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# ADVANCED COMMUNICATION SYSTEM: FOR THE SURVEY OF RAIL TRACKS TO IMPROVE SAFETY OF RAIL TRANSPORTATION

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***Abstract***

*Railway transportation is a backbone of any country for transporting people and cargo. At present Indian railway is the largest network in Asia. So that safety is always big concern. Here in this article low cost railway track surveillance and monitoring system is proposed which will identify drastic and minor changes into the railway track. It consist a high-resolution CMOS camera mounted on robot. It is designed like: it can easily roll on railway track. In case of any obstacle or train coming on track, robot folds itself and provides a path to pass the train. It is controlled by wireless control system, which can be operated from remote location or station. For accurate results, a live video streaming is done to the remote station for future references and comparison of results. On the assembly of robot, a GPS (Global Positioning System) is mounted to know the location of robot on the rail track. An obstacle detector sensor is also mounted on the front of the robot to detect any coming obstacle. In this article ultrasonic method (Non-Destructive Method) is also explained to detects presence of cracks on rail track in real time. Overall, power utilization of this system will be very low by operating this system by solar power. Signal processing and wireless communication system is used as technology, which cuts off the overall cost. By implementing this surveillance system, we can improve the safety parameters of Indian railway by minimizing the errors and reducing the time and cost.*

***Keywords:*** *rail transport, smart communication, video streaming, crack detection*

## 1. Introduction

During the past few years, the rate of increase of railway accidents is propagating due to defect in rail tracks. These defects can occur due to any one of reason like poor maintenance, low inspection, inspection error, etc. These accidents are putting lots of burden on Indian railway to minimize the loss of human life. From past investigations, it is clear the most of the accidents happen due to defect in the rail tracks. According to a survey, the reason of near about 90.2% rail accidents in India is because of derailment and crossing [3]. Due to atmospheric, there is change in thermal properties of rail track, which causes bending in rail track. India's Rail Network is world's fourth longest and most heavily used transportation system, which is spread near about 119,630 [km] (over rail track), which is quite large distance to monitor manually without any errors.

To overcome these problems of rail tracks, here we proposed a system, which helps to detect flaws in rail track by using CMOS (Complementary metal–oxide–semiconductor) camera and ultrasonic sensor. This proposed system helps us to identify the rail track problems by using a wireless network, which receives information from sensor, and transmit it to the remote location station through video streaming. The whole idea of proposed system is based on telecommunication and wireless communication. This robot can roll on the rail track with the help of roller wheels and do the inspection. This robot have inbuilt control system, which is powered by solar arrays, mounted on the top of the robot surface. Another option, use of rechargeable battery is provide into the system during foggy and rainy conditions.

Presented system can be operated by a computer application by sitting at a remote location by use of wireless communication and video streaming. A CMOS camera is mounted on the front of the structure for capturing the video of rail track. A live streaming option is provided into the system, so that the video can be recorded into the remote computer for future verification and comparison of readings. The recording and sending of all information is done by use of GSM (Geographic Messaging Service) and GPS (Global Positioning Sensor). Apart from the video streaming, ultrasonic and infrared sensors are placed on the robot. The use of ultrasonic sensor is to detect any minor crack into the rail track. Ultrasonic method is a NDT (Non-destructive Technique) which uses ultrasound waves to detect any cracks in to a material.

When an ultrasonic wave propagates through the material, it touches the other edge of material, and is reflected. By using duration of time taken by the sound wave, we can easily calculate the thickness of material. Using the same approach in this proposed system, we can detect cracks into the rail track. An infrared type sensor is used in front of the robot structure to measure the continuity of metal rail track.

Another recent research has been done in monitoring of rail track designed a monitoring system which is also operated by power of solar array [7]. In the work they mounted, some solar plates on the system to make it solar powered. In that system, CMOS camera with LCD (liquid-crystal display) is mounted in front of rail and it continuously gives the signal on the LCD by using Wi-Fi signal. If some part of rail track is missing, it shows warning on LCD screen and driver of train has to take some necessary step to stop the train.

Another work on the railway accident is the solar powered crack detector for cracks. This system is equipped with an infrared sensor in front of engine to check the continuity of track. If some crack or track missing is detected, it sends signal to the timer circuit, which is connected, to the engine of rail and turn off the engine. However, this system cannot avoid accidents, which occurs on rail track due to some other reasons [4].

Riccardo Leone et al. [4] proposed a smart device for monitoring the rail track. In this work, a prototype of smart camera was presented which is capable of performing tasks directly on-board. A computer vision method realized ad hoc for the smart camera prototype. Based on simple video analytics, the algorithms are implemented to an embedded device such as smart camera for rail track monitoring.

By getting inspired, form the above technologies, here we have proposed a system, which overcomes all the drawbacks of previous researches. The main contribution of the proposed system are: firstly this system which is solar powered and which does not require any external power supply, secondly this system has special features like video streaming [5], CMOS camera, ultrasonic sensor and infrared sensor, which makes this system totally autonomous to monitor the rail track in remote locations. It provides, quickly and accurately track problems to the maintenance team by minimizing the inspection time and errors. By deploying this system on rail tracks, it will enhance the safety and quality service of Indian Railways.

## 2. Proposed System

The proposed system (Roborail) helps to find out the flaws into the rail track by using as set of sensors, which are ultrasonic sensor and infrared sensor. Here we have suggested ultrasonic technique because it is the most effective technique to measure out the crack formation on rail track. Roborail consists of light structure made of aluminum or steel alloy, so that it can easily roll on the rail track by consuming the less power. The mode of power supply is through solar. Some panels of photovoltaic cells mounted on the top of robot, which provides power to the system. For the communication, a wireless transmission with video streaming is provided. For Indian Railway GSM-R is International standard for communication, which can be used for this robot after getting approval.

The Roborail consist a CMOS camera to capture the high-quality video. On the same time, ultrasonic sensor will be observing any flaws into the rail track. By using video streaming all the observation and condition of track will be transmitted to the remote control station. The main motive to apply video streaming in this robot is to store the observations and compare it in future for official records. Infrared sensor on the front and backside of robot will detect the presence of any obstacle for the safety of Roborail. The main unique thing in this project is design of the robot. Robot design and working is planned in such a way that it does not affect the trains running on the rail track.

As explained above robot has infrared sensors on front and backside to detect any coming obstacle. In case, when the Roborail is performing monitoring operation and it finds out train approaching towards the system, it will automatically fold itself in between the tracks to provide an easy passage to the train. This ability of Roborail makes it unique throughout the all works, which have been done before. System will be equipped with a GPS (Global Positioning Sensor) locate the location of robot.

## 3. System Architecture

The proposed system consists of following units:

1. Solar Powered System;
2. Data Acquisition;
3. Wireless Communication;
4. Signal Processing and Video Streaming;
5. Emergency Convertible Structure.

### Solar Powered System

The most interesting part of this robot is power generation and the proper distribution of the power into the system. An arrangement for the continuous power supply is opted for the Roborail. Roborail system uses, solar cells having efficiency near about 26.8%, to generate enough power to operate all modules of system. Solar panels have an arrangement of solar cells connected in series, which makes solar panel to provide balanced current and output. Solar panel input varies between 0-5 [V] which can be regulating by charging a rechargeable battery and from that, we can get constant voltage. When the system will be inspecting in the night than it will use the power from the charged battery. But in case of darkness or without sunlight, solar panel acts as a current sink, which means a small current came out from battery to solar panel array and it can damage the solar panel. To avoid this situation a blocking diode is placed between solar panel and battery to stop the reverse current from battery to solar panel (Fig. 1).

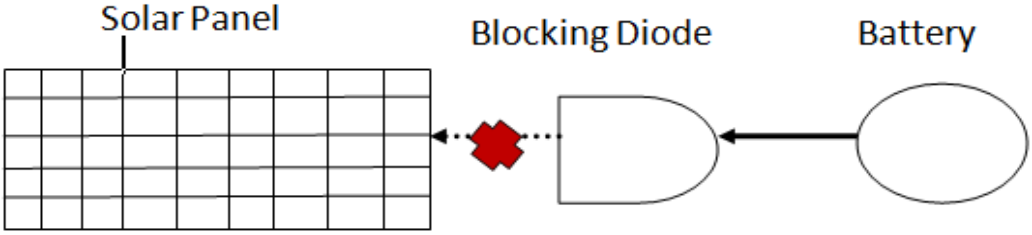


*Fig. 1. Function of blocking diode with variation of temperature [2]*

To recharge the battery, we need at least 4.2 [V] the battery charger. But the output of solar panel varies with the change in intensity of light falling on the panel. For this situation, we can use a low power, low voltage, monolithic step-up converter to maintain a 4.2 [V] to make the battery charge (Fig. 2).

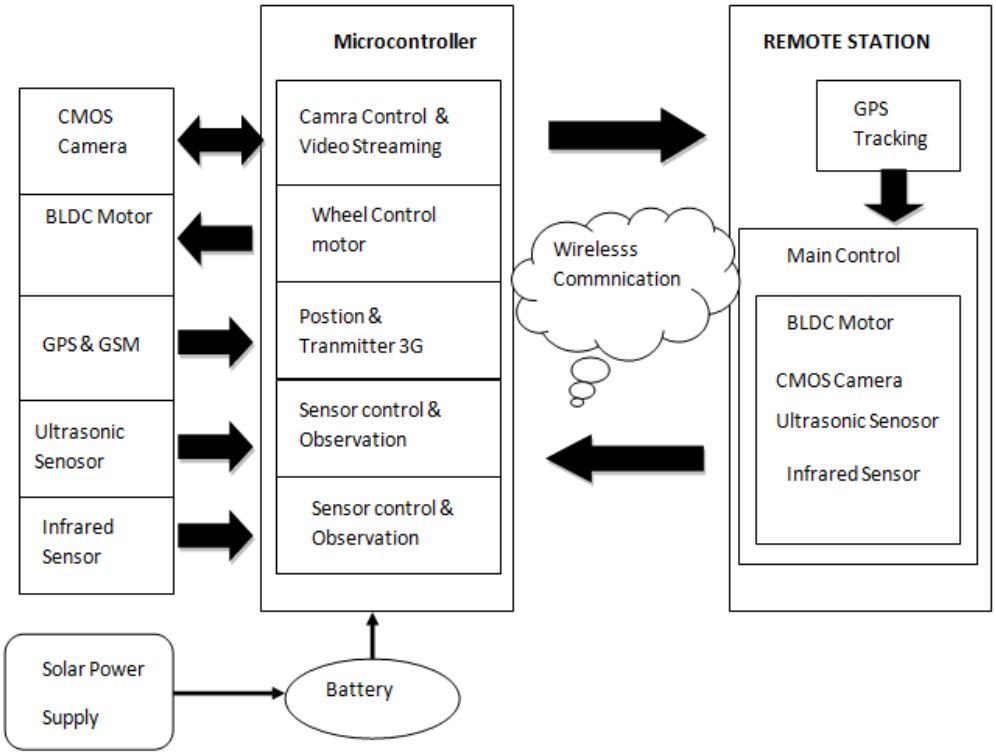


*Fig. 2. System Architecture*

## Data Acquisition

CMOS Camera: A CMOS (Complementary Metal Oxide Semiconductor) Camera is attached in front of the Roborail robot to capture high quality image of track. CMOS camera is attached with controller board to transfer image and video streaming. CMOS technology consists of large array of pixel, and each pixel sensor consist a light sensor and amplifier (Fig. 3).

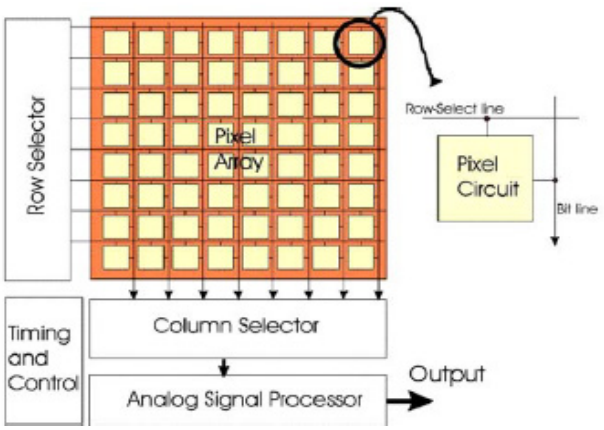


*Fig. 3. Working Principle of CMOS Camera [8]*

CMOS camera have inbuilt analogue to digital converter, with every pixel sensor having light sensor. Light enters from lens, and passes through the colour filters. After being processed from colour filters, it reaches to the pixel array. Each pixel array covert this light into an electric voltage signals so that it can processed by the controller. By using the CMOS camera in the Roborail robot, there is saving of power and it also provides better colour reproduction by using its colour filters. Image captured by CMOS camera can be easily transmitted by its embedded camera processor and small image size.

### Microcontroller

A microcontroller acts as an interface between the remote station and the CMOS Camera, ultrasonic sensor, motor, and wireless transmission. In the system we can use ARM 7 based microcontroller (LPC2148) because of data rate transfer to CMOS Camera is very high, i.e. 30HZ.ARM 7 based microcontrollers (LPC2148) provides 8 to 40 [kB] of on-chip static RAM and 32 to 512 [kB] of on-chip flash program memory. The 128-bit wide interface/accelerator enables high-speed 60 [MHz] operation.ARM 7; based controller provides an interface between the input modules and output modules.

### Ultrasonic Sensor

Ultrasonic for crack detection is a reliable and efficient inspection technology for detection of cracks in metal bodies. The basic principle of ultrasonic sensor to measure the cracks is penetration and reflection of sound wave [1]. The ultrasonic sensor sends out the high frequency sound pulse and then times the how long it takes the eco sound to reflect back to the sensor. Sensor has two opening at the front, one opening transmits the ultrasonic wave and second opening receives the reflected wave. When there is some difference between the times taken by ultrasonic wave, position of crack can be located on body part. Similarly by using this technology and by looking at the graph obtained from the ultrasonic sensor, crack position can be easily identified on the rail track.

### Infrared Sensor

Infrared Sensor is a device, which measures the infrared light emitting from the object in front view of sensor. The main use of this sensor in Roborail is to detect the presence of any object on the rail track. In this proposed system, infrared will be detecting the presence of any coming train on the same rail track where the robot performs the inspection operation.

### BLDC Motor

A Brushless DC motor is used in the robot wheels to roll it on rail track. Torque and rpm of BLDC motor depends on how much weight is the weight of Roborail. For the designed structure of Roborail, a motor having 150 [rpm] and torque 2 [kg-cm] is enough to roll the system on wheels. As the system is solar powered, motor requires 60 [mA] with no load condition and 300 [mA] with full load condition. Choosing a Brushless DC motor as compared to DC motor is a good step. Compared to DC motor, a brushless DC motor have electric commutator instead of mechanical one, which generally provides reliability to the system. Also, the rotor magnets in BLDC motor provides additional magnetic flux, which enhances the overall efficiency of system.

To operate these BLDC motor a special motor controller is mounted, which provides rectangular voltage, stoke for BLDC smooth operation.

## 4. Components for Communication

**The GPS (Global Positioning Sensor):** Since the robot will be monitoring on the rail track and it will be not under direct line of sight, so a GPS unit on the robot will be tracking the position. By using a Software Lab view on the remote station, we can directly track the position of robot. The GPS will be transmitting the co-ordinates to the base station in real time. Through the application, many co-ordinates and map of location can be accessible. In another way, it provides us the location of cracks. When robot found some crack, it will stop there by a sensor and GPS takes the location of the robot and transmit all co-ordinates to the base station for further necessary actions.

**GSM (Global System for Mobile):** GSM provides a high range wireless communication for transferring the data. It is mainly used in system to establish a communication between the remote station computer and the robot GSM module. GSM modem is highly flexible and plays GSM 900 frequency modem for easy integration with RS232, voltage range for the power supply and audio interface make this device good for single communication user [8].

**Signal Processing and Video Streaming:** As the system is equipped with CMOS camera, which capture high quality of video of the track and by using the GSM and GPS module this captured image will be transmitting with the system location to the remote station by live video streaming. For live video streaming from the robot, the remote station is equipped with a computer having software LAB VIEW. By using application of Lab View user can turn on/off the video streaming by stopping the CMOS camera mounted on robot.

## 5. Design of Roborail

The main concern during design of such a system to make it flexible and light weight, so that it can consume very less power. The device-designed model in solid works has been presented in the Fig. 4. This system is designed like that it can run parallel on both tracks. It is provided with 12 wheels, which make this system stable on the rail track. As the structure is made up of aluminum, so it has lightweight, which is plus point. The length between the two parallel rail tracks is 5 feet 6 inch's, which is general distance between two Indian rail tracks [6]. The side wheels, which are mounted on both side of model is to move the system stably on the rail track.

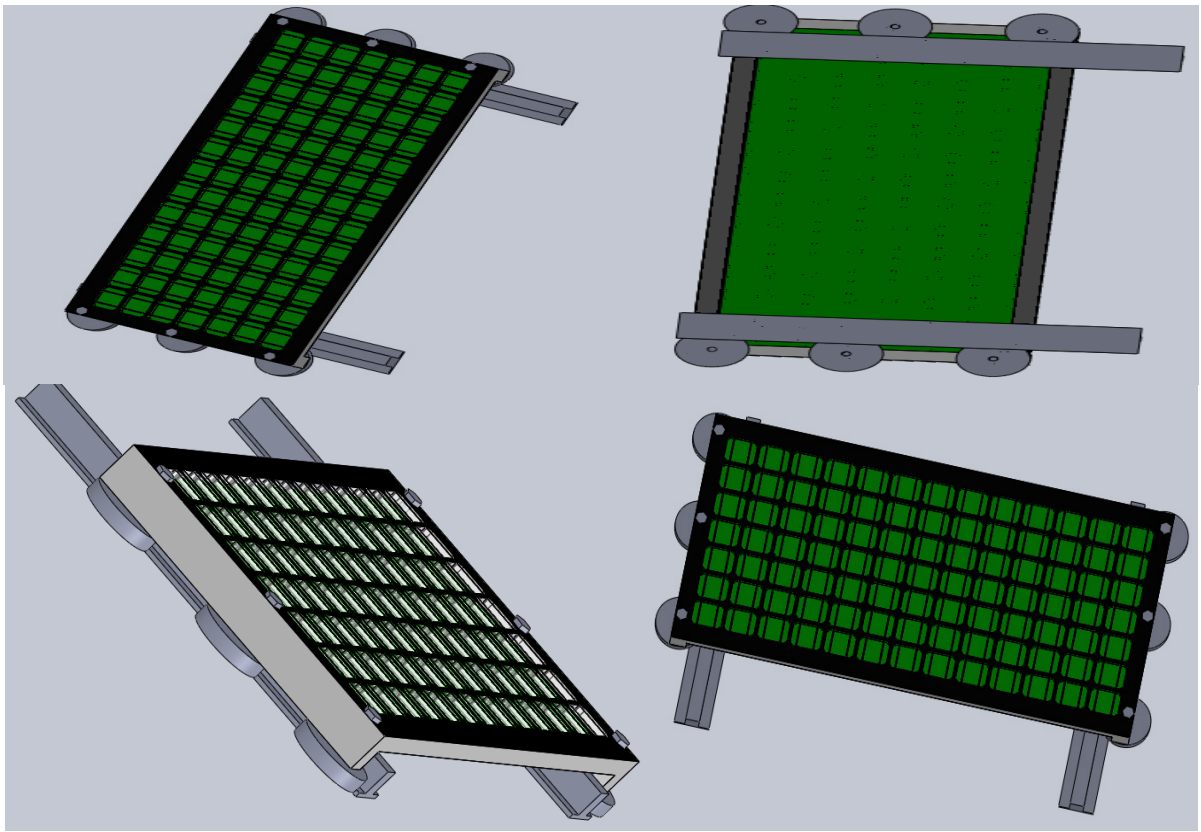

*Fig. 4 Designed solar operated model in Solid Works*

All wheels are made up of steel having outer covering of rubber. The main idea of using rubber on the outer of wheels is to makes the wheel adhere to the rail track. It makes the system stable on the rail track.

On the top view of the model, 5 feet 6 inch solar panel array is mounted which is shown above in Fig. 4. This solar panel can generate more than enough power to operate the system. Below the solar panel, there is a place to put batteries and control unit batteries are placed below the panel, so that they can be charged by the solar panel power. In some cases model can use the charged batteries during cloudy weather without any interruption.

Wheels are provided with BLDC motor, which is powered by the battery. Once the model starts moving on rail track, controller unit turns on the CMOS camera and other sensors. CMOS camera captures a high quality video of track condition and transmitting it through video streaming to the remote location. Ultrasonic sensor also starts transmitting the ultrasonic waves to examine the inner condition of rail track. Both the results of CMOS camera and ultrasonic sensor are transmitted to the remote station. At remote station, all results are getting stored in to a PC for future reference. Video streaming is possible by using a GSM network, which will be sending the real video with location to the remote station.

Two infrared sensors are mounted on front and back side of Roborail to detect the obstacle. The designed model of Roborail is flexible and foldable, which is unique and great advantage .In some special cases when a train is coming on the track of inspection, infrared sensor detects the obstacle in front of the system, in that case this designed system folds itself automatically.

## 6. Conclusion

In this article, an idea about safety of rail transport is presented by designing an advanced communication system in a Rail boat for accurate inspection of rail tracks. Ultrasonic sensor attached on the system will detect the possibility of cracks on the rail track. CMOS camera provides this system a high quality video, which can be streamed to the remote location to take necessary steps after crack detection. Video streaming option helps to monitor the track at any time.

This proposed system provides, railway an efficient and reliable monitoring system equipped with video streaming. This system is solar powered operated, which makes it unique and economical monitoring system for Indian Railway. By using this technology, an effective and reliable monitoring system can be designed for Indian railway to make the rail transportation safer.

## Acknowledgments

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