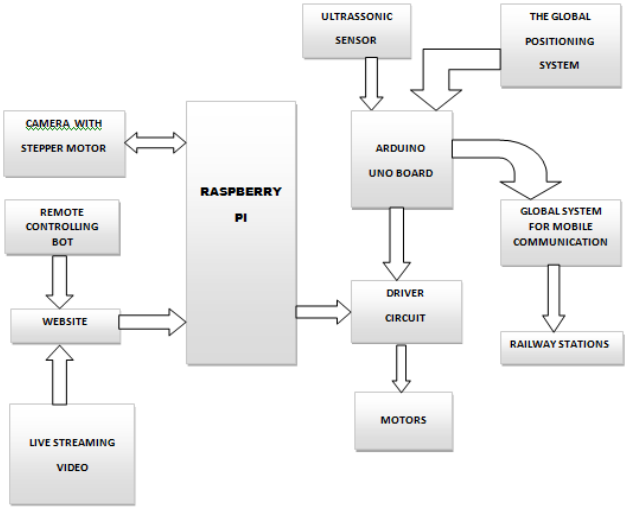

Figure 2: IoT interfaced crack detection system.

The complete system is placed on a four wheeler bot which travels along the rails. Using commands, the bot moves along the track. The Bot is able to move forward and backward and the web camera, which is placed in front of the device, can progress in all four directions of up, down, right and left.

4. Hardware Description

The Raspberry Pi is computer motorized by the Broadcom BCM2835 system-on-a-chip (SoC). This SoC comprises of a 32-bit ARM1176JZFS processor, clocked at 700MHz, and a Video core IV GPU. It also consists of 256MB of RAM in a POP package over the SoC. The Raspberry Pi is powered by a 5V micro USB AC charger or 4 AA batteries.

A DC motor is of a class of rotating electrical machines that converts direct current electrical energy into mechanical energy. . DC motors can function directly from rechargeable batteries, providing power for the first electric vehicles. If external power is applied to a DC motor it acts as a DC generator, a dynamo.

4.1 Crack Detection

An Arduino Uno board as depicted in Figure 3 is one of the basic microcontroller boards used in embedded projects. It is very robust in nature and can support the peripherals efficiently. It is centred on ATmega328. It has 14 digital I/O pins 6 analog inputs, a USB connection, a power jack, an ICSP header, and a reset button. The power required to run the board can be supplied through connecting it to the laptop using a USB cable or plugging an AC-DC power supply.

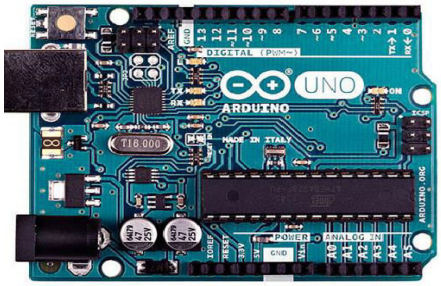

Figure 3: Arduino Uno board.

Ultrasonic sensor represented in Figure 4 assess target by deciphering the reflected signals. Systems typically utilize transducers which produce sound waves at the ultrasonic range, above 18 kHz by converting electrical energy into sound, and then upon receiving the ricochet turn the sound waves into electrical energy which can be calculated and displayed.

Figure 4: Ultrasonic Sensor

A GSM module or a GPRS module illustrated in Figure 5 is a chip or circuit that is used to instigate communication between a cellular device and computing machines. This module consists of a GSM module or GPRS modem motorized by a power supply and interfaces (like RS-232, USB 2.0, and others) for computer.

Figure 5: GSM Module

The Global Positioning System (GPS) shown in Figure 6 is used to determine and detect its meticulous location, and therefore that of its carrier, at intervals. The recorded location can be stored in the tracking unit, or it can be transmitted to a central location database, or Internet-connected computer, using a mobile (GPRS or SMS), radio, or satellite device embedded in the unit.

Figure 6: GPS Module

4.2 Video streaming

A Logitech camera shown in Figure 7 is used for this model. The Logitech webcam HD C270H has in-built microphone with right sound technology. It provides with a 3 megapixels resolution images with an innovative right light Technology, high speed USB 2.0, and video capture at 1280 x 720 pixels.

Figure 7: Web camera

4.3 Website

A website is created individually for the purposes of this module. A Wi-Fi modem is provided to connect to the internet through which the specified website can be accessed. The remote controlled bot and the webcam transmit data onto this website which can be viewed by the privileged authorities to inspect and investigate the defective site.

5. Methods and Methodology

The proposed system uses ultrasonic senor, which produces sound waves at 18 KHz, for sensing the presence of a gap in the rails. In addition to the traditional sensing system and the GSM and GPS system to notify the authorities we have implemented IoT which is a technology which has infinite functions. In our proposed systems are three modules

I. Crack Detection system using ultrasonic sensors.

II. Live video streaming module.

III. Internet of Things

The functionality of the paradigm starts with the ultrasonic sensor transmitting a perfect sine wave to the controller in case of an ideal track. When a rupture is detected a disrupted signal is sent to the Arduino Uno controller which in turn signals the GPS receiver. The GPS receiver will identify the exact latitude and longitude coordinates. The coordinates are sent as a message to the GSM. The GSM module is pre-programmed with the contact information and the coordinates are sent to the intended authorities and railway station. Once a crack is detected, the Raspberry pi controller will initiate the camera. The camera gives a live feed of the crack and can help in the investigation of the intensity and depth of the detected fracture. If the crack detected is only 10% of the accepted range the bot can be programmed to move on till it finds the next crack. The Internet of Things is employed for the authorities to inspect and obtain the live feed sent by the camera. The advantageous embellishments will allow the users to view the developments of the track. The video log can be accessed locally using WLAN hotspot in android mobile phones or through the internet by using the Wi-Fi modem.

Fig 8: Front view

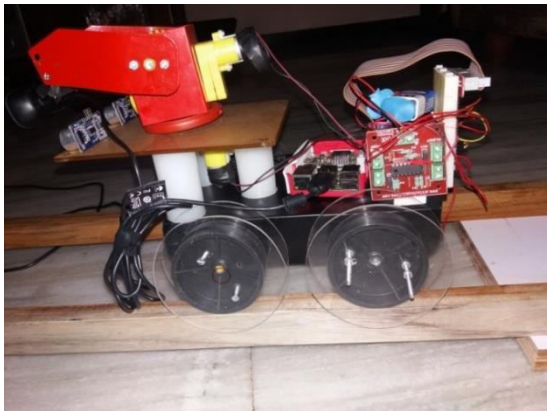

Figure 9: Side view

The system is placed on a four wheeler as shown in Figure 8 and 9 which runs along the track. The bot is remote controlled and the motion of the bot is controlled using commands in VNC viewer and BLYNK software.

5. Software and Simulation Analysis

The software tools such as python v2.7, BLYNK and VNC viewer is used for programming and controlling the system.

Python v2.7 is used for coding the raspberry pi microcontroller. Python is high level programming language which accentuates on the importance of code readability and the codes involved ensures reduced code lines than other high level languages such as Java, C, C++ .

```
if data [0] ==”$GPRMC”:
if data[2]==”A”:
print “latitude:%s”%(data[3])
print “longitude: %s” %( data [5])
```

Figure 10: Codes for GPS activation.

The codes depicted in Figure 10 define the GPS functionality. If no crack is detected the GPS is inactive state. When a crack is detected the latitude and the longitude are collected and the data is published.

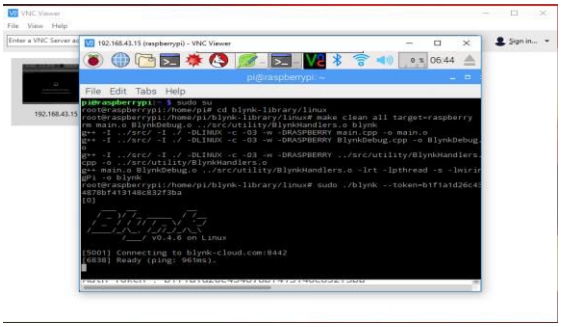

Figure 11: VNC Command Window

Figure 11 depicts the VNC command window. The VNC software is used to synchronize the Bot to the BLYNK software. The source codes of the contraption are present in the VNC software. The commands are simple to the point.

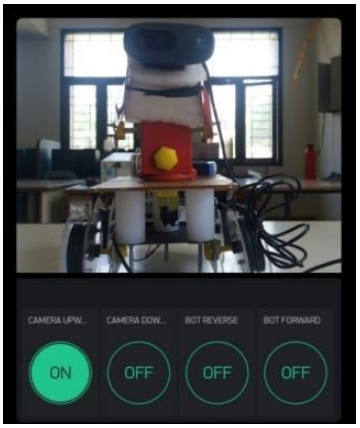

Figure 12: Camera up command.

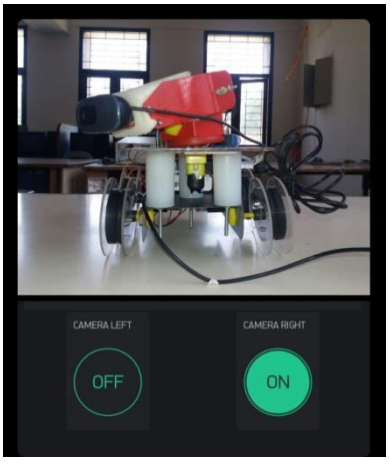

Figure 13: Camera right command

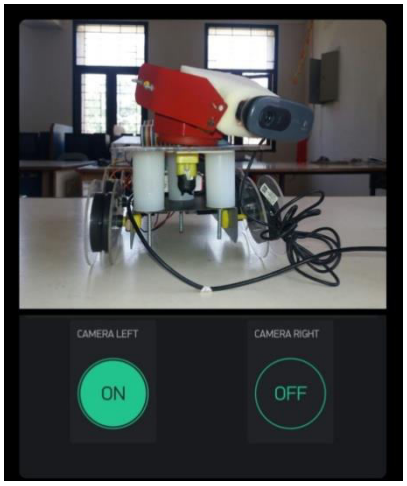

Figure 14: Camera left command.

This simulation is observed using the blynk application. The Figure 12 13 14 show how the bot responds to the commands.

5. Conclusion

The railway is the most commonly used mode of transportation by the people and for goods. The transport system must always be secure. Utilising the benefit of embedded system we can build a system which helps the cause of safe travel. The proposed system is an amalgamation of the conventional method of crack detection and the innovative method of live video streaming and IoT. The entire system is placed on a four wheeler bot which travels along the rails. When compared to existing system which uses IR transmitter and receiver, the proposed system is an innovative technique which lowers the burden of the authorities and increases the accuracy of the crack detection. The process is done at a periodic rate to check for cracks so that causalities can be avoided entirely. The entirety of the model is to ensure that defective rails can be found in time to stop derailment of trains, to save the loss of lives and property.

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