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Automatic Railway Track Inspection for Early Warning Using GPS/GSM System

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Abstract:
This paper proposes the design of crack finding robot for finding cracks in the railway tracks. Here the microcontroller is interfaced with Robot, Global Positioning System (GPS), Liquid Crystal Display (LCD) and Crack Sensor. The IR sensor senses the voltage variations from the crack sensor and then it gives the signal to the microcontroller. The microcontroller checks the variations in the voltage of the measured value with the threshold value. If the microcontroller detects the crack in the railway track, it immediately gets the exact location information using Global Positioning System (GPS) and Global System for mobile (GSM) and sends that location and crack information to the control section. And the control section displays the exact location that is latitude and longitude value in map by using .NET Software. The Liquid Crystal Display (LCD) is used to display the current status of the system. The main aim of this project is finding cracks and location in the railway tracks to avoid the train accidents.

Keywords: ARM cortex STM32, Global Positioning System (GPS) and Global System for mobile (GSM), Liquid Crystal Display (LCD), Artificial Intelligence (AI), light emitting diode (LED), H-Bridge L293D.

I. INTRODUCTION:

Embedded systems are electronic devices that incorporate microprocessors with in their implementations. The main purposes of the microprocessors are to simplify the system design and provide flexibility. Having a microprocessor in the device helps in removing the bugs, making modifications, or adding new features are only matter of rewriting the software that controls the device. Or in other words embedded computer systems are electronic systems that include a microcomputer to perform a specific dedicated application. The computer is hidden inside these products. Embedded systems are ubiquitous. Every week millions of tiny computer chips come pouring out of factories finding their way into our everyday products. Embedded systems are self-contained programs that are embedded within a piece of hardware. Whereas a regular computer has many different applications and software that can be applied to various tasks, embedded systems are usually set to a specific task that cannot be altered without physically manipulating the circuitry. Another way to think of an embedded system is as a computer system that is created with optimal efficiency, thereby allowing it to complete specific functions as quickly as possible. The Transportation of train always depends on the railway tracks (rails) only. If there is a crack in rails, it creates the biggest problem. Most of the accidents in the train are caused due to cracks in the railway tracks, which cannot be easily identified by our naked eyes. Also it takes time to rectify the problem, we are using the crack detector robot, which will detects the crack in the rails and gives alarm. A robot is an apparently human automation, intelligent and obedient in nature but an impersonal machine. The robots have started to employ a degree of Artificial Intelligence (AI) in their work and many robots required human operators, or precise guidance through their missions. Slowly, robots are becoming more autonomous. In the advanced system, the robot designed for finding the crack in the railway track with the help of sensor and the exact location of the railway crack information is send to the control section using Global System for mobile(GSM) and Global Position System (GPS) technology.

II. LITERATURE SURVEY:

The development of an efficient Weigh-In-Motion (WIM) system, with the aim of estimating the axle loads of railway vehicles in motion, is quite interesting from both an industrial and academic points of view such systems, with which the loading conditions of a wide population of running vehicles can be verified, are very important from a safety maintenance perspective. The evaluation of the axle load conditions is fundamental especially for freight wagons, more likely to be subjected at risk of unbalanced loads that may be extremely dangerous both for the vehicle running safety and the infrastructure integrity. In squats and corrugation cause large dynamic forces between wheel and rails, leading to rapid deterioration of rapid quality. There is a strong need for improved detection and maintenance methods to treats such defects at reduced costs, and for better track design to avoid or retard occurrence of them. In the paper aims at studying the interaction between elastic wheels set and ballasted track due to the polygonal wheels. The wheel set is considered a Timoshenko beam with attached rigid-bodies as axle boxes, wheels and brake discs. The track model includes a new model of the rail periodic support consisting in two three directional Kelvin-Voigt systems for the rail pad and the ballast. The main features of the wheel/rail vibration due to the polygonal wheel are analyzed via a new approach of the Green's matrix of the track method. In the prediction of impact forces caused by wheel flats requires the application of time-domain models that are generally more computationally demanding than are frequency-domain models.

III. EXISTING SYSTEM: In the conventional track squat detection, gang man use to run a regular surveillance all the

way through the railway track. This is a cumbersome task, so to overcome this here we are proposing the below method, to know if there are any cracks in the railway tracks. In the advanced system, the robot is designed for finding cracks in the railway tracks. Here the microcontroller is interfaced with Robot, ZigBee, Global Positioning System (GPS), Liquid Crystal Display (LCD) and Crack Sensor. The IR sensor senses the voltage variations from the crack sensor and then it gives the signal to the microcontroller. The microcontroller checks the variations in the voltage of the measured value with the threshold value. If the micro controller detects the crack in the railway track, it immediately gets the exact location information using Global Positioning System (GPS) and Global System for mobile (GSM) and sends that location and crack information to the control section. And the control section displays the exact location that is latitude and longitude value in map by using .NET Software.

IV. PROPOSED SYSTEM:

It proposes the design of crack finding robot for finding cracks in the railway tracks. Here the microcontroller is interfaced with Robot, Global Positioning System (GPS), Liquid Crystal Display (LCD) and Crack Sensor. The IR sensor senses the voltage variations from the crack sensor and then it gives the signal to the microcontroller. The microcontroller checks the variations in the voltage of the measured value with the threshold value. If the microcontroller detects the crack in the railway track, it immediately gets the exact location information using Global Positioning System (GPS) and Global System for mobile (GSM) and sends that location and crack information to the control section. And the control section displays the exact location that is latitude and longitude value in map by using Software. The Liquid Crystal Display (LCD) is used to display the current status of the system

V. METHODOLOGY:

This project is built on ARM cortex STM32 series micro controller, in which we are using an IR sensor which is arranged beside the surveillance wagon. This wagon moves slowly on the railway track to detect if there are any squats are present. IR sensor reflects the light from the railway track. If there is any crack/squat encountered, then the IR emission will not reflect back. If this event is occurred, the vehicle will locate the place using Latitude and longitude from the GPS and send those values over to a mobile phone.

VI. BLOCK DIAGRAM:

The block diagram of developed system is shown in below figure1.The microcontroller unit is used to detect the crack in the track by using the IR transmitter and IR receiver then the corresponding information is send to the control section using GSM, the movement of robot also controlled by the controller.

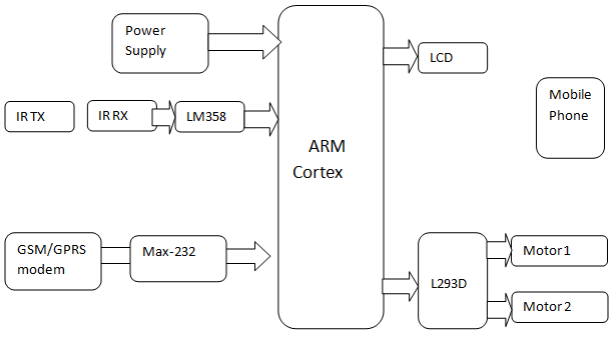

Figure.1. Block Diagram of Automatic Detection of Squats in Railway Track

The display unit is mainly achieved by the 16X2 LCD. A liquid crystal display (LCD) is a flat panel display, an electronic visual display, or video display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly. In this project LCD is used to display sensor value.

VII. HARDWARE SPECIFICATIONS:

Micro controller	:	STM32F030C8T6
Crystal	:	12 MHz
LED	:	5mm Red LED
H-Bridge	:	L293D
Motors	:	Geared motors
GSM/GPS modem	:	SIM 900
LCD	:	16x2 LCD

VIII. COMPONENTS DESCRIPTION:

1) ARM STM32F030C6 CONTROLLER:

The STM32F030x4/6/8/C microcontrollers incorporate the high-performance ARM Cortex-M0 32-bit RISC core operating at a 48 MHz frequency, high-speed embedded memories (up to 256 Kbytes of Flash memory and up to 32 Kbytes of SRAM), and an extensive range of enhanced peripherals and I/Os. All devices offer standard communication interfaces (up to two I^2Cs, up to two SPIs and up to six USARTs), one 12-bit ADC, seven general-purpose 16-bit timers and an advanced-control PWM timer. The STM 32F030x4/6/8/C microcontrollers include devices in four different packages ranging from 20 pins to 64 pins. Depending on the device chosen, different sets of peripherals are included. The description below provides an overview of the complete range of STM32F030x4/6/8/C peripherals proposed. These features make the STM32F030x4/6/8/C microcontrollers suitable for a wide range of applications such as application control and user interfaces, handheld equipment, A/V receivers and digital TV, PC peripherals, gaming and GPS platforms, industrial applications, PLCs, inverters, printers, scanners, alarm systems, video intercoms, and HVACs.

2) BLOCK DIAGRAM:

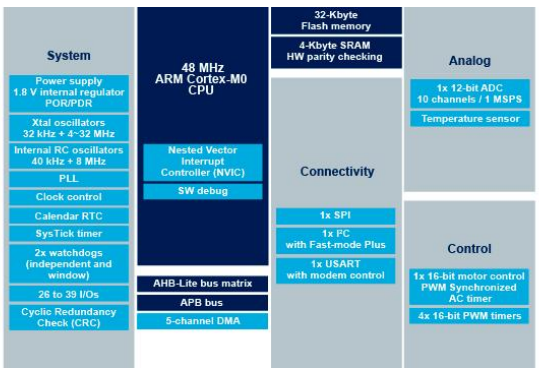

Figure.2.Block Diagram of Micro Controller

3) The Micro Controller contains following features:

Memory, clocks and start-up, General-Purpose Inputs/Outputs (GPIOS), Timers and Watchdogs, General-Purpose Timers (TIM 3, TIM 14 -17) and I/O ports.

IX. GPS:

Figure.3. GPS Module

A GPS receiver calculates its position by precisely timing the signals sent by GPS satellites high above the Earth. Each satellite continually transmits messages that includes

1) The time the message was transmitted
2) Precise orbital information (the ephemeris)
3) The general system health and rough orbits of all GPS satellites (the almanac).

The receiver uses the messages it receives to determine the transit time of each message and computes the distance to each satellite. These distances along with the satellites' locations are used with the possible aid of trilateration, depending on which algorithm is used, to compute the position of the receiver. This position is then displayed, perhaps with a moving map display or latitude and longitude; elevation information may be included. Many GPS units show derived information such as direction and speed, calculated from position changes.

X. GSM:

GSM (Global System for Mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services. GSM (Global System for Mobile communication) is a digital mobile telephone system that is widely used in Europe and other parts of the world. GSM uses a variation of Time Division Multiple Access (TDMA) and is the most widely used of the three digital wireless telephone technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1,800 MHz frequency band. It supports voice calls and data transfer speeds of up to 9.6 Kbit/s, together with the transmission of SMS (Short Message Service).

1) Mobile Telephony Standards:

Table.1. Mobile Telephony Standards

Standard	Generation	Frequency band	Throughput	
GSM	2G	Allows transfer of voice or low-volume digital data.	9.6 kbps	9.6 kbps
GPRS	2.5G	Allows transfer of voice or moderate-volume digital data.	21.4-171.2 kbps	48 kbps
EDGE	2.75G	Allows simultaneous transfer of voice and digital data.	43.2-345.6 kbps	171 kbps
UMTS	3G	Allows simultaneous transfer of voice and high-speed digital data.	0.144-2 Mbps	384 kbps

2) TDMA:

In late1980's, as a search to convert the existing analog network to digital as a means to improve capacity, the cellular telecommunications industry association chose TDMA over FDMA. Time Division Multiple Access is a type of multiplexing where two or more channels of information are transmitted over the same link by allocating a different time interval for the transmission of each channel. The most complex implementation using TDMA principle is of GSM's (Global System for Mobile communication). To reduce the effect of co-channel interference, fading and multipath, the GSM technology can use frequency hopping, where a call jumps from one channel to another channel in a short interval.

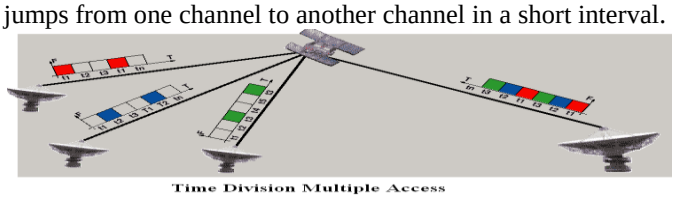

Figure.4. Time Division Multiple Access

TDMA systems still rely on switch to determine when to perform a handoff. Handoff occurs when a call is switched from one cell site to another while travelling. The TDMA handset constantly monitors the signals coming from other sites and reports it to the switch without caller's awareness. The switch then uses this information for making better choices for handoff at appropriate times. TDMA handset performs hard handoff, i.e., whenever the user moves from one site to another, it breaks the connection and then provides a new connection with the new site.

XI. ARCHITECTURE OF THE GSM NETWORK:

In a GSM network, the user terminal is called a mobile station. A mobile station is made up of a SIM (Subscriber Identity Module) card allowing the user to be uniquely identified and a mobile terminal. The terminals (devices) are identified by a unique 15-digit identification number called IMEI (International Mobile Equipment Identity). Each SIM card also has a unique (and secret) identification number called IMSI (International Mobile Subscriber Identity). This code can be protected using a 4-digit key called a PIN code.

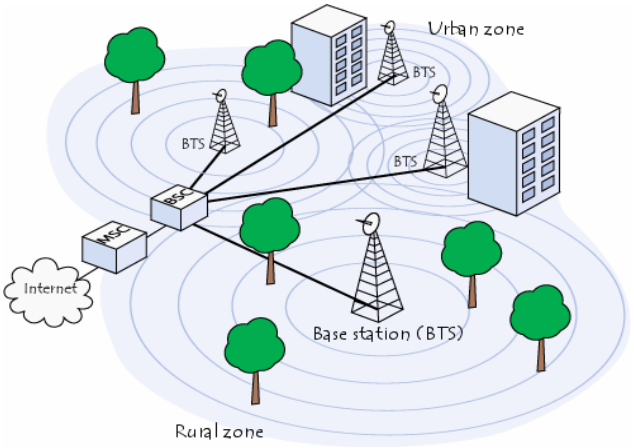

Figure.5. Architecture of GSM network

XII. H-BRIDGE:

An H-Bridge is an electronic circuit which enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards. H-bridges are available as integrated circuits, or can be built from discrete components. H-bridge sometimes called a full bridge the H-bridge is so named because it has four switching elements at the corners of the H and the motor forms the cross bar. The basic bridge is shown in the figure to the right.

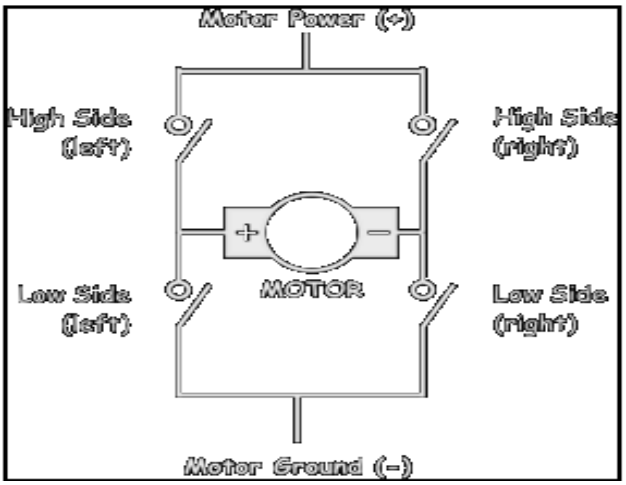

Figure.6. Basic Bridge

XIII. DC MOTOR:

The brushed DC motor is one of the earliest motor designs. It is the motor of choice in the majority of variable speed and torque control applications. The design of the brushed DC motor is quite simple. A permanent magnetic field is created in the stator by either of two means:

- Permanent magnets
- Electro-magnetic windings

If the field is created by permanent magnets, the motor is said to be a "permanent magnet DC motor" (PMDC). If created by electromagnetic windings, the motor is often said to be a "shunt wound DC motor" (SWDC). Today, because of cost-effectiveness and reliability, the PMDC motor is the motor of choice for applications involving fractional horsepower DC motors, as well as most applications up to about three horsepower. DC Motor rotation has nothing to do with the voltage magnitude or the current magnitude flowing through the motor. DC Motor rotation does have to do with the voltage polarity and the direction of the current flow. Whereas the voltage polarity controls DC motor rotation, voltage magnitude controls motor speed. Think of the voltage applied as a facilitator for the strengthening of the magnetic field.

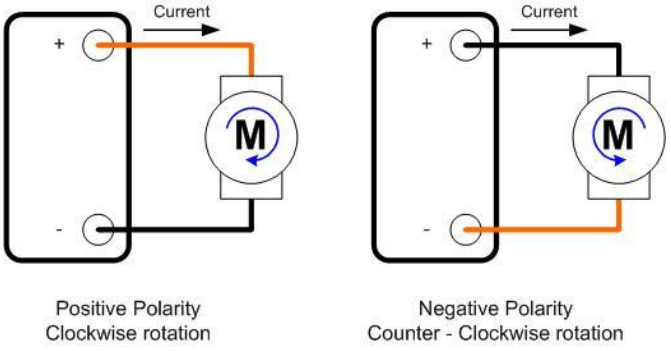

Figure.7. DC Motor with clock and anti clockwise direction

In other words, the higher the voltage, the quicker will the magnetic field become strong. Remember that a DC motor has an electromagnet and a series of permanent magnets.

XIV. 16 x 2 LCD DISPLAY:

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being LCDs are economical, easily programmable, have no limitation of displaying special & even custom characters, A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

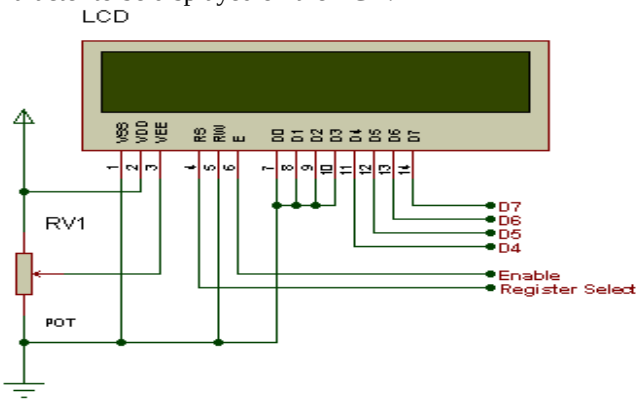

Figure.8. Block diagram of LCD

1) PIN DESCRIPTION:

Table.2. LCD Pin description

Pin No	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Contrast adjustment; through a variable resistor	V_{EE}
4	Selects command register when low; and data register when high	Register Select
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight V_{CC} (5V)	Led+

XV. IR SENSORS:

IR wireless is the use of wireless technology in devices or systems that convey data through infrared (IR) radiation. Infrared is electromagnetic energy at a wavelength or wavelengths somewhat longer than those of red light. The shortest-wavelength IR borders visible red in the spectrum. The longest-wavelength IR borders radio waves. Infrared energy is light that we cannot see, but our bodies can detect as heat. It is part of the electromagnetic spectrum that includes radio waves, X-rays and visible light. All of these forms of energy have a specific frequency, as represented in the chart below.

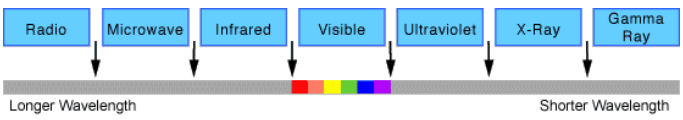

Figure.9. Frequency chart of rays

Infrared energy is comprised of those frequencies that exist just below the red end of the visible spectrum, and for cooking properties they have a very unique benefit - when they strike organic molecules (such as any type of food), they cause the molecules to vibrate, thereby creating heat. Although almost any type of electromagnetic energy can cause heating, for the purpose of cooking, infrared energy is the perfect choice. IR reflectance sensors contain a matched infrared transmitter and infrared receiver pair. These devices work by measuring the amount of light that is reflected into the receiver. Because the receiver also responds to ambient light, the device works best when well shielded from ambient light, and when the distance between the sensor and the reflective surface is small(less than 5mm).

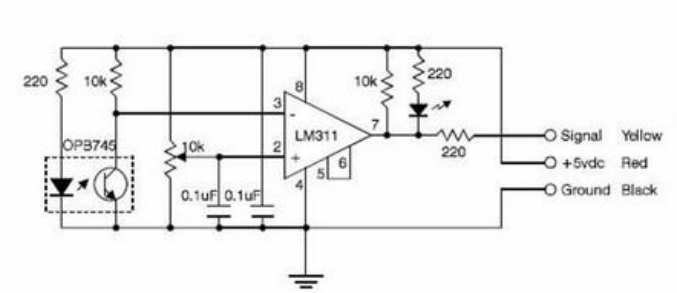

Figure.10. schematic diagram for single pair of infrared transmitter and receiver

XVI. SOFTWARE DESCRIPTION:

An embedded system is the combination of hardware and software where hardware comes under physical layer and software is the predefined instructions given to the hardware. Thus to program the hardware we require a language called Embedded C. And the technology used for programming is Keil vision and technology used to flash the controller is flash magic utilities.

1) Embedded C Format:

- Header files.
- Library files.
- Pin declarations.
- Port declarations.
- Interrupt declarations.
- Global variable declarations.
- Function declarations.
- Main function.
- Local variables.
- Infinite loop.
- Function definitions.
- Interrupt ISR definitions.

2) Keil micro vision v.4:

Keil is technology where the user writes his program and generates a machine file i.e. HEX file which should be carried to microcontroller.

XVII. CHARACTERISTICS:

Two major areas of differences are cost and power consumption. Since many embedded systems are produced in tens of thousands to millions of units range, reducing cost is a major concern. Embedded systems often use a (relatively) slow processor and small memory size to minimize costs. Firmware is the name for software that is embedded in hardware devices, e.g. in one or more ROM/Flash memory IC chips. Embedded systems are routinely expected to maintain 100% reliability while running continuously for long periods, sometimes measured in years. Firmware is usually developed and tested too much harsher requirements than is general-purpose software, which can usually be easily restarted if a problem occurs.

XVIII. RESULT:

The microcontroller is interfaced with Robot Global Positioning System (GPS), Liquid Crystal Display (LCD) and Crack Sensor. The IR sensor senses the voltage variations from the crack sensor and then it gives the signal to the microcontroller. The microcontroller checks the variations in the voltage of the measured value with the threshold value. If the microcontroller detects the crack in the railway track, it immediately gets the exact location information using Global Positioning System (GPS) and Global System for mobile (GSM) and sends that location and crack information to the control section and the control section displays the exact location that is latitude and longitude value in map by using .NET Software.

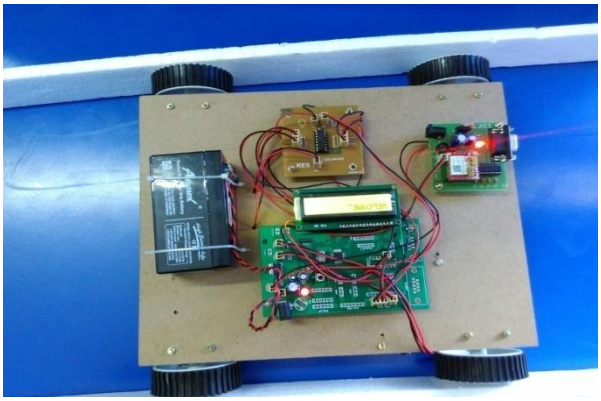

Figure.11. Automatic detection of squats in railway track.

XIX. CONCLUSION:

The microcontroller is interfaced with Robot, GSM, Global Positioning System (GPS), Liquid Crystal Display (LCD) and Crack Sensor. The IR sensor senses the voltage variations from the crack sensor and then it gives the signal to the microcontroller. The microcontroller checks the variations in the voltage of the measured value with the threshold value. If the microcontroller detects the crack in the railway track, it immediately gets the exact location information using Global Positioning System (GPS) and Global System for mobile (GSM) and sends that location and crack information to the control section. The control section displays the exact location that is latitude and longitude value in map by using .NET Software. The Liquid Crystal Display (LCD) is used to display the current status of the system. The exact location of the crack in the track with can easily be identified with the help of Global Positioning System (GPS) and Global System for mobile (GSM).

XX. FUTURE SCOPE:

This project can be further enhanced by using long range continuity sensors, ultrasonic sensors and surveillance drones for unmanned squat detection system.

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