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Prevention of Railway Accidents by Track and Fire Detection Using IoT

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Abstract: Railway accidents are a common occurrence now-a-days. Recent survey shows that accidents mainly occur due to derailment, fire and negligence at level crossings. So in this paper we are proposing a system to overcome the accidents mainly due to above reasons. For detecting any damage in the track we are using IR sensors and flex sensor. Fire sensors are placed in each compartment. Action is taken as soon as flame is detected using buzzer and sprinkler. All this are embedded in a single system. For controlling of level crossing a separate microcontroller unit is used. IR sensors are used to detect the arrival and departure of train. IoT is used to connect the physical devices and exchange data.

Keywords: Derailment, Level crossing, compartment detachment, IoT (Internet of Things) and embedded system.

I. INTRODUCTION

The Indian Railway network is the largest rail-passenger transport and it is now the backbone of the country's transport infrastructure. In India, most of the commercial transport is being carried out by the railway network because it is being cheapest mode of transportation preferred over all other means of transportation such as buses, flights etc. The rapidly improving economy of India has resulted in an exponentially increasing demand for transportation in recent years, and this has resulted into a very huge rise in the volume of traffic in the Indian Railway network. Transport is a key necessity for specialization that allows production and consumption of products to occur at different locations [1]. Now-a-days there is an increase in accidents in the railway system. Sadly 15% of all accidents occurred in the world last year, happened in India [2]. In this system we are mainly concentrating on three major accident causing factors. We will look into these briefly in the following paragraphs.

Derailment means when a train runs off its track. One of reason for this is cracks in the rail. Cracks are caused due to wear and tear or natural causes like flood, earthquake etc. Detection and maintenance of rail defects are major issues for the rail community all around the world. In this system there are two means to detect the crack in the track.

When a railway line crosses a road or path the intersection formed is called level crossing. The accidents in level crossings are mainly caused due to negligence of the road users. Earlier in level crossings a flagman would wave a red flag or lantern to stop all traffic and clear the tracks. Gated crossings are common in many areas. Now-a-days electrically closable gates are used everywhere but most of them are operated manually. Accidents are also caused due to untimely closure of these gates. In this system a unique way to control the gates automatically is implemented.

Fire accidents in the railway systems are of major concern as they cause more damage than any other accidents. Fire spreads rapidly due to fanning effects so it is necessary to control this fire. The cause of this fire may be due to carrying inflammable goods like petrol, kerosene, wood etc. or fire could be set intentionally by some people for causing damage. In this system a method for controlling fire quickly and to prevent spreading of fire is devised.

II. PROBLEM STATEMENT

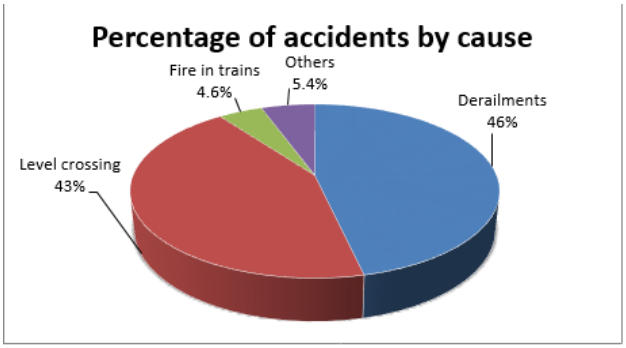

Fig 1. Percentage of accidents due to various factors

Above is a chart which shows the percentage of accidents caused due to various factors. There were a total of 803 accidents in Indian Railways killing 620 people and injuring 1855 people. [6] We can see that derailment comes first with a 46.5% which makes this the number one problem. Next are accidents due to level crossing which constitute about 43.5% of the total cause. Lastly there are fire accidents which constitute up to 4.6% of the total causes. So it is necessary to come up with a solution to prevent accidents caused by these factors.

III. PROPOSED SYSTEM

A. Block diagram

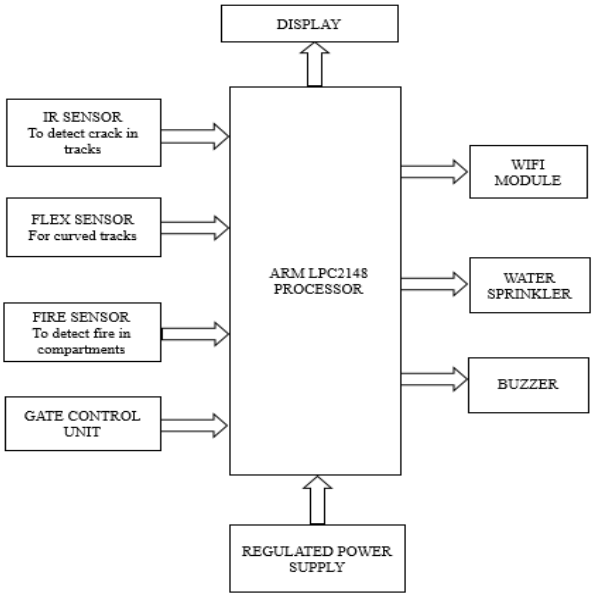

Fig 2. Main block diagram

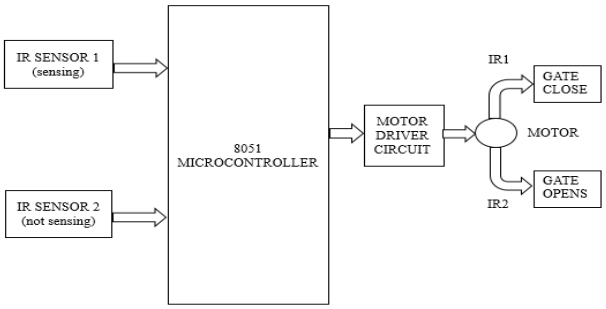

Fig 3. Gate control unit

B. Hardware

a) ***ARM LPC2148*** – ARM (Advanced RISC Machine) is a 32-bit RISC (Reduced Instruction Set Computer) processor architecture developed by ARM Holdings. ARM7 is one of the widely used micro-controller family in embedded system application. LPC2148 is the widely used IC from ARM-7 family. It is manufactured by Philips (NXP) and it is pre-loaded with many inbuilt peripherals making it more efficient and a reliable option for the beginners as well as high end application developer.[3]

b) ***Regulated power supply*** - It is an embedded circuit; it converts unregulated AC into a constant DC. With the help of a rectifier it converts AC supply into DC. Its function is to supply a stable voltage (or less often current), to a circuit or device that must be operated within certain power supply limits. The output from the regulated power supply may be alternating or unidirectional, but is nearly always DC. [4]

c) ***IR Sensor*** - IR transmitter sends an IR radiation which is reflected of a surface and falls upon a receiver. Due to the falling of light on the receiver a potential difference is created across the ends. This potential difference is recognized by microcontroller as high or low.IR transmitter consists of LED that emits IR radiations and IR receiver receives the IR rays transmitted by IR transmitter. [5]

d) ***Relay*** - It is an electrically operated switch. Relays are used where it is necessary to control a circuit by a separate low power signal or where several circuits must be controlled by one signal. [5]

e) ***DC motor and motor driver*** - A DC motor is a device that converts electrical energy into mechanical energy. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction. L293D is a 16-pin IC which can control a set of two DC motors simultaneously in any direction. [4]

f) ***LCD Display*** - It is used for displaying alphabets, numbers and also special symbols. The proposed system uses 16*2 alphanumeric displays. [5]

g) ***Microcontroller*** – It is a small computer on a single integrated circuit. A microcontroller contains one or more CPUs (processor cores) along with memory and programmable input/output peripherals. Program memory in the form of ferroelectric RAM often included on chip, as well as a small amount of RAM. [4]

h) ***ESP8266 Wi-Fi module*** - *It is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to Wi-Fi network. Each ESP8266 module comes pre-programmed with an AT command set firmware. In this system Wi-Fi ESP8266 is used to provide the platform to communicate over the internet. [4]*

i) ***Fire sensor*** - The sensor uses the IR flame flicker techniques, which enables the sensor to operate through a layer of oil, water vapor, dust, or ice. Fire sensor can detect the smoke and fire and they are given to the ARM controller. [4]

j) ***Buzzer*** - A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke. [4]

C. Flowchart

The train starts moving forward when the motor's input (namely Motor 1 and motor 2) are set high. There are 2 IR sensors placed in front of the train on both the sides (Left and Right). These two IR sensors will be continuously detecting the track. If the Right IR stops sensing, then "RIGHT SIDE CRACK DETECTED" message will be displayed in the LCD. A Stop () function is called which will clear Motor 1 and motor 2 and thus the train stops moving. If the Left IR stops sensing, then "LEFT SIDE CRACK DETECTED" message will be displayed in the LCD. A stop () function is called which

will clear Motor 1 and motor 2 and thus the train stops moving.

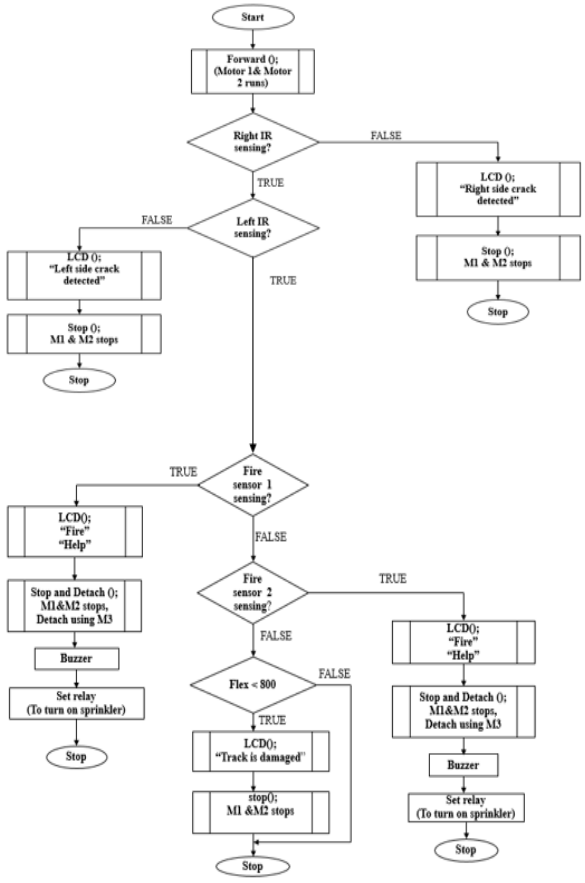

Fig 4. Main Flowchart

A fire sensor is placed in each compartment. When the flame is sensed the sensor will alert the controller and relay will be set high and sprinkler will be activated. Stop and Detach () function is called which will stop the movement of the train by clearing the values of motor 1 and motor 2. Another motor (Motor 3) is used to detach the compartment to prevent fire from spreading. The message "FIRE" and "HELP" will be displayed on the LCD. Buzzer is used to alert the passengers about the fire.

A flex sensor is placed in the curved track areas to detect any damage in the rail. In normal condition, (the track is not damaged and flex sensor is bent) the resistance of the flex sensor is high. Let's consider this resistance value as threshold value. If there is any damage in the curved rails, the flex sensor will stand straight. This condition is shown when the value of the resistance of the flex sensor falls below the threshold value. The train will stop if the resistance value drops.

In gate controlling unit, we use two IR sensors (to detect arrive and departure of train), Red and green LED (to indicate the traffic flow) and a motor (to open and close the gate). The first IR sensor will detect the arrival of the train. As soon as it senses the gate will close with help of motor. The red LED glows indicating the vehicles on the road to stop. The second IR sensor will constantly be sensing movement of the train. Once the last compartment of the train leaves the gate crossing there will be no movement for sensing. The gate will now open with help of the motor and the green LED glows indicating the vehicles to move.

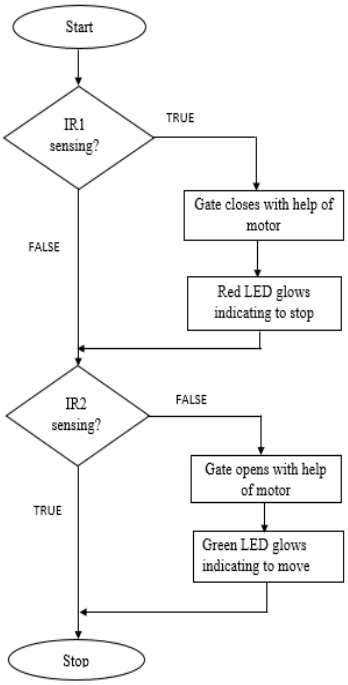

Fig 5. Gate controlling unit flow chart

IV. Experimental Setup and Results

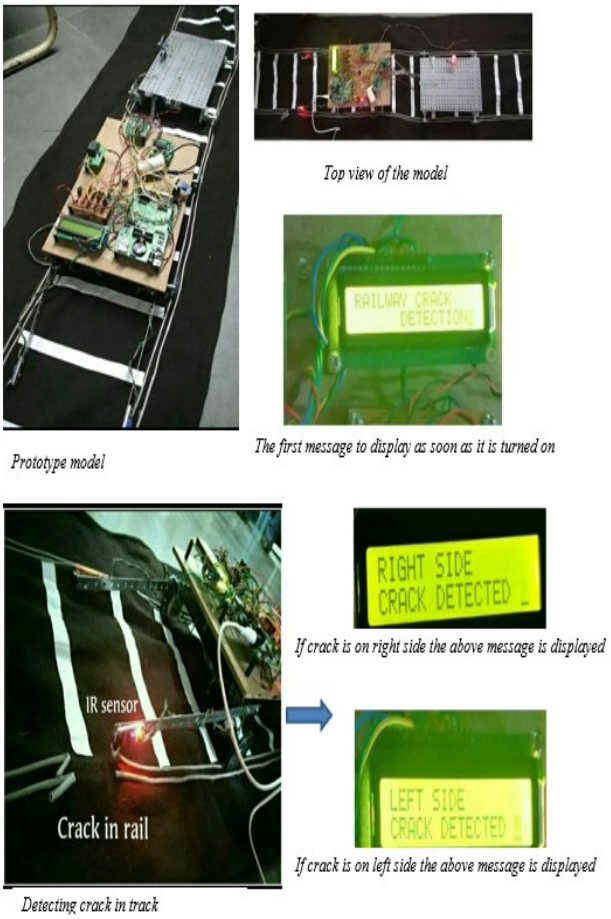

Fig 6. Crack Detection

A. Crack Detection

The prototype model is seen in the above figure. When the model is turned on the first message displayed on the LCD is "RAILWAY CRACK DETECTION". We can also see in the above figure that two IR sensors are placed on either side of the train. These IR sensors are placed in front of the model to detect the crack in rail. The train stops moving as soon as the crack is detected. Depending on which side the crack is message will be displayed on the LCD accordingly. If the crack is detected on the left side "LEFT SIDE CRACK DETECTED" is displayed. If the crack is detected on the right side "RIGHT SIDE CRACK DETECTED" is displayed.

B. Fire detection

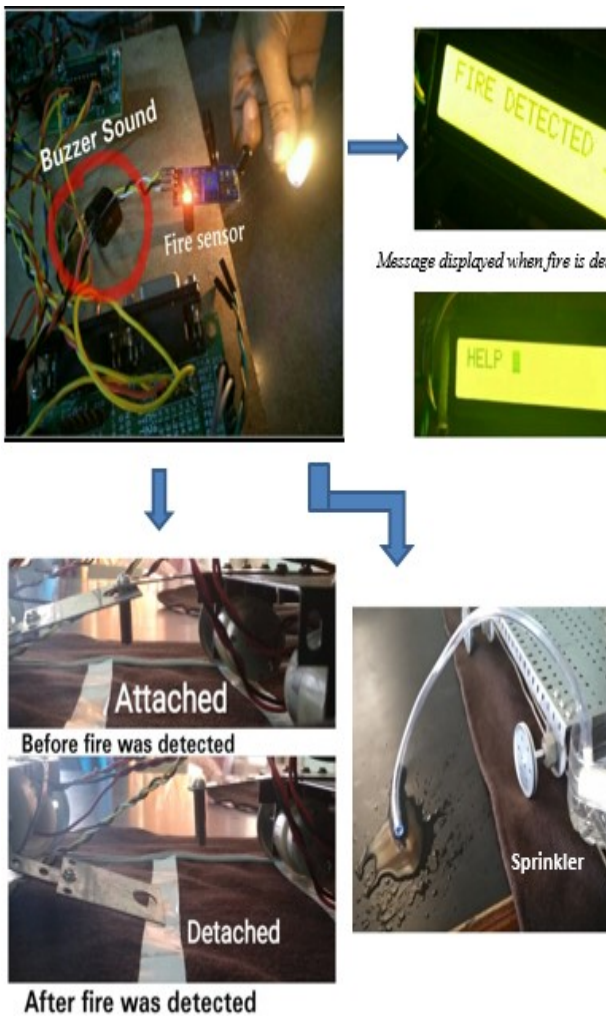

Fig 7. Fire Detection

A fire sensor is placed in each compartment. This sensor will detect the fire using flame recognition technique. As soon as the fire is detected the compartments will detach from one another by using L-clamp and a DC motor. This quick detachment prevents the spreading of fire. Sprinkler will also be activated when fire is detected. By using sprinkler we are controlling the fire and reducing the damage caused by it. The buzzer used in the model is used to alert all the passengers in train that fire has occurred. This will help the passengers to take some timely action to get to safety. The messages "FIRE" and "HELP" are displayed on LCD.

C. Gate Control

In this system we have made a separate gate controlling unit using a microcontroller. This unit is placed where railway tracks and roads intersect. By using this we are achieving automatic opening and closing of gate. The opening and closing is done by DC motor which responds to the status of IR sensors. Two IR sensors are placed at extreme ends of this unit. The first IR sensor will sense the motion of approaching train and closes the gate. The red LED will glow indicating road vehicle users to stop. The second IR sensor will be sensing the movement of the train. When there is no movement detected by the sensor gate will be closed by the motor. The green LED will glow indicating road vehicle users to move. By using this unit road users will be safe from accidents and automatic controlling of gate is achieved.

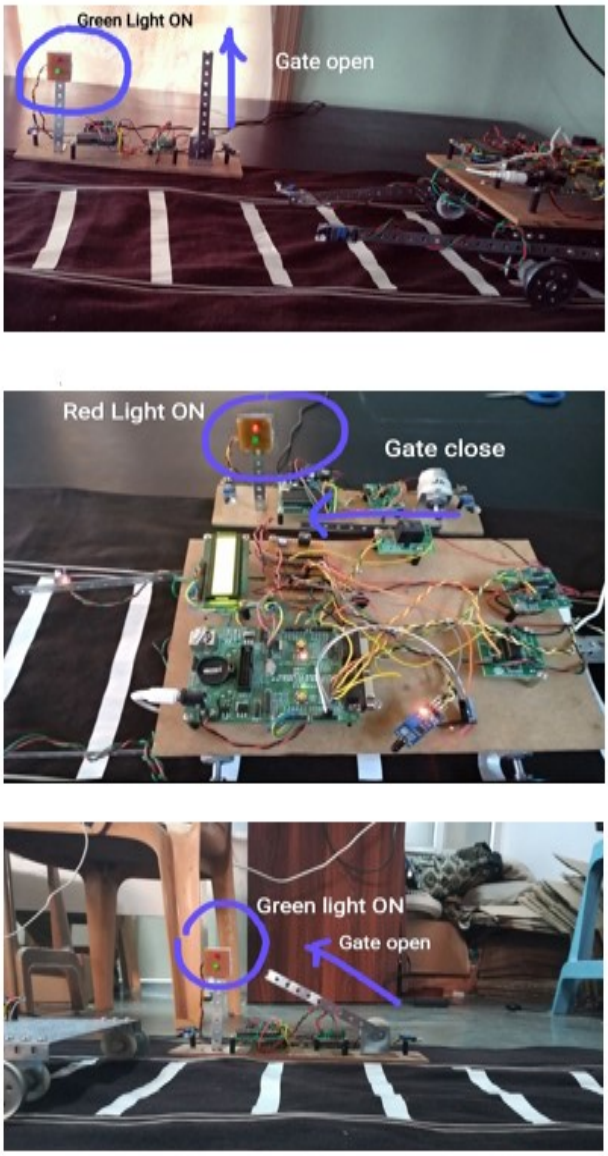

Fig 8. Opening and closing of gate in crossing

D. Message displayed in the app over WiFi

IoT is used to connect the physical devices and exchange data. An app called "TCP UDP PING IP CONFIGURATION" is installed on the phone. Whenever

fire or crack is detected a message will be sent to the mobile over the internet. To receive these messages on the phone the user must first connect to the Wi-Fi and then open the app. The target IP address and target port number must be entered. The last step is to press connect button. The following screenshots show the messages which were received when the crack was detected on left or right side and when fire was detected.

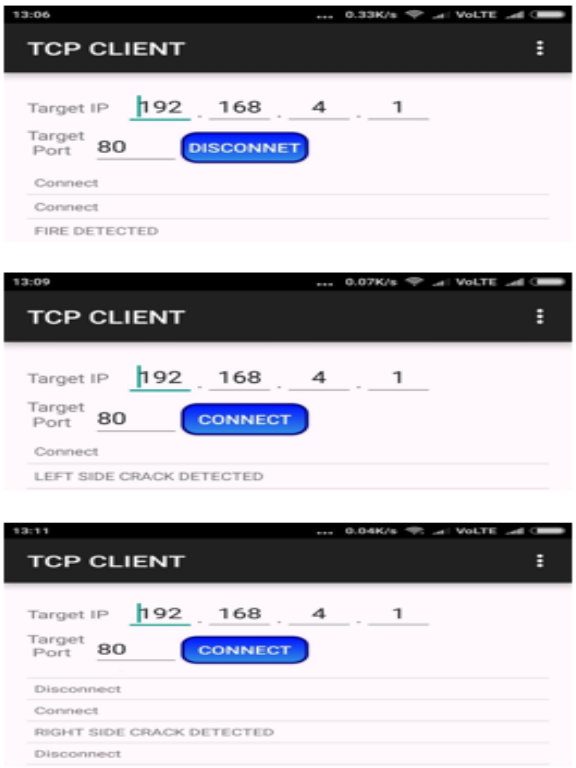

Fig 9. Screenshot of message as seen in App

V. Conclusion and Future Scope

The accidents in railways occur due to various reasons. Here the accidents due to three reasons are overcome. The vehicle is used to inspect the railway track for any cracks and detect them; it will have a great impact in the maintenance of the tracks which will help in preventing train accidents. The regions where manual inspection is not possible, like in deep coal mines, mountain regions and dense thick forest regions can be done using this method. Helps in maintenance and monitoring the condition of railway tracks without any errors and thereby maintaining the tracks in good conditions. For the detection of fire accident in train, this system uses a fire sensor. When fire is detected by the sensor water sprinkler is turned on immediately and then the compartment is detached automatically to avoid spreading of fire to other compartments.

To avoid the accidents caused by level crossing, there is no need of gatekeeper and automatic gate operation is done by motor. This system avoids manual errors and provides ultimate safety to road users. By this proposed model lives can be saved by avoiding accidents. The idea can be implemented in large scale in long run to facilitate better safety standards and provide effective testing infrastructure for achieving better results in the future. There are quite a few advantages of this system. The chances of accidents and breakdown of railways are minimized to a greater extend. In case of accidents the system provides quality service. Efficiently used in remote places because of large carrying capacity of trains the track may get damaged more frequently. By using this system, the rail is checked more accurately even in places where human can't work. Effective use of time as service is provided at faster rate due to which delay of the train can be minimized. Reduced work as most of the work is done automatically; the workload of railroad brakeman will be reduced. Accurate detection of crack with the help of IR sensors. Man power is reduced as manual checking of tracks is not required as sensors do the work and even automatic closure of level crossing is done without the help of gatekeeper.

A few disadvantages of this system are that the vehicle is operated in battery power, so rechargeable battery must be used to drive the vehicle. It also requires large investment of capital thus establishment of the entire network is a costly task. The cost of construction, maintenance and overhead expenses are also very high.

The future scope of this project is as follows. A train that runs on virtual rails can be implemented in future. These trains can be fitted with sensors so that it moves without the need of metal rails. Usage of solar-powered trains so that train can run on its own power without refuelling. CCTV systems with IP based cameras for monitoring the visual videos captured from the track can be used in future. It will increase the security for both railways and passengers.

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