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Design & Fabrication of Railway Track crack Detection Prototype

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ABSTRACT

India's railway network, which stretches over 1,15,000 kilometers throughout the country, is one of the worlds longest. However, in terms of dependability and passenger safety, Indian Railways falls short of world norms. Among other things, defects in the tracks caused by a lack of prompt discovery and maintenance raise major concerns about the safety of rail transport operations. According to a recent study, more than 25% of the track length needs to be replaced owing to crack growth. Because of the time required and the need for qualified experts, manual track detection is time-consuming and ineffective. The goal of this article is to address the problem by building an autonomous railway track fracture detection system. This paper describes research that attempts to develop a reliable railway crack detection strategy based on an Ultrasonic sensor assembly system that prevents train accidents. With GSM modules, it is also capable of alerting authorities via SMS messages. Now a day's measure track distance with a high-cost LVDT with low accuracy, but we employ a low-cost ultrasonic sensor with great accuracy for the aforesaid process. The advantage of this technology is that it may be used for detection both during the day and at night. The benefits include lower costs, lower power consumption, and shorter analysis times. The suggested technology makes it simple to pinpoint the specific position of the broken rail track, which can then be repaired immediately, saving countless lives.
Keywords: Railways, Track, Crack Modal, Catia Design & Development

INTRODUCTION

The railway line of India is the world's fourth largest railway system. The Indian rail network is still expanding, attempting to meet the country's economic demands. Despite India's fast growth in rail travel, the related safety infrastructure facilities are still inadequate. As a result, there have been several derailments, resulting in significant loss of irreplaceable human lives as well as property. Further investigation into the factors that cause these rail accidents reveals that approximately 60% of all rail accidents are caused by derailments, with approximately 90% being caused by gaps on the rails caused by natural causes (such as excessive expansion due to heat) or by antisocial elements.

This study focuses on one of the most effective strategies for preventing railway accidents.
The goal of this project is to address the problem by building an autonomous railway track fracture detecting system. This paper describes research that attempts to create a robust railway crack detection strategy utilizing an Ultrasonic sensor assembly system, which prevents train accidents by detecting cracks on railway tracks. Furthermore, it is capable of notifying authorities via SMS messages as well as providing position information using GPS and GSM modules. Transport is a critical requirement for specialization since it allows for the production and consumption of things to take place in diverse areas. Throughout history, transportation has been a catalyst for growth since improved transportation leads to more trade. Economic prosperity has always been based on expanding transportation capacity and rationale. However, transportation infrastructure and operation have a significant influence on the environment and are the main drainers of energy, making transportation sustainability and safety a serious issue. In India, rail transport plays an important role in providing the required transportation infrastructure to support and satisfy the ever-increasing needs of a fast-rising economy.

India currently has the world's fourth largest railway network. However, we have not yet achieved really worldwide standards in terms of reliability and safety characteristics. “Figure 1”. Shows different types of accidents form year 2001 to 2017

Comparison of Indian railways with the Great Britain railways

- The railway network in the United Kingdom is 15,799 kilometers long. It has a fairly small population in comparison to India.
- network. The total ridership is 1.718 billion passengers. In India the maximum permissible
- Trains go at 160 km/h in the United States and 300 km/h in the United Kingdom. India
- has more than four times the length of the operational routes than Britain. Indian railways also
- handle around six times the number of passengers handled by the Britain rail system

Comparison chart

- In terms of rail safety in both countries, the United Kingdom has 0.74 deaths per billion.
- passenger kilometers while India has 2.74 deaths per billion passenger kilometers

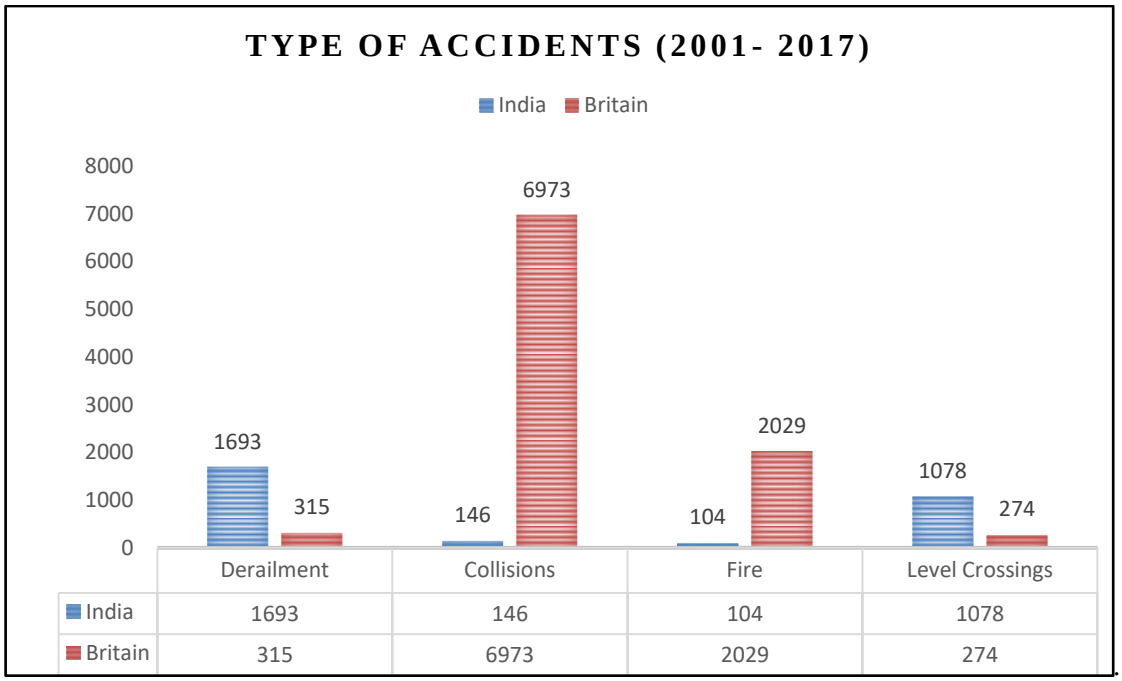

Figure 1Type of Accidents From 2001-2017

Literature survey:

Cracks in rails have been identified to be the main cause of derailments in the past, yet there have been no cheap automated solutions available for testing purposes. First LVDT was used instead of ultrasonic**,Ch. Muneendra Rao et al. [1]** Discussed about the technical details and design aspects of the model which are using to detect the crack which involves components like GPS module, PC, IR-photo diode. So, author conclude that the system is economical, time saving and we can implement it on large scale in order to safe India. **Li Zhuang et al. [2]** proposed a double-layer data-driven framework for the automated vision inspection of the rail surface cracks is proposed in this paper. Based on images of rails. the proposed framework is capable to detect the location of cracks firstly and next automatically obtain the boundary of cracks via a feature-based linear iterative crack aggregation (FLICA).**Prof. V. S. Shah et al. [3]** Discussed that the LVDT process which is having less accuracy to measure the crack instead of that we can use ultrasonic sensor consist of GSM module it is applicable in the detection during both day and day night. So, they conclude that in this system is presented to detect cracks in tracks effectively with ultrasonic sensors and by using wireless modules the information passed to authority. **N. Karthick et al. [4]** Proposed to use crack detection sensor this will be placed in the train engine. By this, if some crack is detected in track the starts to slow down and stop at the respective point automatically and exact place of the crack would be given to control room So, in this work he concluded the crack on the track face to face collision and de-railment all this occurrence's sense automatically and accidents are prevented **N. L. Bhojwani et al. [5]** Studied there is a need to have new technology which will be robust, efficient and stable for both crack detection in railway track as well as object detection. Then concluded that, a Railway track crack detection using sensors and is a dynamic approach, which combines the use of GPS tracking system and GSM module to send alert messages and the geographical coordinate of location**Saurabh Srivastava et al. [6]** Discussed manual inspection and detecting a crack on these railways tracks is very tedious process and consumes lot of time and human resource. Then concluded that,using this Autonomous patrolling vehicle for purpose of railway track inspection and crack detection**Arun Kumar et al. [7]** Discussed that in previously existing system work proposed system run with robot which having LED & LDR sensor assembly, but these sensors are makes systems slow, tedious

& time consuming. Then concluded that, system with GSM & GPS module, which will give real time location & coordinates in the form of Short Message Service. **Rijoy Paul et al. [8]** proposed that the Indian Railways apparently lacks new technologies, therefore chances of human error are more and it is one of the major causes of rail accidents in India. There is compromise in safety measure & delay in installing anti-collision devices and shortage in manpower. Then concluded that, a method to detect cracks in railway tracks has been presented using image processing techniques. **Xiukun Wei et al. [9]** In this paper discussed the railway track fastener defect (mainly for the fastener missing and broken cases) detection and classification issues are concerned. Then concludes that innovative and intelligent methods using image processing technologies and deep learning networks are proposed.

PROPOSED SYSTEM

This system involves the design of crack finding robot for finding cracks in railway tracks. This system uses controller for interfacing the robotic vehicle and crack detection sensor. The sensing device senses the voltage variations from the crack sensor and then it gives the signal to the microcontroller. The microcontroller checks the voltage variations between measured value and threshold value and controls the robot according to it. The robotic model is interfaced with the microcontroller with the help of motor driver circuit. If any crack occurs in the rail, the robot will be stopped and then a SMS will be sent "Figure 2" Represents Block diagram for proposed system.

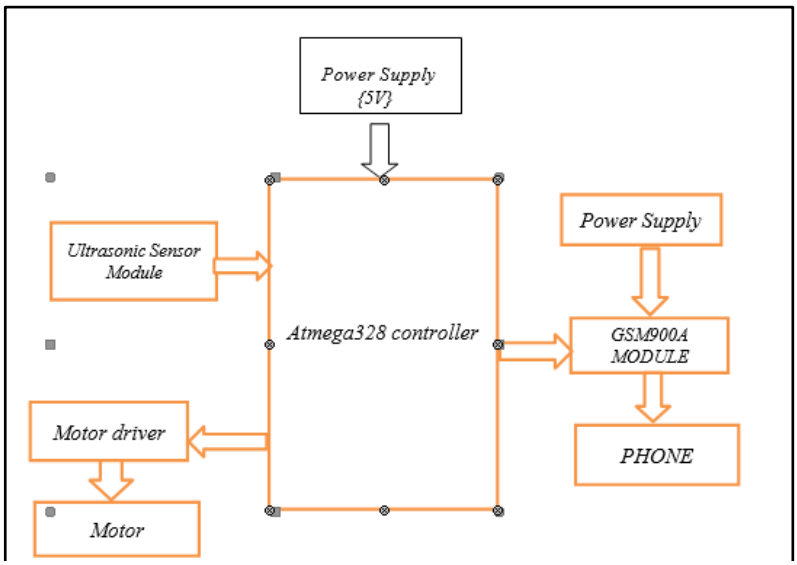

Figure 2Block Diagram for Proposed System

A. Block Diagram Description

Above diagram shows the block diagram of the proposed "Railway Track Crack Detection System". In this system we are using Arduino Uno microcontroller, which acts as a brain of the system. This microcontroller controls the circuit function. Various components are interfaced with this microcontroller to perform desired operation of the system. The hardware components used in this system requires regulated power supply for the operation.

In this system we have interfaced two Ultrasonic sensors with the microcontroller for the distance and detection of the crack present in the track of the railway line. To communicate the received information, we used a GSM modem. It sends message when crack is detected along with the distance from where the vehicle started. So, we get the distance at where the crack is located. The GSM send message to the control room. Immediate crack repairing can be done with this automatic vehicle. Two DC motors are used to move the robot in forward direction. These motors are interfaced and controlled through the microcontroller with the help of driver circuit. We used L293D driver IC, it starts and stops the motor as and when required.

B. working

The hardware is provided with a 240V power supply from source. This supply is converted into 5V for the controller IC. At this instant, the dc motors start rotating at 10 rpm initiating forward, movement of the vehicle. The GSM module is powered on by 12V. The ultrasonic sensor which is attached on one side of the vehicle, starts sensing and measuring the distance between the track and the sensor. If this distance is greater than the threshold value set for the sensor, crack is detected.

At this point, the vehicle stops for a brief period of time. During this time, the controller signals crack detected through the GSM module. After the message is received by the concerned authority, the motor starts again and moves the robot in

forward direction. If there is no crack detected, that means the distance between the sensor and the track is below or equal to the threshold value set, the vehicle continues to move along the track. “Figure 3”proposed flow chart of system.

Flow Chart

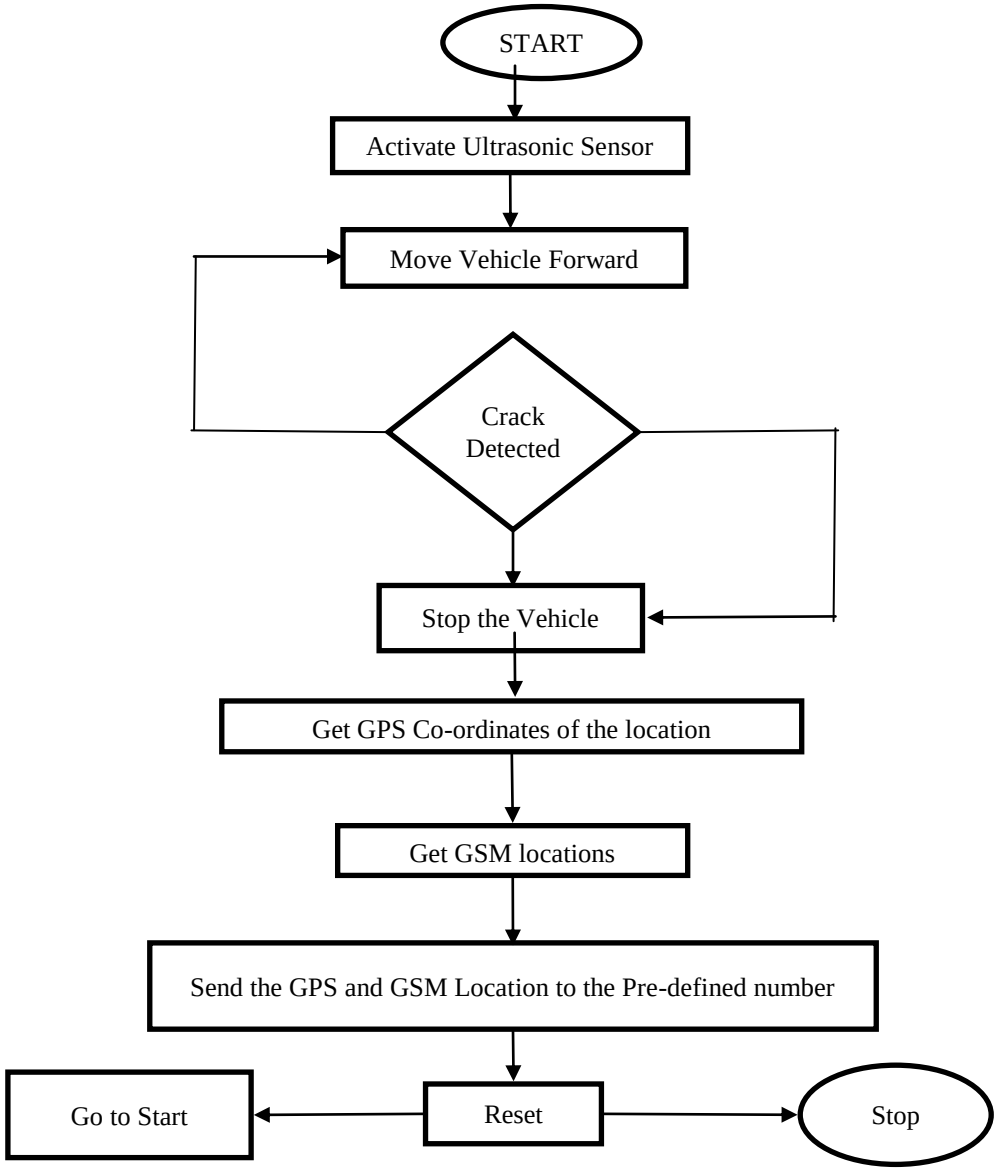

Figure 3Proposed Flow Chart of System

COMPONENTS & ANALYTICAL CALCULATION

A. **Arduino Uno Microcontroller:** The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs,16MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and reset button. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial convertor.

B. Power Supply: The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) battery. The board can operate on an external supply of 5 v . If more than 12Vis used then the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

C. General Description: HC-SR04 distance sensor is commonly the current consumed by the sensor is less than 15mA and hence can be directly powered by the on board 5V pins (If available). The Trigger and the Echo pins are both I/O pins and hence they can be connected to I/O pins of the microcontroller. To start the measurement, the trigger pin has to be made high for 10uS and then turned off. This action will trigger an ultrasonic wave at frequency of 40Hz from the

transmitter and the receiver will wait for the wave to return. Once the wave is returned after it getting reflected by any object the Echo pin goes high for a particular amount of time which will be equal to the time taken for the wave to return back to the sensor. The amount of time during which the Echo pin stays high is measured by the MCU/MPU as it gives the information about the time taken for the wave to return back to the Sensor. Using this information, the distance is measured as explained in the above heading

D. GSM Module: This is an ultra-compact and reliable wireless module. The SIM900A is a complete Dual- band GSM/GPRS solution in a SMT module which can be embedded in the customer applications allowing you to benefit from small dimensions and cost-effective solutions. Featuring an industry-standard interface, the SIM900A delivers GSM/GPRS 900/1800MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. With a tiny configuration of 24mm x 24mm x 3 mm, SIM900A can fit almost all the space requirements in your applications, especially for slim and compact demand of design.

E. Motor Driver IC L293d: A motor driver is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver act as an interface between Arduino and the motors. The most commonly used motor driver IC's are from the L293 series such as L293D, L293NE, etc. These ICs are designed to control 2 DC motors simultaneously. L293D consist of two H-bridge. H- bridge is the simplest circuit for controlling a low current rated motor. We will be referring the motor driver IC as L293D only. L293D has 16 pins.

F. DC Motor: High Torque 10 RPM DC geared motor. Motor with less RPM is preferred for precise result.Recommended to be used with DC Motor Driver 20A or Dual DC Motor Driver 20A

Analytical Calculations

Fram

With high strength and stiffness to weight ratios, plywood is very cost effective to use in structural applications such as flooring, shear walls, formwork and webbed beams. The panel shear of plywood is nearly double that of solid timber due its cross laminated structure

Dimensions

Frame dimension	=	300mm length, 200 mm wide
Thickness	=	4 mm on trial and error method
Wheels Diameter	=	70 mm
Frame material	=	Ply Wood
Area of frame	=	(2(L*B) +(B*H) +(H*L))
		2((300*200) +(200*4) +(4*300))
		124000 mm^3
Area	=	0.124 m^2 software
Calculated Area	=	124000 mm^2
Mass of frame with material	=	0.154 Kg
	=	1/12 x M (w2 + l2)
	=	1/12 x 0.154(300^2+200^2)
	=	**1668.3 Kg.mm^2**
	=	$\boldsymbol{\tau = \frac{M * Y}{I} = \frac{3678.75 * 2}{1668.3} = 4.41\ Mpa}$
		$M = Maximum\ bending\ in\ the\ frame = N$
		$y = yield\ cross - section\ from\ half\ thickness = 2mm$
		$\tau = stress\ in\ Mpa$
		$I = moment\ of\ inertia\ kg/mm^2$
		$M = force * distance$

$$M = 12.2625 * 300\ mm\ length = 3678.75\ N.mm$$

Force	=	load to put on frame
	=	Battery = 1kg
	=	Other electronics components =250 grams
Total load	=	1+0.25 = 1.25 Kg
		1.25*9.81 = 12.2625 N

Wood Plywood 13.8 Ultimate Yield strength Hence Design is safe.

Motor selection on total pay load of component

Selection Motor

Assume Total weight on the frame	=	2Kg =2*9.81 = 19.62 N
FOs	=	2
Final load	=	FOs* load on frame =19.62*2
	=	39.24 N =40 N

No wheels 4

Load is distributed into 4 wheels

Actual load	=	total load / no. of wheels
	=	40/4 =10N
Torque	=	½ Force X wheel Diameter
	=	½ X 10 X 70mm
	=	350 N.mm
	=	0.35 Nm.
Diameter	=	diameter of wheel (d= 70 mm) standard available in market, internal diameter (d 10mm).

DESIGN BY USING CATIA SOFTWARE V5

Computer-aided design (CAD) is the use of computer systems to aid in the creation, modification, analysis, or optimization of a design. Computer-aided manufacturing (CAM) is an application technology that uses computer software and machinery to facilitate and automate manufacturing processes. Many CAD vendors market fully integrated CAM systems, aptly called CAD/CAM systems. These CAD/CAM packages deliver many advantages. For starters, they feature a common user interface that allows CAD operators to quickly learn the software. Moreover, users can easily transfer CAD data to the CAM system without worrying about translation errors or other difficulties. And finally, some integrated systems provide full associatively, which means that any modification to the CAD model will prompt the associated tool path to be automatically updated. Computer Aided Design (CAD) has completely changed the drafting business and made the storage and retrieval of projects much easier. However, manual drawing is still very important and provides the basics of learning to draw.

The first system was very expensive, the computer graphics technology was not so advanced at that time and using the system required specialized H/W and S/W which was provided mainly by the CAD vendors. The first CAD systems were mainframe computer supported systems, while today the technology is for networked but standalone operating workstations (UNIX or WINDOWS based systems). AUTODESK was the first vendor to offer a PC based CAD system the AUTOCAD (beginning of 1980). Today WINDOWS is the main operating system for CAD systems. The first applications were for 2D-Drafting and the systems were also capable of performing only 2D modeling. Even today 2D-drafting is still the main area of application (in terms of number of workplaces). Later, (mid-1980), following the progress in 3D modeling technology and the growth in the IT H/W, 3D modeling systems are becoming very popular. 3D modeling is at the beginning wire frame based. Aerospace and automotive industries were using surface modeling systems for exact representation of the body of the product.

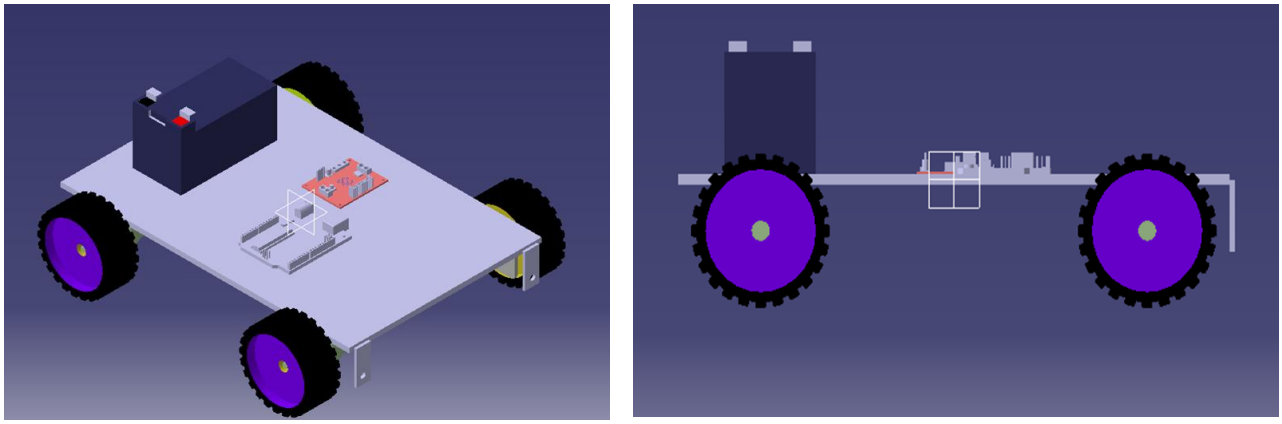

Figure 4 Catia Model for Railway Track Crack Detection

a) Manufacturing processes

Manufacturing processes are the steps through which raw materials are transformed into a final product. The manufacturing process begins with the creation of the materials from which the design is made. These materials are then modified through manufacturing processes to become the required part. Manufacturing processes can include treating (such as heat treating or coating), machining, or reshaping the material. The manufacturing process also includes tests and checks for quality assurance during or after the manufacturing, and planning the production process prior to manufacturing

b) Actual product

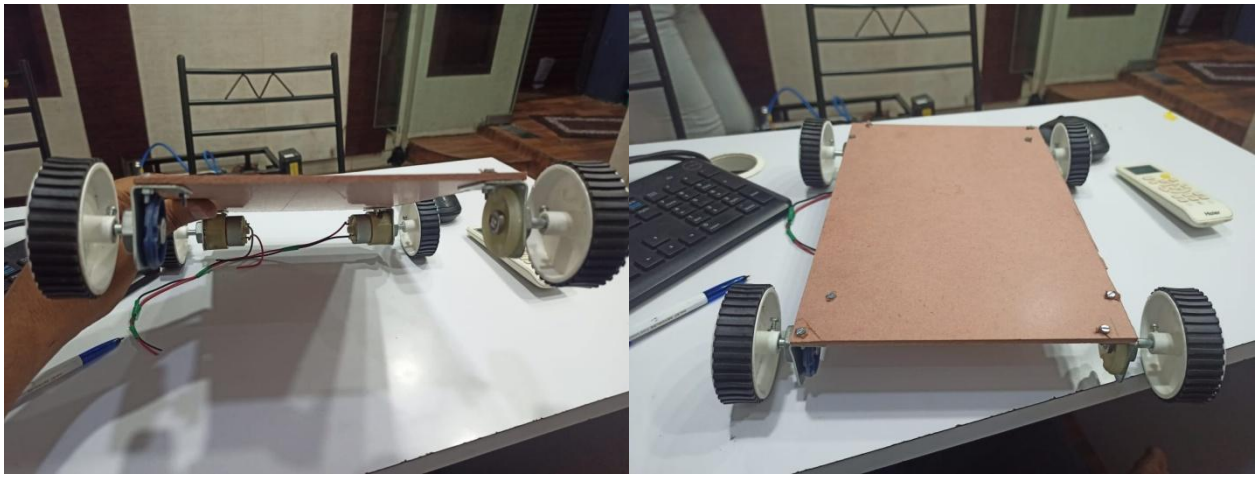

Figure 5: Actual (Fabricated) Model of Railway track Detection

CONCLUSION

The prototype's main goal is to utilize an ultrasonic sensor to detect cracks in train tracks and use a GPS module to display the exact location of the crack on a web interface. This technology has ability to be implement on a big scale to provide safe and reliable infrastructure for improved results. The suggested system has the following advantages: there is no noise, the output is extremely accurate, and the cost is significantly lower than the composite system. This technique we can use at any time of day or night. Solar panels can be used to power the system instead of the rechargeable battery, allowing for the utilization of renewable energy sources.

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