CHAPTER ONE

INTRUDUCTION

1.1 General Review

In today's world transport is a key necessity for specialization that allows production and consumption of products to occur at different locations. Transport has throughout history been a spur to expansion as better transport leads to more trade. Economic prosperity has always been dependent on increasing the capacity and rationality of transport [1], but the infrastructure and operation of transport has a great impact on the land and is the largest drainer of energy making transport sustainability and safety are major issues.

Sudan was once home to Africa's largest railway network, with more than 4,000 kilometers of track running from the Egyptian border to Darfur in the west, Port Sudan on the Red Sea coast and Wau in what is now South Sudan.

Today, after decades of mismanagement and neglect, most of the country's rail track is out of service. But the government, with the help of Chinese money and expertise, wants to rebuild it and restore some of the industry's former glory [2].

Because there is now a big considerable need for the use of railway networks due to large proportion of the travel, road traffic is expensive so the railway is cheaper, faster, safer and carrying more passengers. The combination of these factors places significant pressure on existing infrastructure leading to increased demand for the inspection and maintenance of rail systems.

1.2 Problem Statement

The main problem about a railway analysis is detection of cracks in the structure. The principal problem has been the lack of cheap and efficient technology to detect problems in the rail tracks and of course, the lack of proper maintenance of rails which have resulted in the formation of cracks in the rails. Most of the accidents in

the train are caused due to these cracks in the tracks, these accidents have been a big problem for railways for life security and timely management of services which cannot be easily identified. Recent researches on rail detection show that early detection of rail flaws especially of cracks, is of paramount importance for the safe and reliable operation of rail networks around the world [3].

Finding of these cracks in railways tracks with the conventional methods takes time consumption due to manual checking. It reduces the accuracy too. Accidents occurs due to track breaking needs to be identified in real time before a train actually arrived near the broken track and get subjected to an accident.

1.3 Objectives

The main aims of this study are to:

- Design of a mobile robot to detect the cracks in the railways.
- Implementation of the crack detector mobile robot.

1.4 Methodology

- Study of all related previous works.
- GSM module is used to send SMS to mobile phone.
- GPS is used to send and receive the current latitude and longitude values of the place.
- IR sensor is used to detect obstacles in front of the robot by either emitting and/or detecting infrared radiation.
- An Arduino of type UNO R3 is used as main controller of robot.
- Simulation of the system is done using PROTEUS electronic simulation package.

1.5 Layout

This research contains Five chapters. Chapter One is an introduction. Chapter Two presents the theoretical background includes an important techniques and the literature review. Chapter Three concentrates on the hardware and software

considerations. Chapter Four discuses the system implementation and testing results as well as cover the simulation of the overall system with PROTEUS software. Then the conclusion and recommendations of the research are present in chapter Five.

CHAPTER TWO

THEORETICAL BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

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. Hence, owing to the crucial repercussions of this problem, an efficient and cost effective solution suitable for large scale application is required.

Usually crack is measured manually by specialists. This is done via a track checker which is a small railway carriage used to audit the gauge and integrity of railway tracks. The first track checkers were simply people that walked on the tracks, making sure that the tracks were not damaged, these people were also called track walkers. A modern track checker, however is a small carriage on wheels and can be automated or driven by one engineer who is also known as a "Track Checker". This carriage drives along the tracks of a railway.

Track walkers are famously still employed in a stations along the railway line as in Atbara Sudan's main railway city, however, this lacks efficiency and objectivity which are needed for quantitative analysis. Besides, it can be very dangerous for people because the very high speed railway and it's critical to retrieve the crack properties precisely. Consequently, some new detection methods must be developed to improve the inspections. Although the government has taken necessary steps to safe journey but due to these cracks the accidents will happens, so this study deals with one of the efficient method to avoid this accidents [2]. In this research, different kinds of rail defects inspection and maintenance methods are described and a basic algorithm is readdressed that makes use of sensors for detecting cracks and breakages in the railway tracks.

With the evolution of communication technology, tracking has come a long way and being able to track objects like vehicles has become more achievable. New alternatives became used instead of the previous methods. These alternatives are based on using GPS (Global Positioning System) technology integrated with other technologies.

2.2 Microcontroller

A microcontroller is in some ways, a cross between a microprocessor and a microcomputer. The first controllers to gain really widespread use were the Intel 8048, which was integrated into PC keyboards and its successor, the Intel 8051, as well as the 68HCxx series of microcontrollers from Motorola. Today, microcontroller production counts are in the billions per year, and they are integrated into many important appliances.

Like microprocessors, the term microcontroller refers to a single device, however it contains the entire microcomputer on that single chip. Therefore a microcontroller is a processor which is equipped with memory, timers, parallel I/O pins and other on-chip peripherals. It used in automatically controlled products and devices and it has been designed in particular for monitoring and/or control tasks. The driving element behind all this is cost. Integrating all elements on one chip saves space and leads to both lower manufacturing costs and shorter development times this saves both time and money which are key factors in embedded systems which the control unit integrated into the system. Additional advantages of the integration are easy upgradability, lower power consumption and higher reliability which are also very important aspects in embedded systems.

The basic internal designs of microcontrollers are pretty similar. Figure 2.1 shows the block diagram of a typical microcontroller. All components are connected via an internal bus and are all integrated on one chip. The modules are connected to the outside world via input/output (I/O) pins.

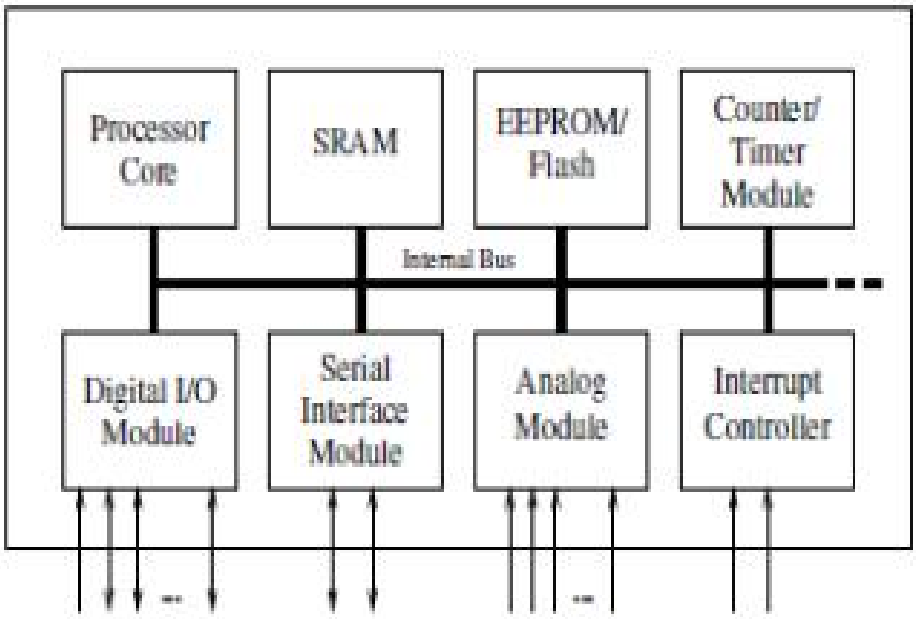

Figure 2.1: Basic layout of a microcontroller

Microcontrollers are generally tailored for specific applications and there is a wide variety of microcontrollers to choose from, it is divided into categories according to their memory, architecture, bits and instruction sets. The first choice a designer has to make is the controller family which defines the controller's architecture. All controllers of a family contain the same processor core and hence are code compatible but they differ in the additional components like the number of timers or the amount of memory. There are many different controller families like 8051, PIC, Motorola, Atmel's AVR family and others [4].

The ATmega328 is a single-chip microcontroller created by Atmel in the mega AVR family which offers our widest selection of devices in terms of memories, pin counts and peripherals, enabling reuse of code and knowledge across projects, it is a low-power CMOS 8 bit microcontroller based on AVR enhanced Reduced Instruction Set Computer (RISC) architecture. Datasheet document contains all the specs of the chip from functionality to assembly point of view, it has been officially released by Atmel. The most common implementation of this chip is on the popular Arduino development platform namely the Arduino Uno and Arduino Nano models. The Key parameters of ATmeg328 are 32 k bytes Flash, 32 Pin Count, 20 MHz Max Operating Freq, 8-bit AVR CPU, 23 Max I/O Pins, 24 External Interrupts [5].

2.3 Arduino

Arduino is an open source electronics platform accompanied with a hardware and software to design, develop and test complex electronics prototypes and products. The hardware consists of a microcontroller with other electrics component which can be programmed using the software to do almost any task. With the Arduino board, user can writes programs and create interface circuits to read switches and other sensors to control motors and lights with very little effort. The simplicity of the Arduino language makes it very easy for almost everyone to write programs without understanding of complex algorithms or codes. Arduino takes off the efforts required in complex coding and designing hardware, the open source nature of Arduino has been the main reason for its spreading. Since it is an open source project, all the files related to hardware and software is free and available for personal or commercial use. The open source nature doesn't require any licenses to develop, use, redistribute or even sell the product. The Software files which includes all the source code library are also open sourced and the user can modify them to make the project more versatile and improve its capabilities [6].

The Arduino Platform:

Arduino is composed of two major parts:

- Arduino board which is the piece of hardware in which the user works on when building his objects. It is a small microcontroller board. The board contains all the components that are required for this microcontroller to work properly and to communicate with computer. There are many versions of this board, one of these is the Arduino Uno which is the simplest one to use and the best one for learning on.
- Arduino IDE is the piece of software which is run on the computer. The Integrated Development Environment (IDE) is a special program running on computer that allows to write sketches for the Arduino board in a simple language modeled after the Processing, The main features of the (IDE) are: simple to use , open source (Free) , programming style similar to C language [7].

2.4 Global System for Mobile communication (GSM)

The GSM which is one of the representative wireless networks which has low power, low cost and convenience to use. Global System for Mobile Communications originally from group special mobile is the most popular standard for mobile telephony systems in the world, it used by over 1.5 billion people across more than 212 countries and territories. GSM networks operate in a number of different carrier frequency ranges with most 2G GSM networks operating in the 900 MHz or 1800 MHz bands. The longest distance the GSM specification supports in practical use is 35 kilometers.

A GSM modem is a specialized type of modem which receives a SIM card and operates over a contribution to a portable operator, just like a mobile phone. From the mobile operator viewpoint, a GSM modem aspects fair similar a portable receiver. When a GSM modem is linked to a CPU, this permits the CPU to use the GSM modem to communicate over the mobile network.

One of the key features of GSM is the Subscriber Identity Module, commonly known as a SIM card. The SIM is a detachable smart card containing the user's subscription information and phone book. This allows the user to retains his or her information after switching handsets [8].

2.4.1 GSM User Services

GSM offers much more than just voice telephony, it offers three basic types of services:

- Telephony services or teleservices: These services are further transited in the ways of Voice Calls, Video text and Short Text Messages(SMS)
- Data services or bearer services: ,is the essential building block leading to widespread mobile internet access and mobile data transfer.
- Supplementary services: These services include caller identification, call forwarding, call waiting, multi-party conversations..

2.4.2 GSM features

The features of GSM that account for its popularity and wide acceptance are:

- Improved spectrum efficiency
- International roaming
- Low-cost mobile sets and base stations (BSs)
- High-quality speech
- Compatibility with Integrated Services Digital Network (ISDN) and other telephone company services.
- Support for new services [9].

2.5 Global Positioning System (GPS)

The Global Positioning System is a space-based navigation system that provides location and time information in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites and used to find the location of any object or vehicle continuously using satellite signals. It consists 24 satellites that circle the globe once every 12 hours to provide worldwide position, time and velocity information, makes it possible to precisely identify locations on the earth by measuring distance from the satellites.

Originally the system was designed only for military applications, Since the early 1970s, the United States Government has spent tens of billions of dollars to develop, produce and operate GPS as a dual use (military and civilian) system. GPS is operated by the U.S. Department of Defense (DoD). But even before the system reached its full operational capability in 1995, the civilian user community had enthusiastically adopted GPS for its own applications.

Some of its applications are personal navigation, vehicle navigation, agriculture, mobile resource management, crime tracking, mapping and GIS [10].

2.5.1 Structure of GPS

Figure 2.2 shows the three major GPS segments

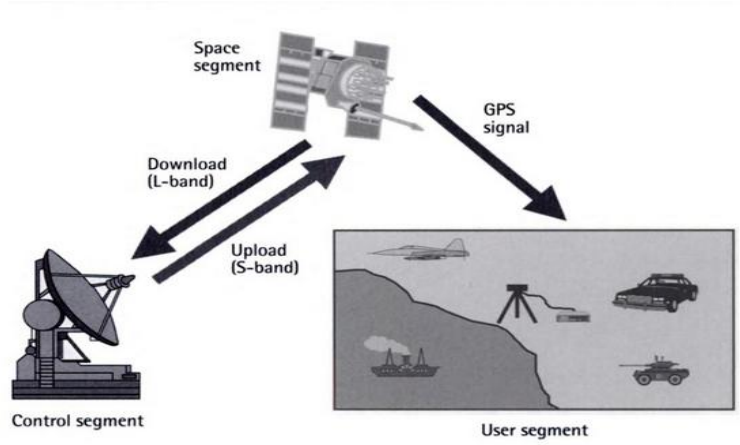

Figure 2.2: GPS segment

- The space segment: Consists of satellites circling the earth constantly moving making two complete orbits around the earth in just under 24 hours. It can receives satellite signals anywhere in the world at any time [11]. The satellites are arranged in their orbits so a GPS receiver on earth can always receive a signal from at least four satellites at any given time (the three satellite signals are necessary to locate the receiver in 3D space and the fourth satellite is used for time accurateness) [10]. Each satellite transmits low radio signals with a unique code on different frequencies, allowing the GPS receiver to identify the signals. The main purpose of these coded signals is to allow for calculating travel time from the satellite to the GPS receiver, since these are low power signals and won't travel through solid objects, it is important to have a clear view of the sky.
- The control segment: The control segment tracks the satellites and then provides them with corrected orbital and time information, it consists of one master control station and four unmanned stations which receive data from the satellites and then send that information to the master control station where it is corrected and sent back to the GPS satellites.
- The user segment: The user segment consists of the users and their GPS receivers .It includes all military and civilian users. With a GPS receiver connected to a GPS antenna, a user can receive the GPS signals which can be used to determine his

or her position anywhere in the world. GPS currently available to all users worldwide at no direct charge[11].

When a GPS receiver is turned on, it first downloads orbit information of all the satellites, once downloaded it is stored in the receiver's memory for future use. Even though the GPS receiver knows the precise location of the satellites in space, it still needs to know the distance from each satellite it is receiving a signal from. That distance is calculated by the receiver, by multiplying the velocity of the transmitted signal by the time it takes the signal to reach the receiver. The receiver already knows the velocity, which is the speed of a radio wave or the speed of light. To determine the time part of the formula, the receiver matches the satellites transmitted code to its own code, and by comparing them determines how much it needs to delay its code to match the satellites code. This delayed time is multiplied by the speed of light to get the distance.

2.5.2 GPS Difficulties

In spite of all advantages, there are some problems faced by this system as:

- GPS signals relatively weak (actually buried in background noise)
- Signals cannot penetrate into concrete and steel buildings or underground
- Signals can be blocked by buildings and other structures
- Susceptible to interference or jamming
- Reflected signals cause position error [12].

2.6 Infrared (IR) sensor

The sensors is a device which provides a usable output in response to a specified measurand [13]. The purpose of a sensor is to respond to some kind of an input physical property and to convert it into an electrical signal that is compatible with electronic circuits. The sensor's output signal may be in the form of voltage, current, or charge. It is very difficult to classify sensors under one criterion and hence, different criteria may be adopted for the purpose [14].

An infrared sensor is one of the most commonly used sensor which is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared

radiation. It used to detect obstacles in front of the robot or to differentiate between colors depending on the configuration of the sensor and can measure the heat of an object as well as detects the motion .

The IR sensor emits IR light and gives a signal when it detects the reflected light. The circuit required to make an IR sensor consists of two parts, the emitter circuit and the receiver circuit as shown in Figure 2.3

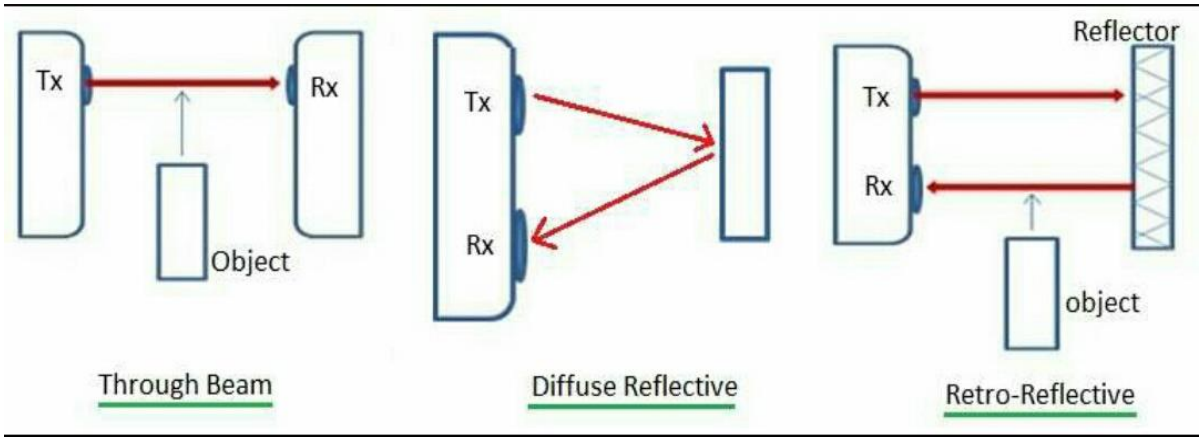

Figure 2.3: IR sensor working

The emitter is simply an IR Light Emitting Diode (LED) and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode, its resistance and correspondingly its output voltage change in proportion to the magnitude of the IR light received.

It works by using a specific light sensor to detect a select light wavelength in the Infrared spectrum. By using a (LED) which produces light at the same wavelength as what the sensor is looking for. When an object is close to the sensor, the light from the LED bounces off the object and into the light sensor. This results in a large jump in the intensity which can be detected using a threshold [13].

2.7 Direct Current (DC) Motor

Almost every mechanical movement that we see is accomplished by an electric motor. Electric machines are a means of converting energy, the motors takes electrical

energy and produce mechanical energy.

The direct current motor or the DC motor has a lot of application in today's field of engineering and technology starting from an electric shaver to parts of automobiles, in all small or medium sized motoring applications DC motors come handy. In most cases, regardless of type, electric motors consist of a stator (stationary field) and operate through the interaction of magnetic flux and electric current to produce rotational speed and torque.

There are different kinds of DC motors but they all works on the same principles and they works on the principal when a current carrying conductor is placed in a magnetic field, it experiences a torque and has a tendency to move [15].

2.8 Robotics

Robotics is the branch of mechanical engineering, electrical engineering and computer science that deals with the design, construction, operation and application of robots as well as computer systems for their control, sensory feedback and information processing.

These technologies deal with automated machines robots for short that can take the place of humans in dangerous environments or manufacturing processes or resemble humans in appearance, behavior and or cognition.

2.8.1 Types of robotics

i- Mobile robotics: Which is concerned with robots that move around mostly on the ground, but also in the air and under water. It uses locomotion mechanisms such as wheels, tracks or legs and usually move on the ground.

ii- Manipulator robotics: Which is concerned mostly with robotic arms of various types, they refer to various robot arms and grippers and can move on one or more dimensions [16].

2.8.2 The key parts of a robot

The basic parts of robot shown in figure 2.4 are:

i-The sensors: The sensors are the 'eyes' of the robot, they may take the form of tactile, electrical or optical devices among others and are used to obtain information

on the position of the articulations and on objects in the robot's environment.

ii- An effectors:

Any device on a robot that has an effect on the environment. They produce movements in the individual articulations with power provided by the actuators. Such systems may take the form of cables, bands, gears etc. All effectors have some mechanism that allows them to do their work.

iii- An actuator:

Is the mechanism that enables the effecter to execute an action or movement and includes electric motors, hydraulic or pneumatic cylinders and various other technologies. These mechanisms actuate the wheels, tracks, arms, grippers, and all other effectors on robots.

iv- Controllers:

Play the role of the brain and the nervous system, provide the hardware and/or software that makes the robot autonomous by using the sensor inputs and any other information to decide what to do and then to control the effectors to execute that action. The robot's controller sends commands to the robot's effectors to produce the desired effect on the environment based on the robot's task ([16], [17]).

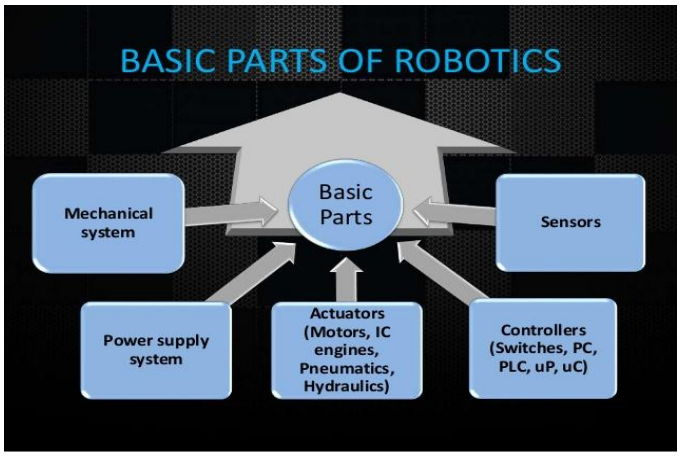

Figure 2.4: Basic robot parts

2.9 Literature Review

Recently there are several methods of techniques used for inspecting cracks in railway tracks, the new method which utilizes simple components beside a GPS module such as GSM Modem, IR transmitter and receiver based crack detector assembly is very useful in railway crack detection. This idea can be implemented in the long run to facilitate better safety standards and provide effective testing infrastructure for achieving better results in the future.

Prashanthi Antari et.al [8] discussed a system that proposes a cost effective solution to the problem of railway track crack detection utilizing IR assembly. this project is implemented with LPC2148 microcontroller using GSM module and GPS receiver.. Ramavath Swetha et.al [18] their project aims in designing railway track crack detection autonomous vehicle using microcontroller, IR obstacle sensors assembly system, which detects the cracks along its path. The vehicle is also capable of monitoring the location of the crack by using the GPS module and alerts through SMS messages using GSM module. The central component of the whole system is a PIC microcontroller. The vehicle is powered with the help of solar panel and lead acid battery assembly. The project is designed in such a way that it detects the cracks or deformities on the track which when rectified in time will reduce train accidents. The addition of solar panel is an added advantage, which also helps conserving the power resource.

An algorithm for crack detection in rail tracks is uses Light Emitting Diode and Light Emitting Resistor (LED-LDR) assembly which tracks the exact location of faulty track. In this method the researchers Shailesh D. Kuthe et.al [19] utilized a method that is unique in the sense that while it is simple, the idea is completely novel and hitherto untested. The project discusses the technical and design aspects in detail and also provides the proposed robust crack detection algorithm as so as presents the details of the implementation results utilizing simple components inclusive of IR LED-Photodiode based crack detector assembly. The main aim of this system is to sense the output of photodiode from onboard IR sensor as soon as the crack is

detected on rail track. So with help of infrared module, this will capture the instantaneous detection time and number of that respective crack which is used to calculate the distance for particular crack by knowing the speed of moving robot.. Avinash. SelvamrajuSomalraju et.al [20] also proposed a system that utilizes LED-LDR configuration for railway crack detection, simple components inclusive of a GPS module, GSM Modem and LED-LDR based crack detector assembly. The proposed broken rail detection system automatically detects the faulty rail track without any human intervention. The design proposed by the authors includes LEDs which are attached to one side of the rails and the LDR to the opposite side.

There are many advantages for the proposed systems mentioned above when compared with the traditional detection techniques. The advantages include less cost, low power consumption and less analysis time. By this proposed system the exact location of the faulty rail track can easily be located which will mended immediately so that lives can be saved.

Techniques that employ ultrasonic tide over some of the problems mentioned earlier, but they can only inspect the core of the track that is, it cannot check for surface and near surface cracking where most faults are usually located… P.Navaraja [21] introduced the integration of ultrasonic and total station for railway track geometry surveying system. This project consist of GPS module, GSM modem, IR sensor, PIR sensor for application of communication purpose, crack detection and finding of human being present in the railway track. The GPS module and GSM modem help to find and sending railway geometric parameter of crack detection to nearest railway station.

Another important technique for crack detection is a track surveying with wireless sensor. Wireless networks can keep an eye on situations impossible to monitor, this is done by using sensors to gather data. Information is sent hopping wirelessly across a web of these devices to a central location where it’s collected and analyzed, else this sensors can detect current conditions in a rail, such as temperature, track status or wheel imbalances. This information will be sent wirelessly to the locomotive

engineer and even ahead to the next station or to headquarters.. M. Kalaimathi, et.al [22] their surveying system can be used for both ballast and slab tracks. The authors have proposed a cheap and simple scheme with sufficient ruggedness which is suitable in the Indian scenario that uses an LVDT arrangement to survey track geometry by using multi sensor which has proved to be cost effective as compared to the existing methods. This sensor it will send information immediately by using GSM. Bridge damage status is monitored by the sensor and wireless modules, when the sensor not getting signal immediately nearby wireless system notifies and alert or informs to the current train on the track. The above task is achieved through microcontroller, GPS, GSM, LVDT.

In another method recent research's has investigated the use of microwave horn antennas for crack detection. K.Vijayakumar et.al [1] presents a crack detection using microwave sensors. Their paper describes how a microwave horn antenna can be used to detect the cracks in a rail track based on the simulation results obtained from the High Frequency Simulation Structure (HFSS), it has been shown that the design of the microwave sensor has the potential for detecting defects in the rail surface including minor cracks as well as more serious.

Finally, the problem inherent in all these techniques is that the cost incurred is high. Then after going through all these papers, I came to a conclusion to do a project which would provide better safety standards in a cost effective way for railway crack detection. This research proposes a cheap, novel yet simple scheme that uses an IR-LED and Photodiode arrangement to detect the crack in railway lines which proves to be cost effective as compared to the existing methods.

CHAPTER THREE

HARDWARE AND SOFTWARE CONSIDRATIONS

3.1 System Description

The proposed crack detection scheme can be clarified through the block diagram shown in Figure 3.1. The IR sensor is used to find out the crack in the rail and sends the value of its corresponding voltage to the microcontroller to drive the robot via the DC motors. The microcontroller then sends the current latitude and longitude coordinates of the crack that received by the GPS receiver to the relevant authority in the form of a text message by using the GSM module .

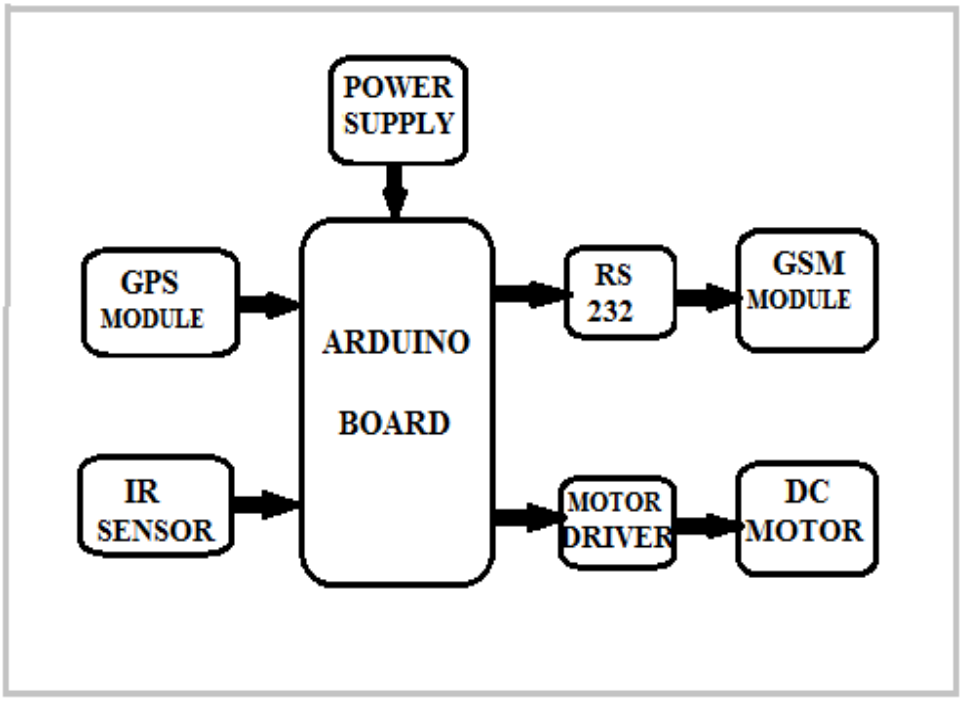

Figure 3.1: Block diagram of crack detection system

From this scheme the proposed system consists of many technologies such as GPS and GSM technologies which have been described previously, also several specific components that need to be well defined and explained in a more details before explain how they work and connect them in the circuit.

3.1.1 Arduino Uno

An Arduino board of type Uno(R3) shown in Figure 3.2 is used. It is one of the most common and widely used with a wide variety shields. "Uno" means One in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno version 1.0 will be the reference versions of Arduino moving forward.

Arduino UNO is one of the most popular development boards in robotics and electronics as well as. The board is very popular due to its flexibility, ability to connect different robotic parts including sensors, actuators, etc. UNO's features include a USB interface that doesn't require drivers to communicate with operating systems like Windows or Mac OS and can be programmed with the Arduino software. The ATmega328 on the Arduino Uno comes with a boot loader that allows user to upload new code to it without use of an external hardware programmer.

An UNO R3 Starter Kit board is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a USB connection, a 16 MHz crystal oscillator, a power jack, a reset button and more. It contains every things needed to support the microcontroller, simply connects it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno R3 works with all existing shields but can adapt to new shields which use these additional pins. Arduino shields are easy to use boards which can be use to perform various tasks to make the project in no time[23].

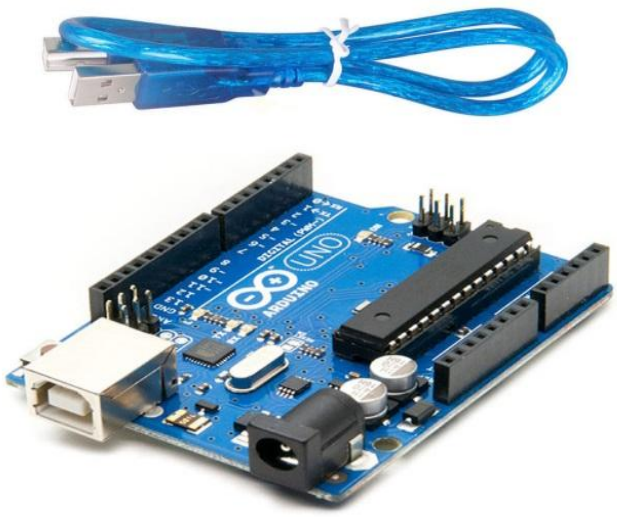

Figure 3.2: Arduino UNO R3 board

Figure 3.3 shows the basic overview of Arduino UNO R3

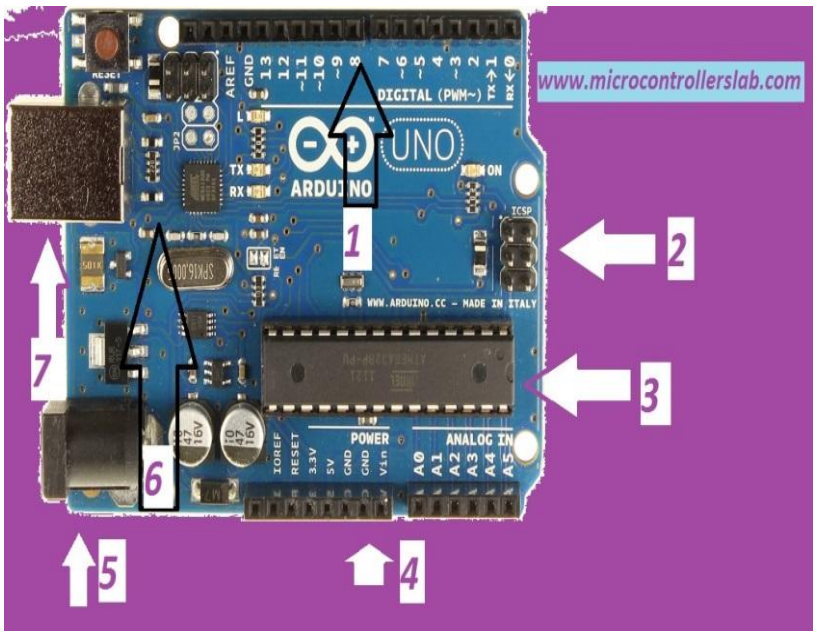

Figure 3.3: Board component

1- Digital input or output pins to communicate with external devices.

2- In-circuit serial programming (ICSP) used to program boot loader

3- On board ATMEGA32 microcontroller.

4- Analog pins and power pins. Analog pin are used to communicate with analog world like sensors etc, basically it is analog to digital converter channels.

5- 5-12 volt DC power supply connector

6- On board programmer used to upload sketch into micrcocontroller

7- USB connector is used to connect Arduino UNO R3 with computer and to upload sketches from computer to on board microcontroller [24].

3.1.2 IR sensor fabrication

The main electronic components that needed to build an infrared detector circuit are IR LED and Photodiode. An IR LED is a type of LED which emits light in frequency range of infrared and it used as a source of infrared rays, an IR Photodiode is a type of diode which detects light, it acts as a light source and it looks exactly like an LED sometimes with a dark blue or black film on the outer casing. It has a very high

resistance when no light is falling on it. This infrared transmitter and receiver is called as IR TX-RX pair and it can be obtained from any decent electronics component shop with little cost. Also other additional elements required for this sensor such as a resistances of 330Ω, 10 kΩ ohm and a transistor of type 2222. Figure 3.4 shows simple infrared (IR) detector components with IR LED and Photodiode.

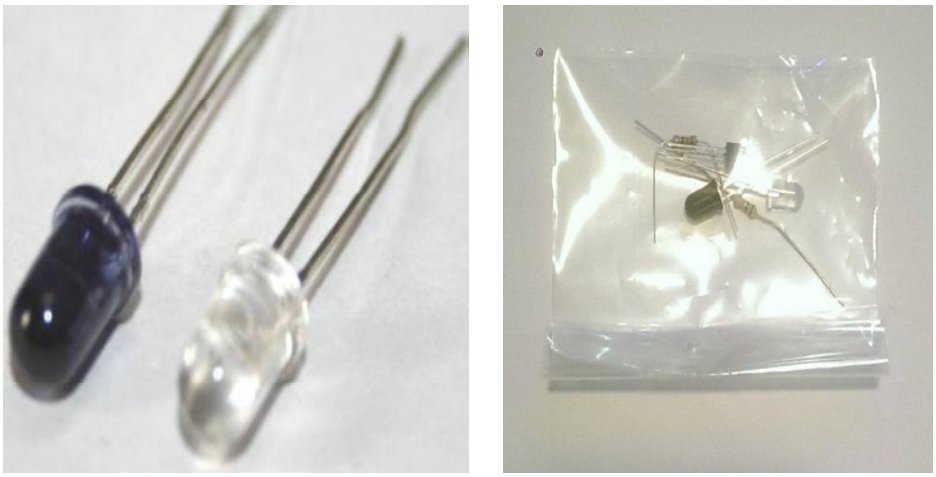

Figure 3.4: IR LED pair and its components

3.1.3 GPS module

GPS receiver of type SKM53 shown in Figure 3.5 has been used as the GPS module. It is a special designed starter kit which offer convenient yet safer GPS module for user with ultra high sensitivity and smart antenna GPS module. By referring to the SKM53 datasheet, it is embedded with GPS antenna which enables high performance navigation in most stringent applications and solid fix even in harsh GPS visibility environments.

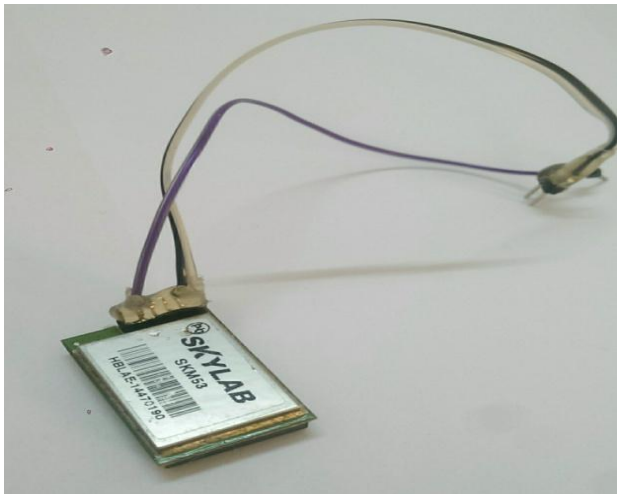

Figure 3.5: SKM53 GPS module

Basically, SKGPS-53 will send the data continuously as long as it is powered up. In a nutshell, by using this module can actually view the current time, date, latitude, longitude and so on. In further application it can used to interface with smart phone, microcontroller such as Arduino or PIC and so forth to know our location. Meanwhile, when use it people needs to expose it to the sky to capture the stronger signal. Otherwise, we will not receive the signal by GPS antenna if we inside a closed window room.

3.1.4 GPRS/GSM module

The SIM 900 GSM module shown in Figure 3.6 has been chosen to achieve the SMS functionality. GPRS/GSM Module is an ultra compact and reliable wireless module. Unlike mobile phones, a GSM modem doesn't have a keypad and display to interact with. It just accepts certain commands through a serial interface and acknowledges for those, these commands are called as AT commands.

The GPRS Shield is like a cell phone, provides a way to use the GSM cell phone network to receive data from a remote location. The shield allows to achieve this via the short message service and audio GPRS Service. This shield is compatible with all boards which have the same form factor and pin out as a standard Arduino board. The main features are:

- 5V Power Supply

- SIM Card holder and GSM Antenna present onboard.
- Free serial port connecting.

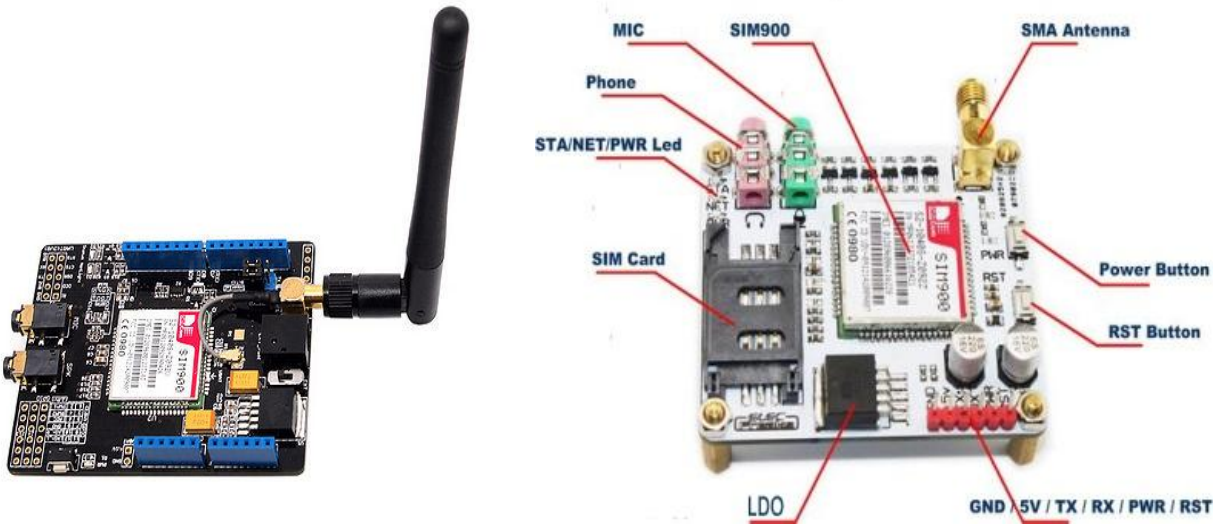

Figure 3.6: GPRS module

3.1.5 Motor driver

The DC motor driver of type L293D is used. It is a dual H-bridge motor driver IC which can interface and control two DC motors in both clockwise and counter clockwise direction. It has a 16-pin which can control the motors simultaneously in any direction, good for under 600 mA, runs at 5V logic and suitable for motor voltages from 4.5V up to 36V. It works on the concept of H-bridge which is a circuit that allows the voltage to be flown in either direction to rotate the motor in clockwise or anticlockwise direction.

In a single L293D chip there are Two H-Bridge circuit inside the IC which can rotate the Two dc motor independently. Due to its size it is very much used in robotic application for controlling DC motors. Figure 3.7 is the pin diagram of L293D motor controller.

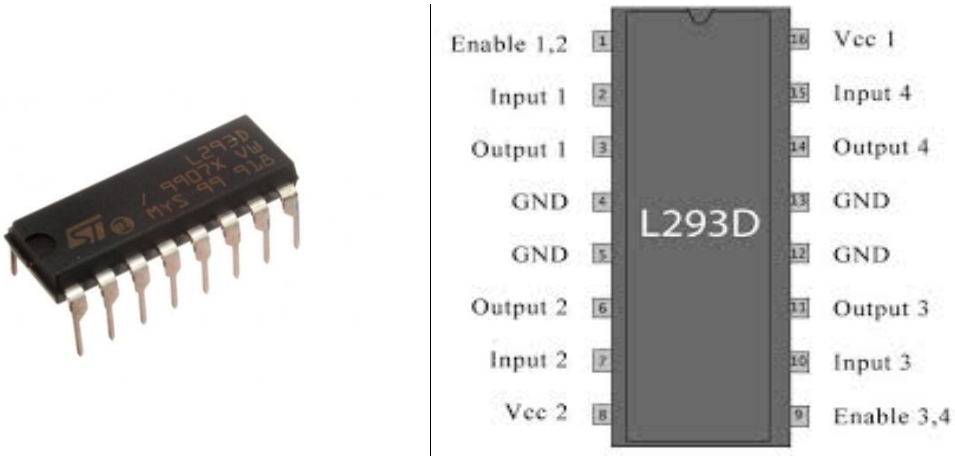

Figure 3.7: L293D pin diagram

The left input pins (pin 2, 7) and right input pins (pin 15, 10) will regulate the rotation of the motors that connected across the left and right side respectively. The motors are rotated on the basis of the inputs provided across the input pins as logic 0 or logic 1 [25].

3.2 System Software Consideration

Arduino code

The code of the Arduino is written using C language as shown in appendix. The approach of the program is consists of four parts, the first part is related to input\output pin configuration of Arduino UNO. The second part concerns with the movement of the engine in the forward direction and getting the sensor reading as well as determine whether there is a crack or not by evaluation the analog reading of sensor (Z). The Third part illustrates the latitude and longitude coordinates of the crack received by the GPS module. In fourth part, coordinates are transmitted to a predefined mobile phone by means of the GSM module. Accordingly, at the end the vehicle resumes its movement forward until detecting of a new crack. All these steps are illustrated in a flow chart as shown in Figure 3.8

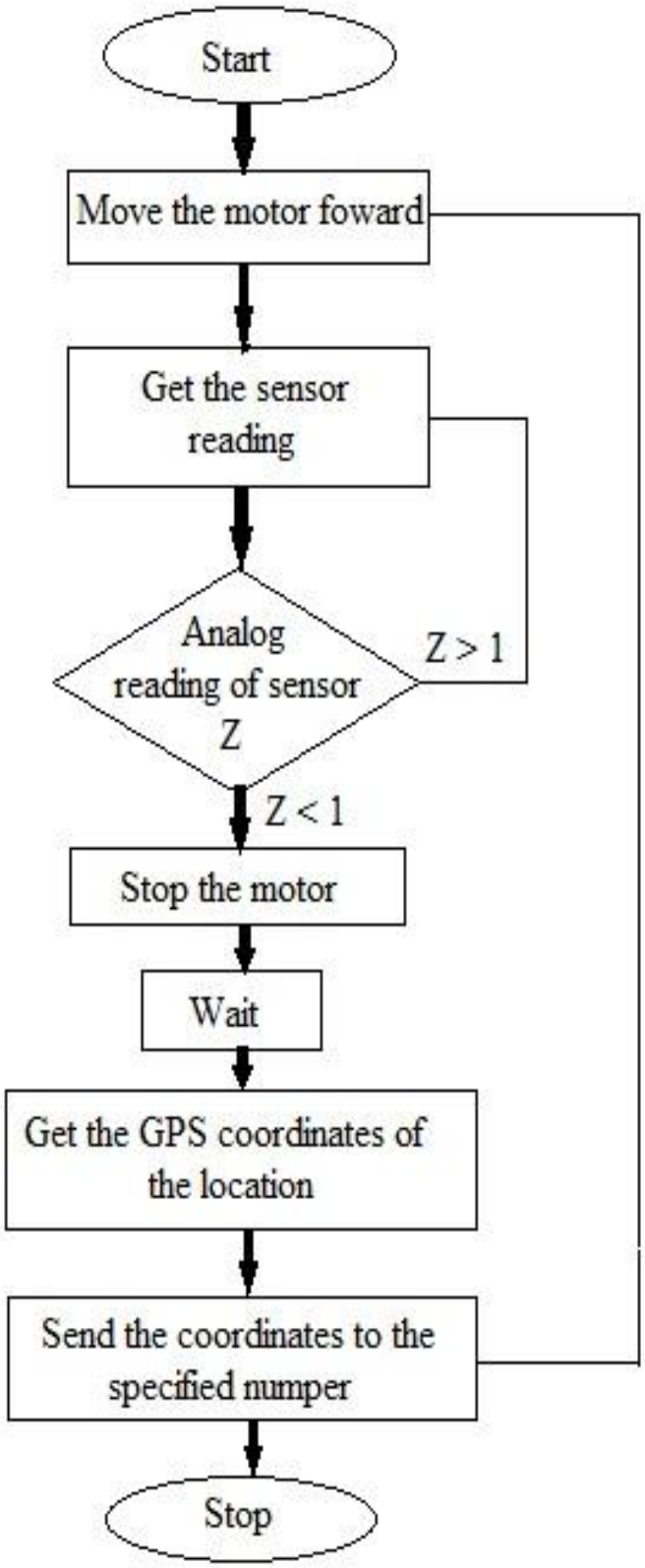

Figure 3.8: System flow chart

CHAPTER FOUR

SYSTEM SIMULATION AND IMPLEMENTATTION

4.1 System Simulation

System simulation done by Proteus software is a simple method for identify the errors included in electrical or electronic circuits by using computers. It allows the engineer to test the design before it is built in the real situation.

The overall circuit shown in the Figure 4.1 is designed and tested using an Arduino Uno, GSM module, GPS module and IR sensor libraries.

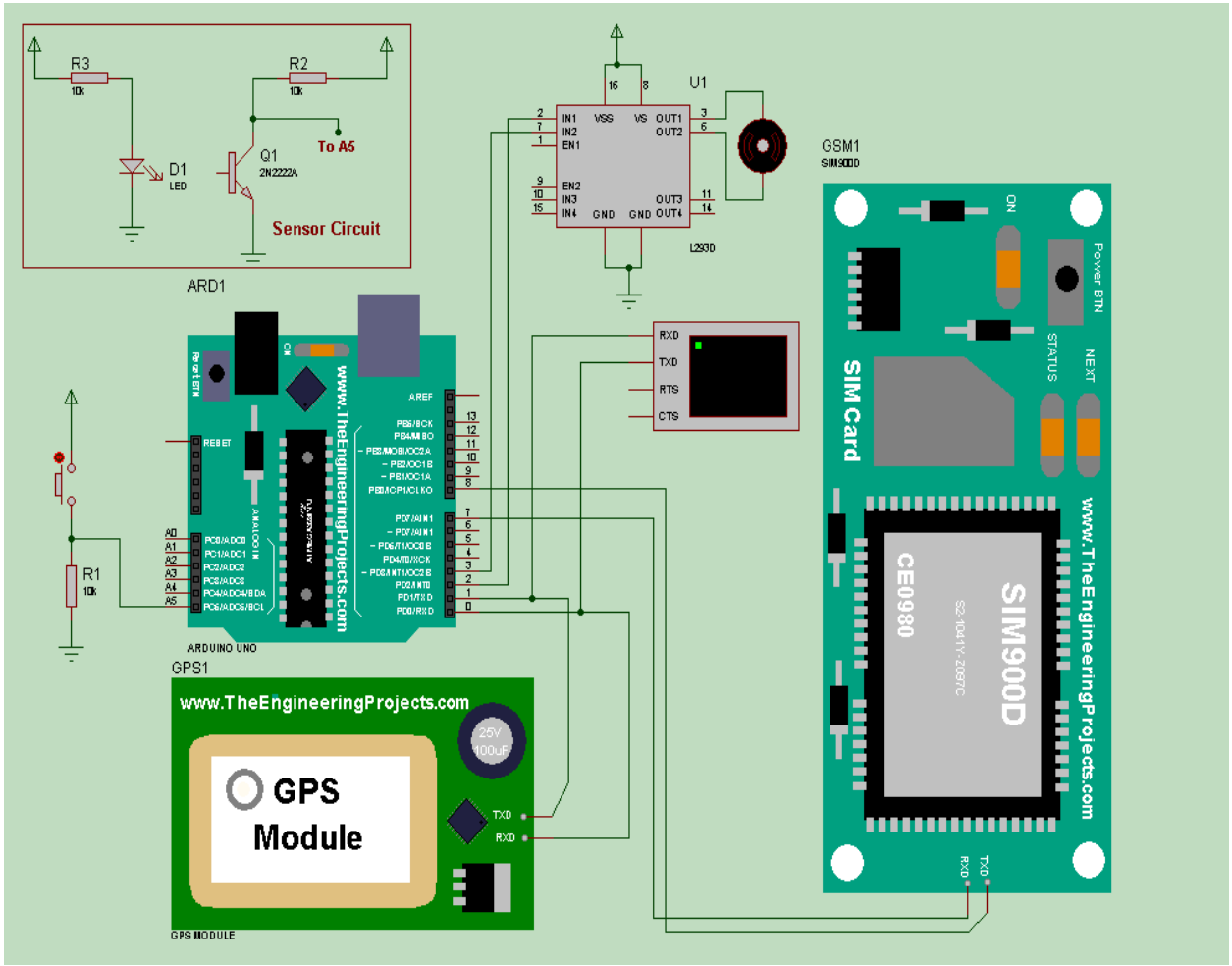

Figure 4.1: Overall circuit diagram

The first step be follow is to upload the Arduino program in a hex form by double clicking on the module as shown in Figure 4.2

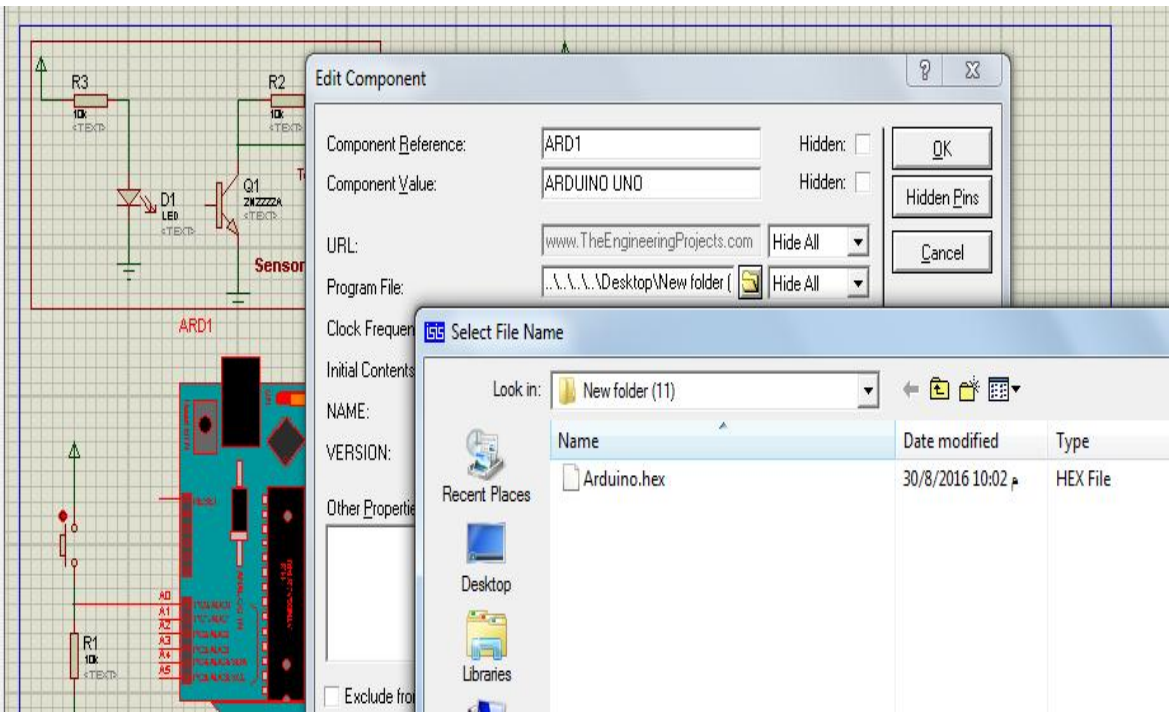

Figure 4.2: Uploading the Arduino program

By clicking a play button simulation will run and while the switch is pressing, the motor is runinng indicating that there is no crack in rails as shown in Figure 4.3.

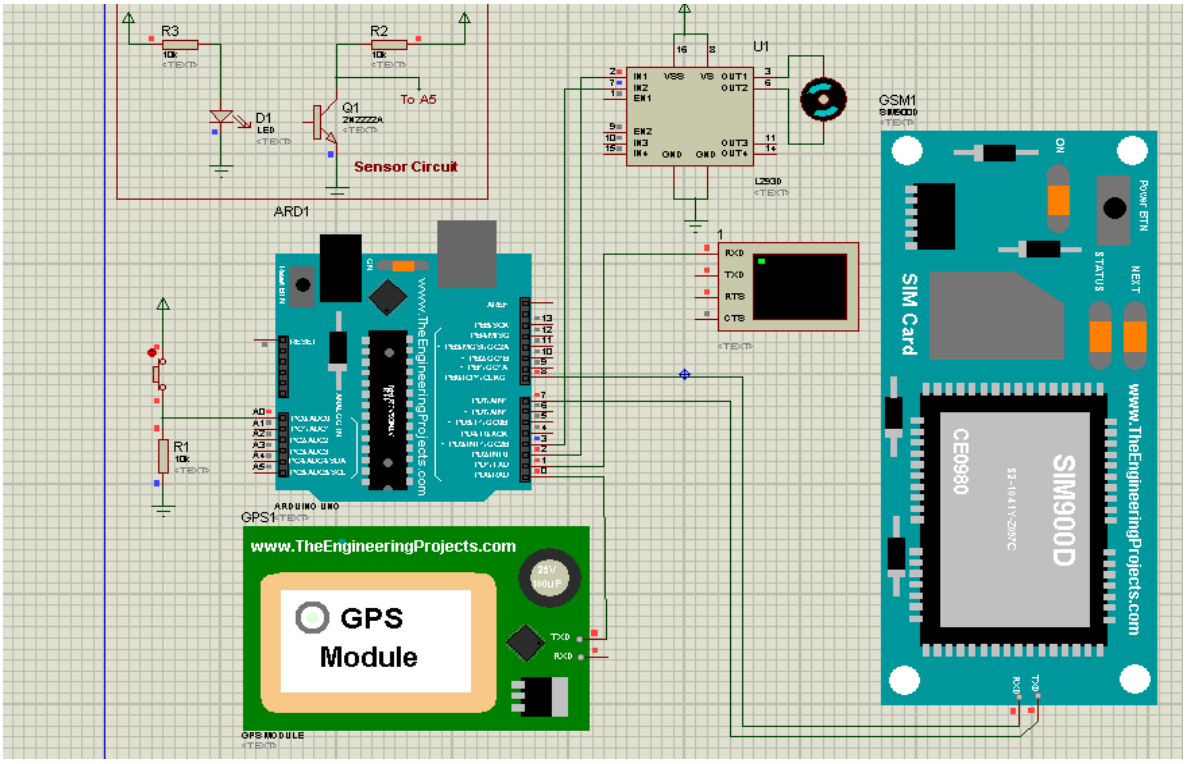

Figure 4.3: The sircuit with no crack detected

When the switch is off this means there is a crack and the motor will stop running as shown in figure 4.4

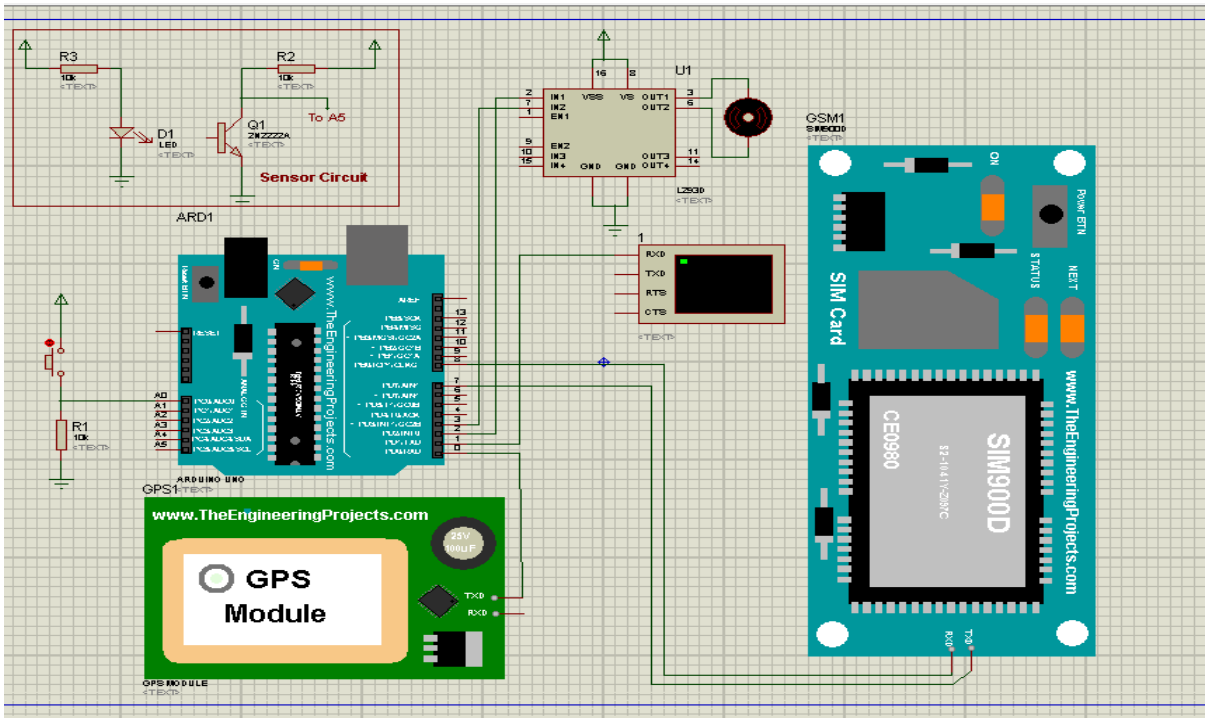

Figure 4.4: The sircuit with crack detected

To get the desired result, the first step is to upload the hex program of GPS module by the same way as shown in Figure 4.5

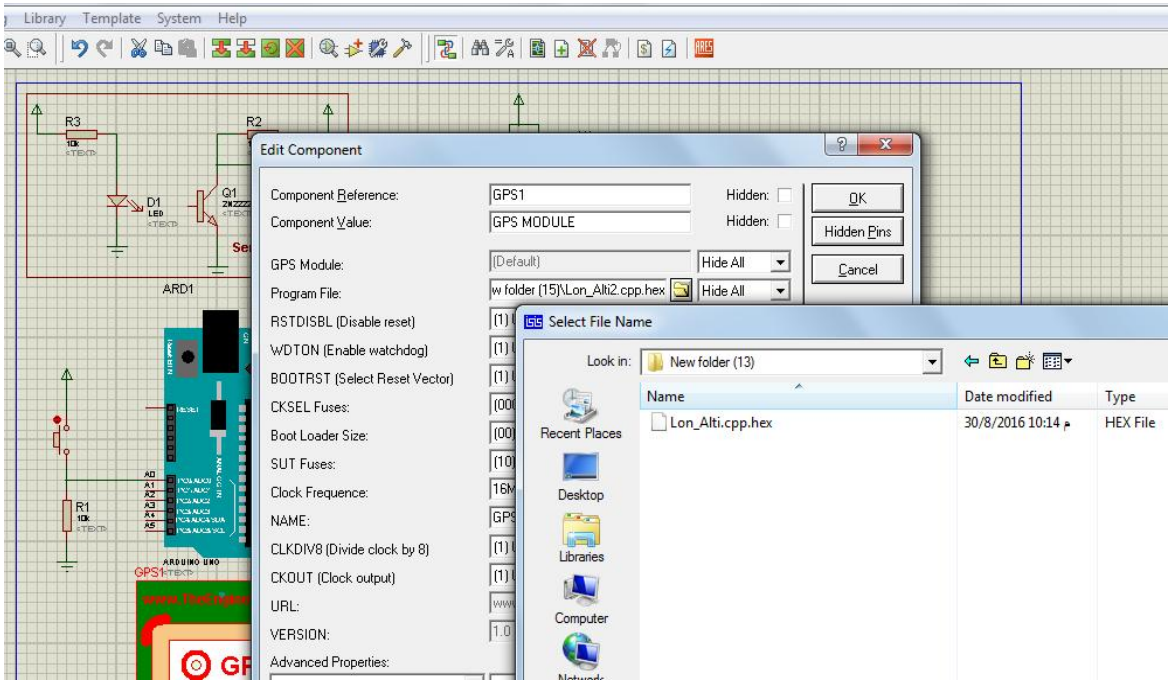

Figure 4.5: Uploading the GPS program

When the simulation is run the latitude and longitude data appear in a virtual monitor screen.

The second step is to upload the hex program of GSM module as shown in Figure 4.6

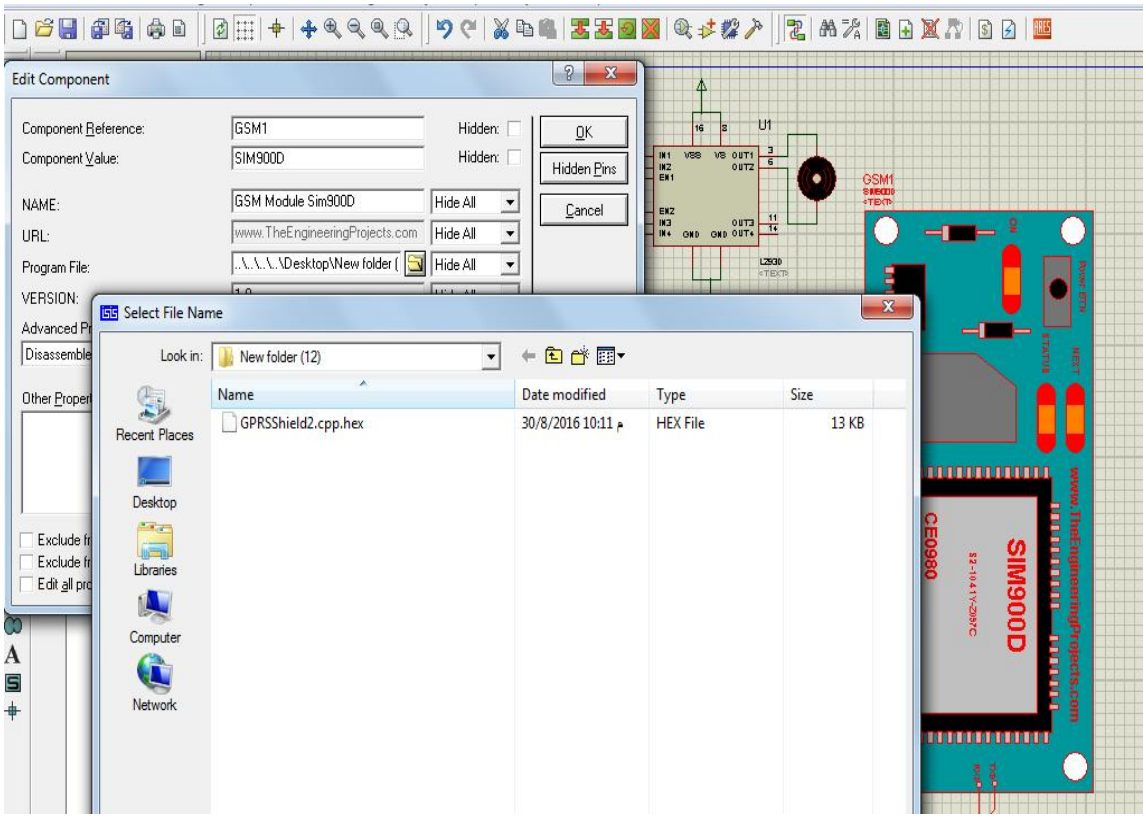

Figure 4.6: Uploading the GSM program

The message appears in the screen indicating that the module is ready to send the data as shown in Figure 4.7

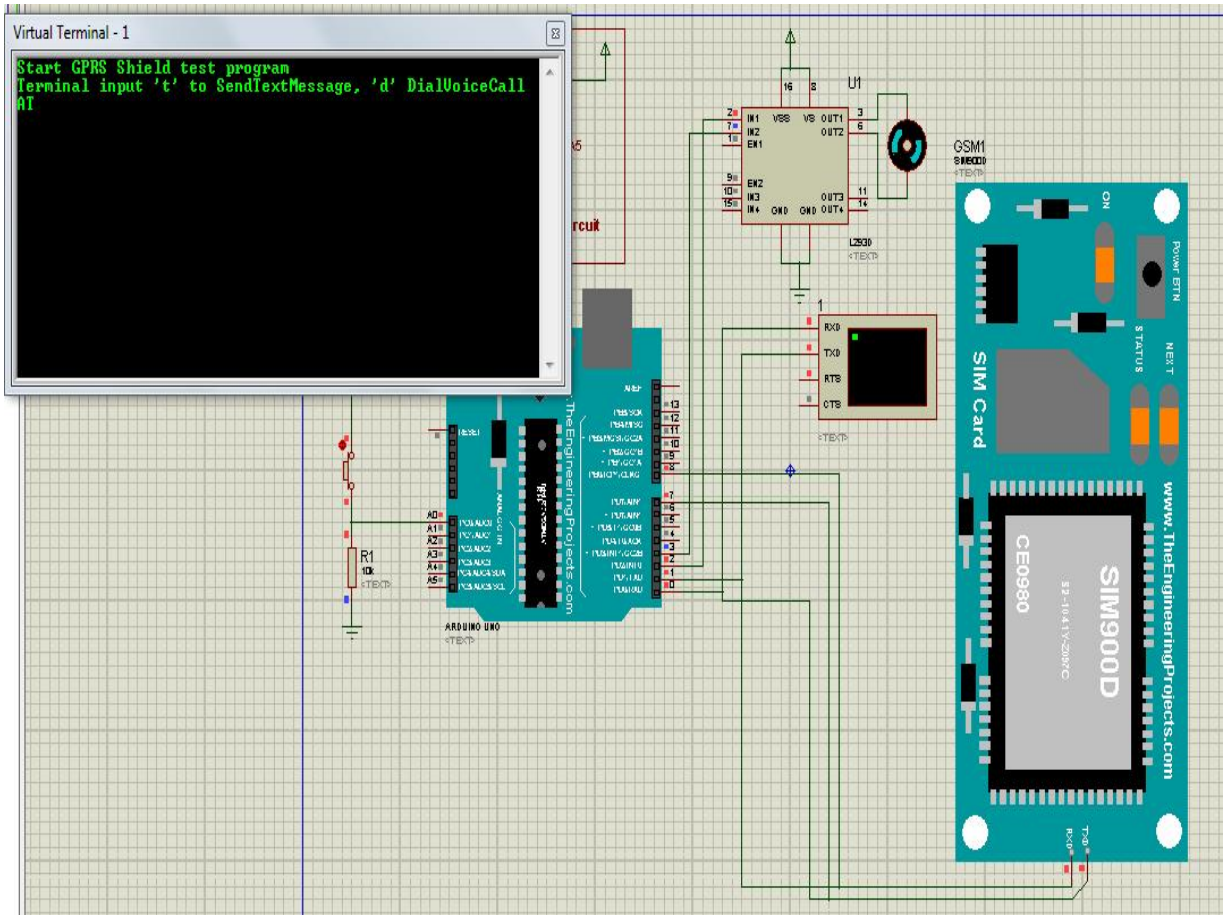

Figure 4.7: Sending the SMS

4.2 System Implementation

The proposed crack detection system shown in Figure 4.8 consists of an infrared sensor transmitter and receiver assembly that functions as the rail crack detector. In order to detect the current location of the device in case of detection of a crack, a GPS receiver whose function is to receive the current latitude and longitude data is used. To communicate the received information, a GSM modem has been utilized.

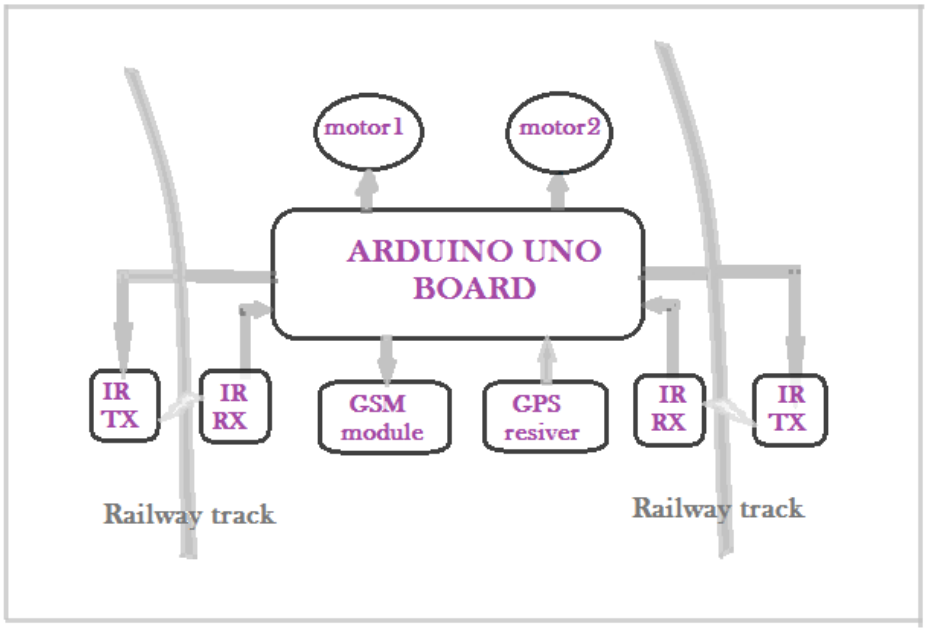

Figure 4.8: Crack detection System architecture

The first implementation step is the building of a mobile robot chassis that shown in Figure 4.9 it's actually a traditional robot similar to a simple toy car without cover and with two DC motors drive with a four wheels which are powered by 5V power supply. Also one IR sensor has been fixed in front of the robot to detect the crack in the railway.

The circuit board containing mainly the Arduino UNO board, motor driver, GPS and GSM modules.

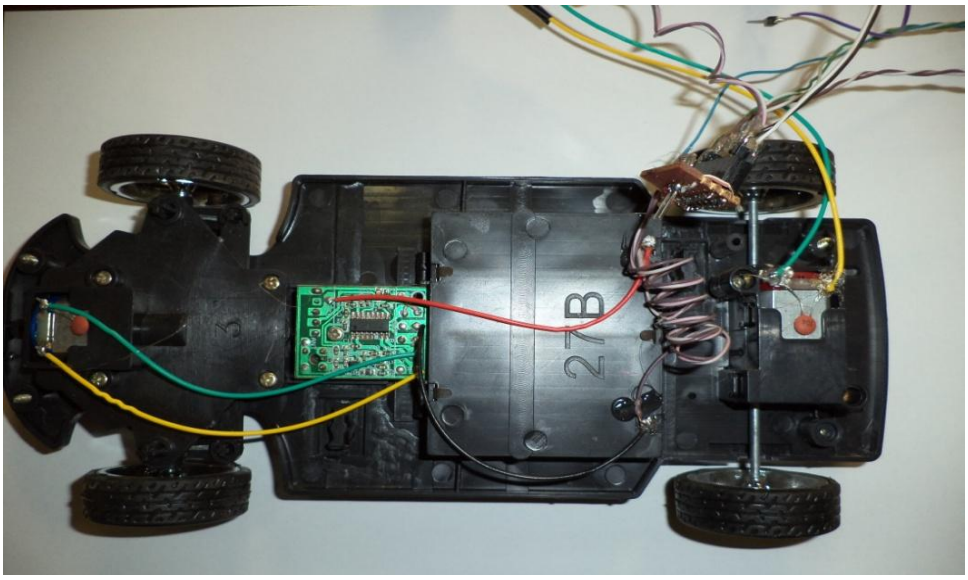

Figure 4.9: Robot chassis

4.2.1 Sensor connections

Figure 4.10 shows the IR sensor. The IR LED and the photodiode are placed side by side close together. The LED emits the light continuously while moving over the tracks, if there is a crack in the railway the light of the LED fall on the LDR through the gaps formed due to crack. The LDR is connected with 10Ω resistor, the change in potential difference between the light dependent resistor and 10Ω resistor gives the required output to identify cracks in rails.

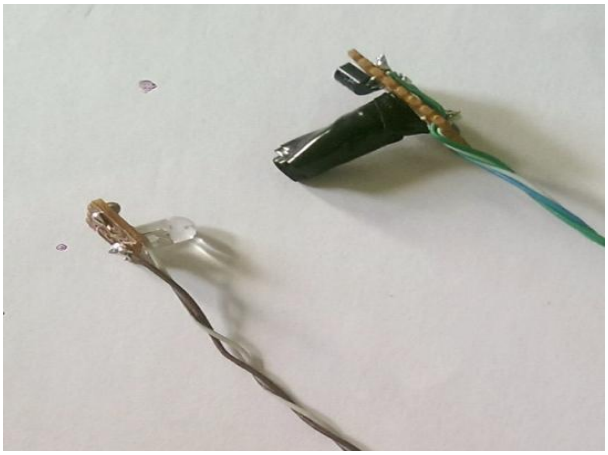

Figure 4.10: The sensor before installed on the wheels

The TR sensor has three terminals. The output terminal is connected to Arduino through Pin A0. The second and third terminals are connected to Arduino power and ground pins respectively.

4.2.2 GPS module connections

To get latitude and longitude data from Arduino UNO via SKM53 module only three terminals are needed. The data terminal which the module sends GPS satellite data is connected to RX pin of Arduino (pin0) and the two other terminals (power and ground) of GPS are also connected to Arduino power and ground pins respectively. typical connections are shown in Figure 4.11

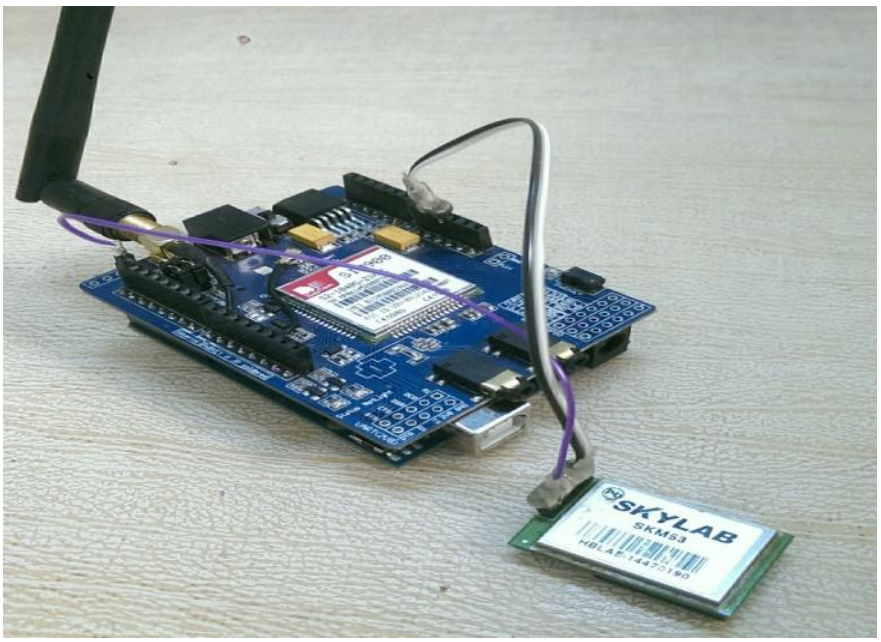

Figure 4.11: Connection of the GPS module with Arduino board

4.2.3 GSM module connections

In order to send the GPS coordinates as a text message to the predefined number it must provide a mobile phone and GPRS shield with a SIM card. The overall steps followed for sending this message are:

- Inserting the SIM card into onboard slot that is mounted on the GSM shield as shown in Figure 4.12

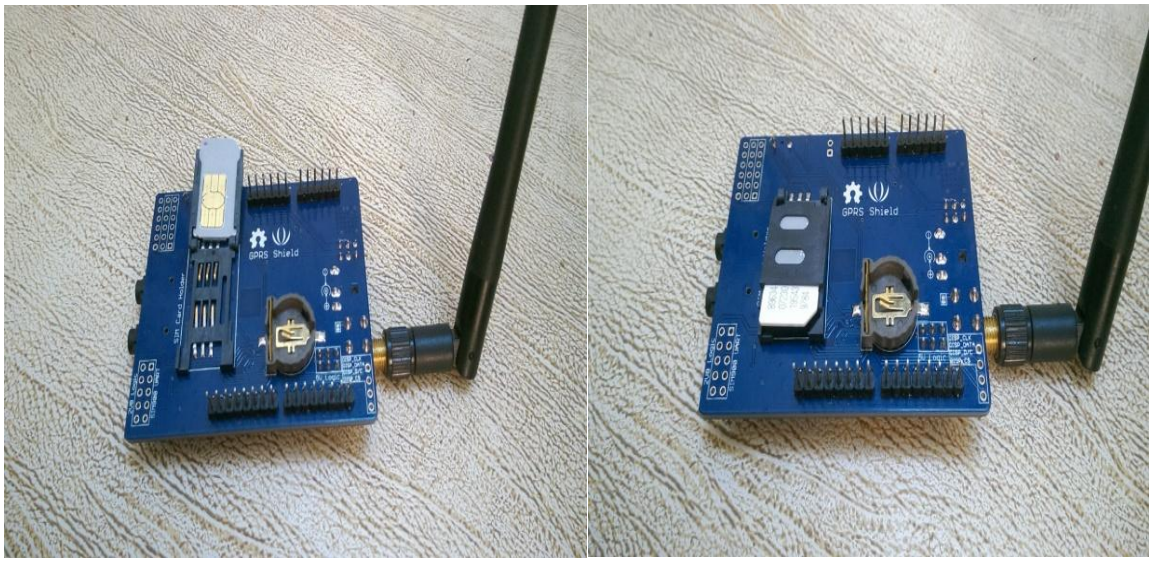

Figure 4.12: Inserting the SIM card

- Plugging the module into the Arduino board as shown in Figure 4.13

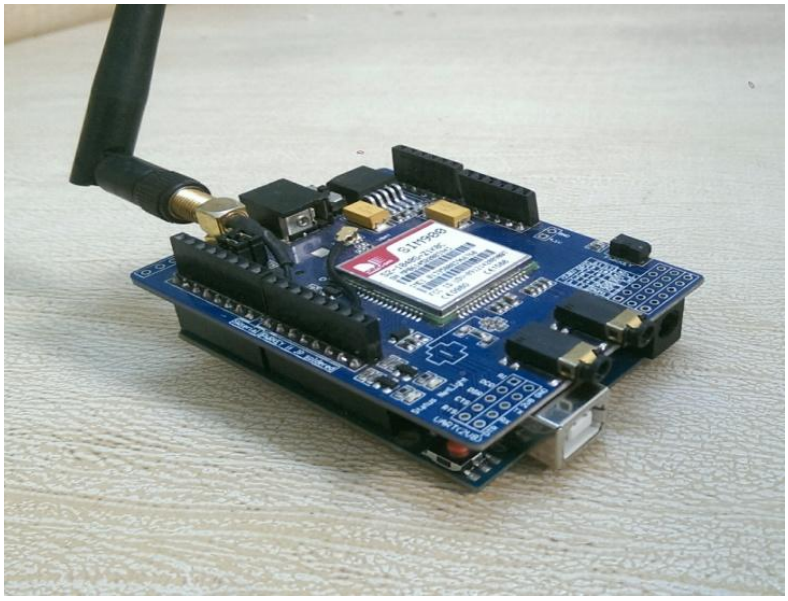

Figure 4.13: Plugging the GSM module with Arduino

- Starting the shield by connecting the external power supply through an Arduino USB cable and pressing the power On/Off switch for a few moments so the power On/Off indicator LED glows as shown in Figure 4.14

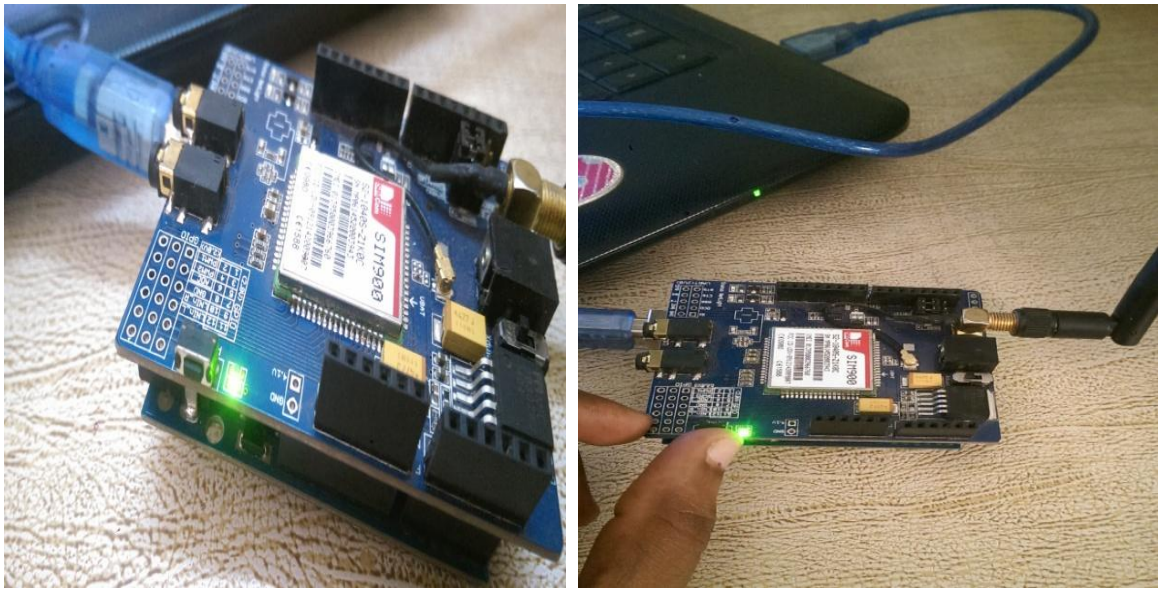

Figure 4.14: Power on the shield

- Notice the blinking rate of network LED, it starts to blink in fast for few

seconds (Searching for network). Once the connection is established successfully the LED will blink continuously every three seconds as in Figure 4.15.

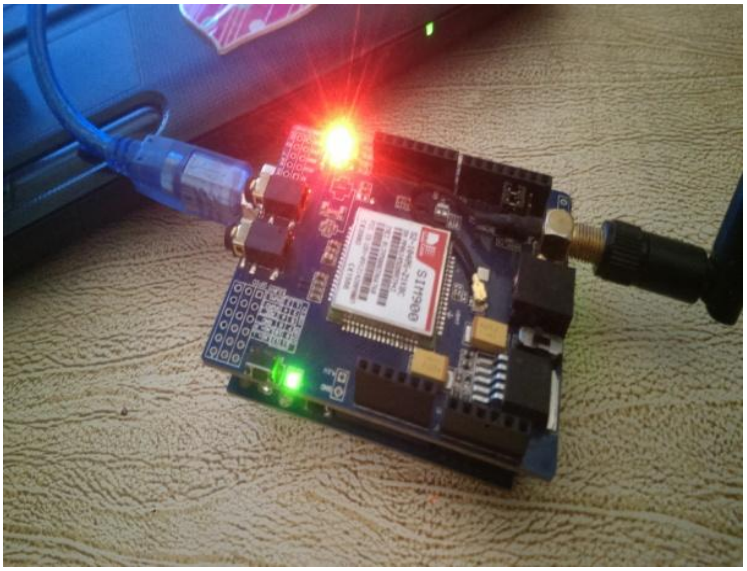

Figure 4.15: Initializing the GSM shiled

4.2.4 DC motor driver connections

The L293D driver basically can drives two motor in the same time, the driver power and ground pins (pin8 and pin5) are connected to the Arduino power and ground respectively. The input pins (pin2 and pin7) are connected to Arduino pin2 and pin3 for forward and backward respectively. The driver outputs (pin3 and pin6) are connected to motor terminals. Figure 4.16 shows the connection according to these pins.

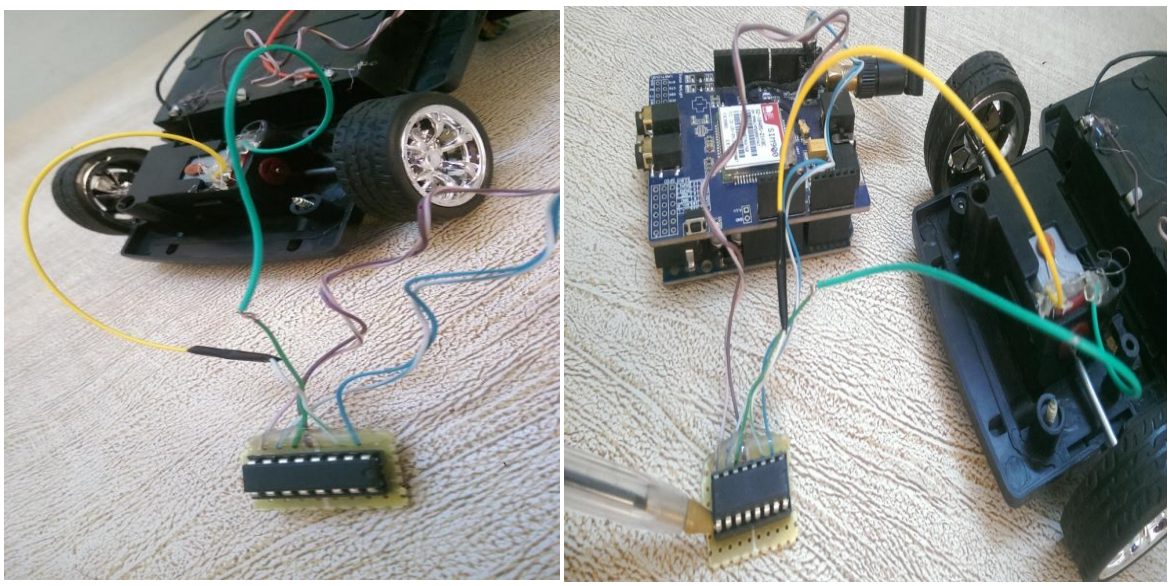

Figure 4.16: Connecting of motor driver

The operation of the motor is done through the input logic at pin2 and7. Input logic 00 or 11 will stop the motor, logic 01 and 10 will rotate it in clockwise and anticlockwise directions, respectively.

Finally the whole mobile robot system is shown in Figure 4.17.

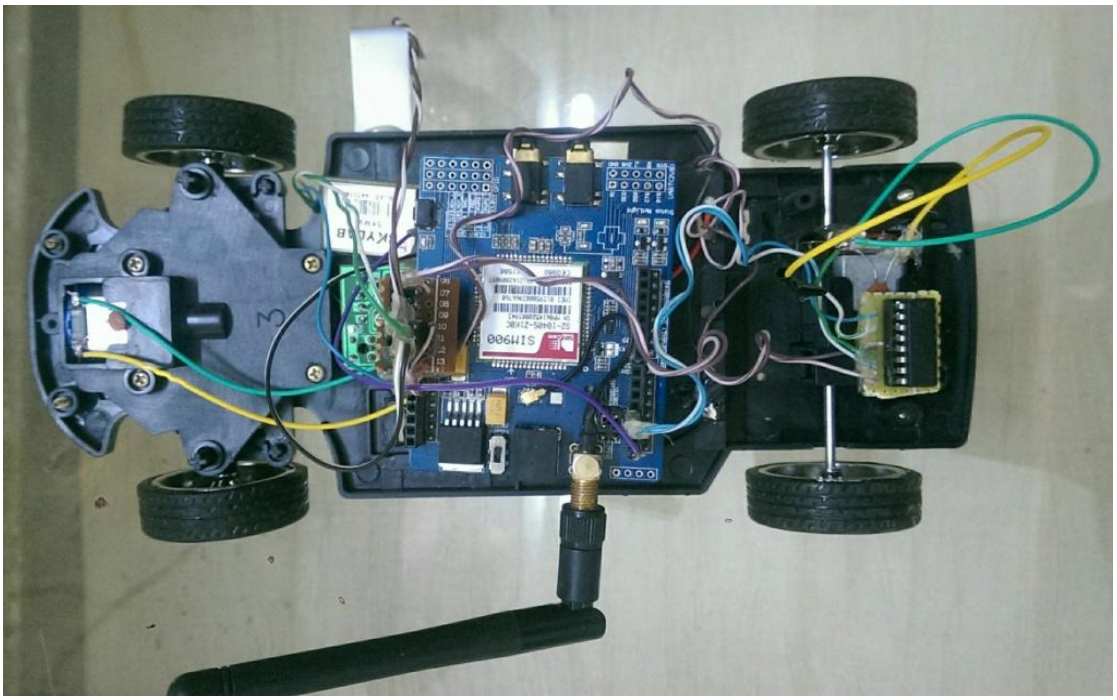

Figure 4.17: Components assembled on a model robot

The last implementation step is connecting the Arduino to the laptop via USB cable to upload the program as shown in figure 4.18

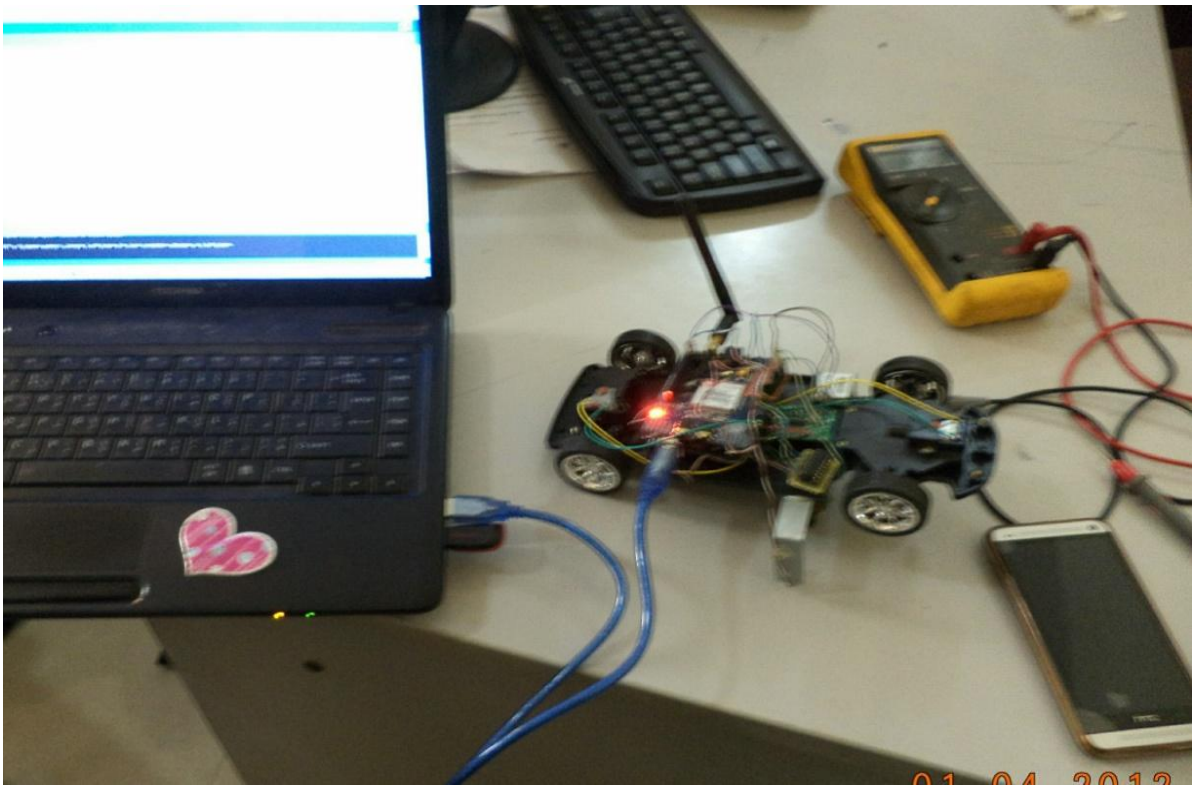

Figure 4.18: Overall system

System Testing

When the system is powered ON, Arduino sends pulses commands to motor drive through pin2. The motor begans to rotate and the robot moves in forward direction on railway track.

Without cracks in the tracks the analog reading of IR sensor is greater than 1. Figure 4.19 shows the readings in the serial monitor window

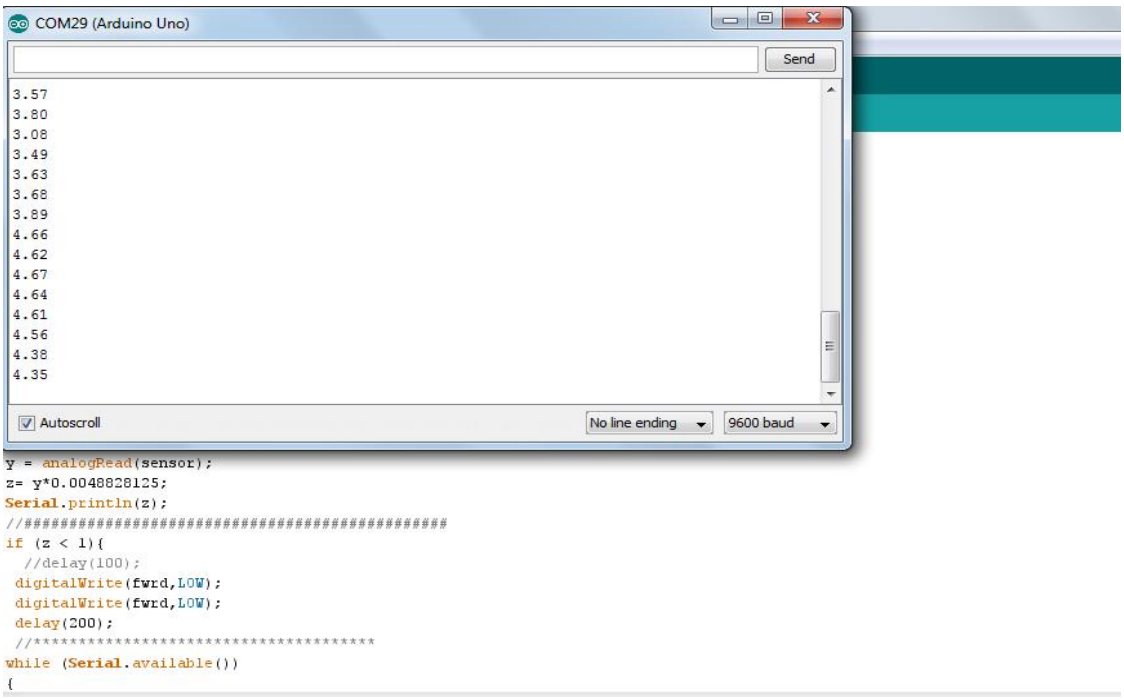

Figure 4.19: Snapshot of the sensor readings without crack

When IR sensor reading is zero, it means that there is a crack, the robot stop moving and the sensor stopped the checking process and gives the following reading as shown in Figure 4.20

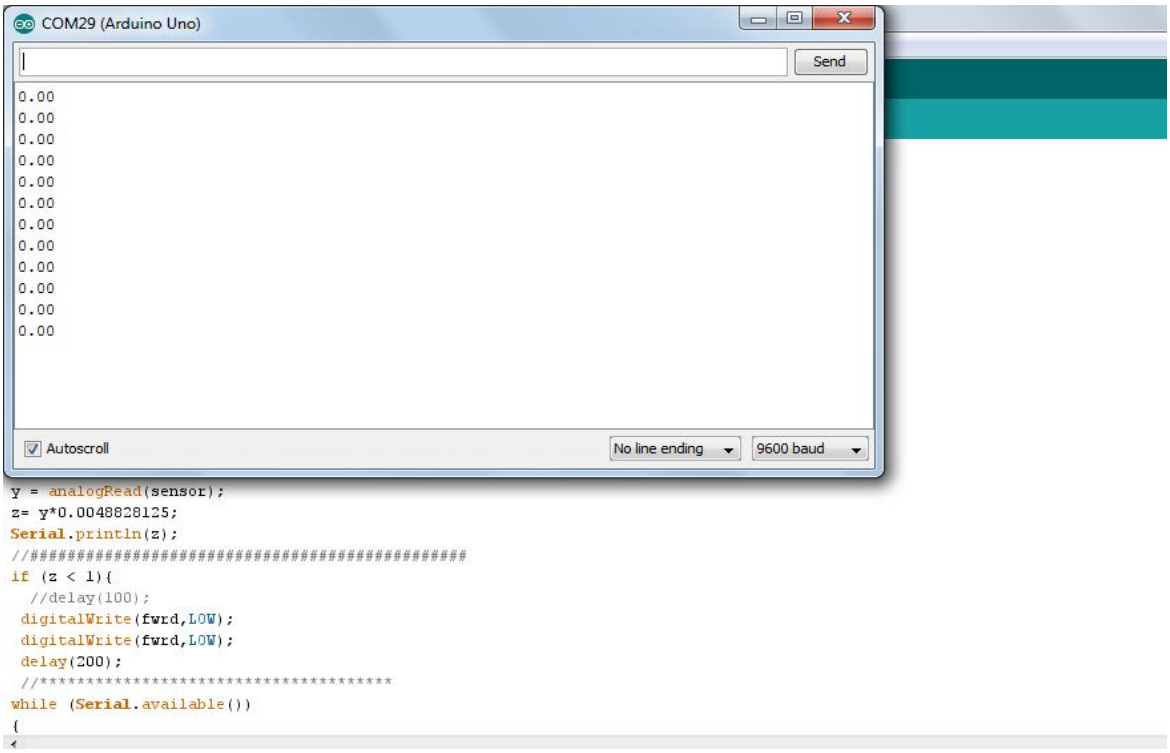

Figure 4.20: Snapshot of the sensor readings with crack

Then the GPS module receives the current latitude and longitude coordinates appeared in the screen. Figure 4.21 shows a snapshot of sample readings of the test in a serial monitor window.

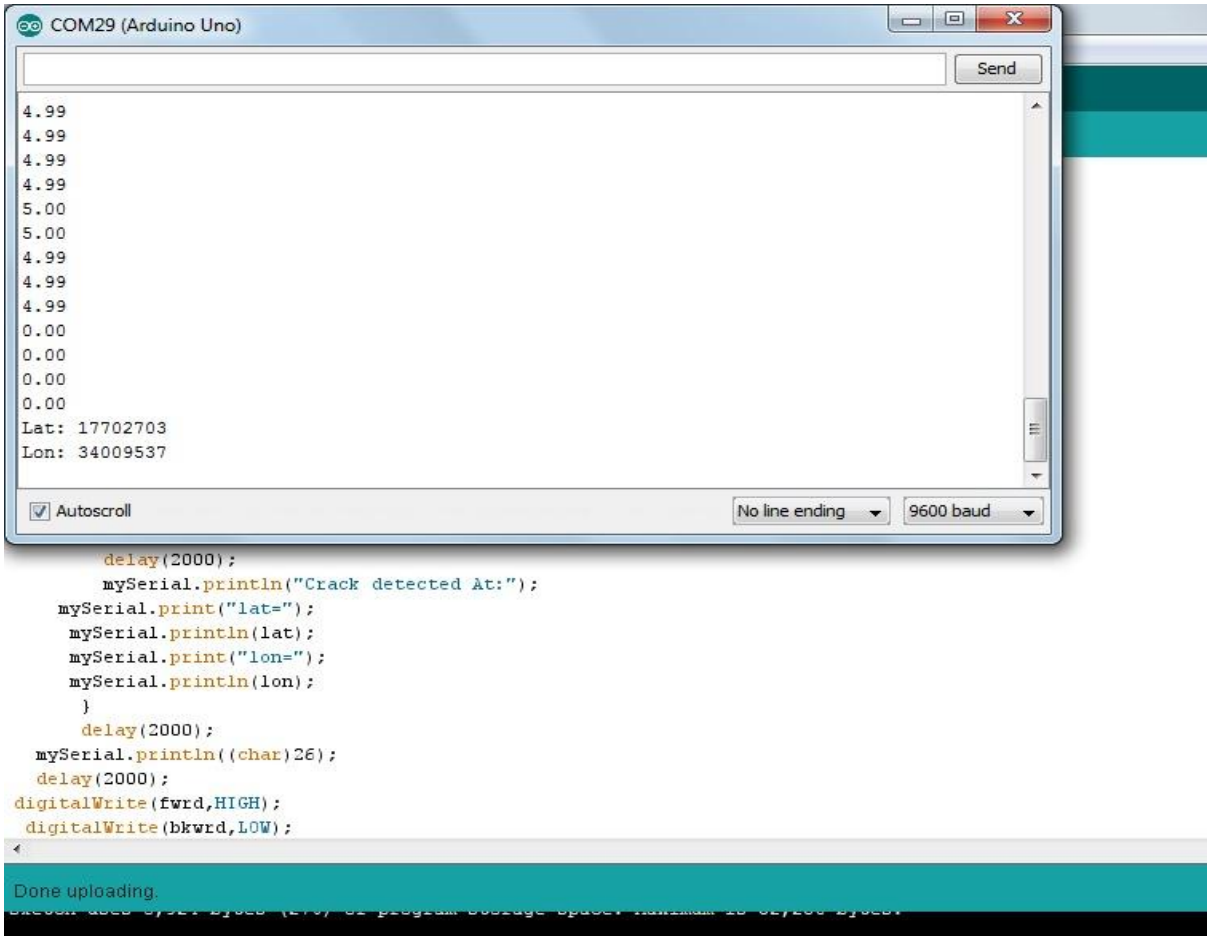

Figure 4.21: Snapshot of the sample readings

At that moment data was sent as a message to the phone number as in Figure 4.22

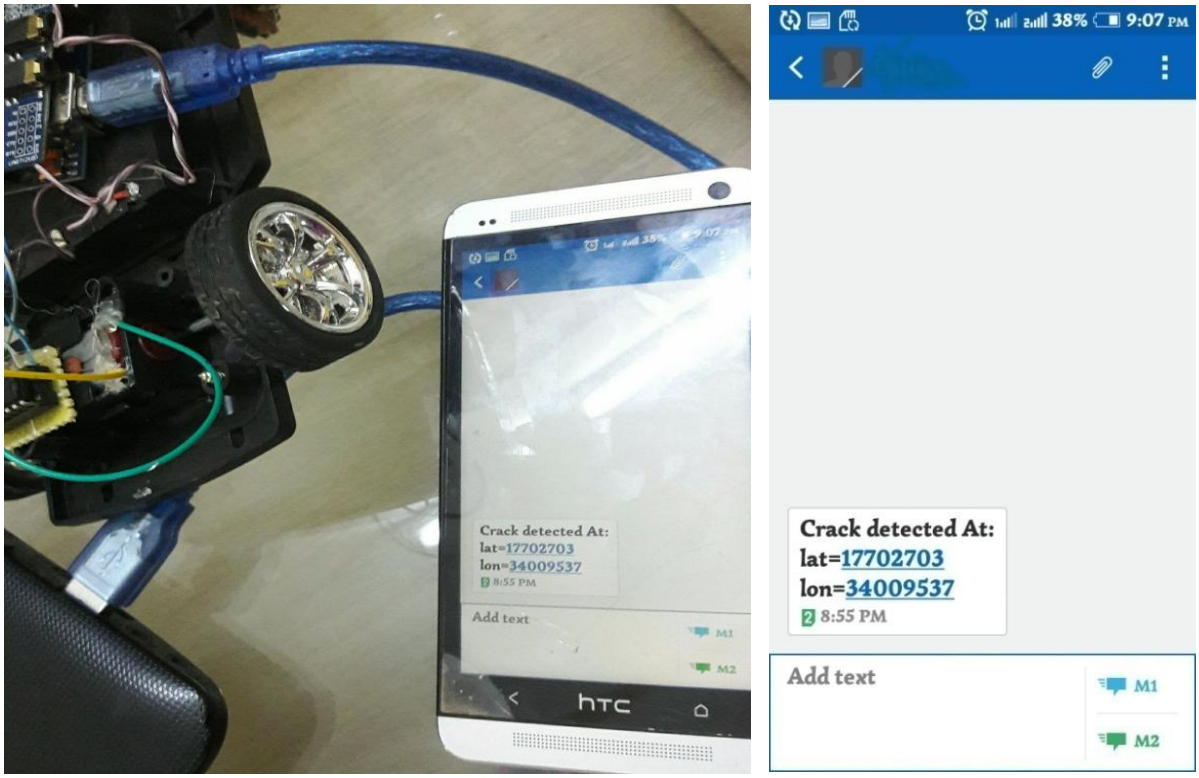

Figure 4.22: Crack position received as SMS

Finally After the SMS was sent, the robot continues its movement forward till detecting of a new crack.

CHAPTER FIVE

CONCULUSION AND RECOMENDATIONS

5.1 Conclusion

The main aim of this study is to replace the manual method of crack detection of railway using robotic crack tracing system. The system simulation was done using Proteus software. The hardware was designed and implemented using simple components inclusive of an Arduino board interfaced to IR sensor, motor, a GSM and a GPS modules. The system is robust and cost effective, it is convenient to regions where manual inspection is a hard and requires a lot of afford like in mountain areas, dense forest and a far regions.

The system with its both software and hardware sides has been tested and it performed well. Thus, considering the results that achieved it has remained projected that if the system is applied in railways it saves a lot of time compared with the traditional detection techniques, since it is completely automated monitoring the condition of tracks are done with fewer chances for error to occur, hence it will preventing train accidents to very large extent.

5.2 Recommendations

Through the implementation of this study there are some points may be taken as suggested future works, these are summarized as:

- Monitoring the system parameters such as speed.
- Developing a precautions system to prevent the vehicle from accidents.

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Appendix

Arduino code:

```
#include <SoftwareSerial.h>
#include "TinyGPS.h"
#include<String.h>
#include<ctype.h>
TinyGPS gps;
SoftwareSerial mySerial(7, 8);
int sensor=A0;
int fwrd=2;
int bkwrd=3;
 int x,i,y;
 long lat, lon;
 //**********************************************
void setup() {
pinMode (sensor,INPUT)  ;
pinMode (fwrd,OUTPUT)  ;
pinMode (bkwrd,OUTPUT)  ;
Serial.begin(9600);
mySerial.begin(9600);
}
//####################################################
void loop(){
 float z,t;
 digitalWrite(fwrd,HIGH);
 digitalWrite(bkwrd,LOW);
y = analogRead(sensor);
z= y*0.0048828125;
Serial.println(z);
//####################################################
```

```
if (z < 1){
  //delay(100);
 digitalWrite(fwrd,LOW);
 digitalWrite(fwrd,LOW);
 delay(200);
 //**************************************
while (Serial.available())
{
int c = Serial.read();
if (gps.encode(c))
{
gps.get_position(&lat, &lon);
Serial.print("Lat: ");
Serial.println(lat);
Serial.print("Lon: ");
Serial.println(lon);
delay(200);
//*********************************************
if (lat > 0 && lon >0){
mySerial.print("AT+CMGF=1\r");
       delay(2000);
        mySerial.println("AT + CMGS = \"+249113415060\"");
        delay(2000);
        mySerial.println("Crack detected At:");
    mySerial.print("lat=");
     mySerial.println(lat);
     mySerial.print("lon=");
     mySerial.println(lon);
      }
      delay(2000);
  mySerial.println((char)26);
```

```
  delay(2000);
digitalWrite(fwrd,HIGH);
 digitalWrite(bkwrd,LOW);
delay(300);
}
}
```