# Landmine Detection Robot with Rocker-Bogie Mechanism

**Neelum R. Dave[1] Nishi Tyagi[2] Shreya Singh[3] Shreyas Raut[4]**
[1]Assistant Professor
[1]Department of Electronics & Telecommunication Engineering
[1,2,3,4]Dr DY Patil Institute Of Engineering & Technology,Pimpri-Pune, India

*Abstract*— This paper deals with design and implementation of a novel low cost- six wheels mine detection robot. The powering, driving and controlling circuits are illustrated. It is multitasks cooperative controlled robot for personal land-mine detection and provides video streaming to show the exact location where the landmine is buried. It is capable of operating very long time using a new mechanism for the mine detection. An efficient design of the rocker-bogie mechanism robot is obtained. A proximity sensor system that identifies the robot environment and operation is developed. The robot detects the mine with the help of the proximity sensor and streams the video enabling the operator to control the robot wirelessly from a safe distance.

***Key words:*** Landmine Detection Robot, Rocker-Bogie Mechanism

## I. Introduction

According to current estimates, 100 million landmines, mostly antipersonnel mines laid in over 60 countries, kill over 20,000 persons a year as shown in Fig.1. In recent years, many organizations and universities in different countries have increasingly recognized the significance of low cost and sustainable technologies for mine detection and extraction. The current solution for removing landmines from civilian areas is the use of trained technicians who manually search for buried objects using a metal detector. A human operator, on the other hand, sweeps a mine detector from side to side while moving forward to cover ground; this process is rather slow (20-50 square meters per hour). The operator can follow the ground profile with the detector head close to the ground without hitting the ground or any objects on it. The operator can also vary the width of sweep to suit a particular situation, and is usually not limited by terrain. However, the manual method is slow, hazardous, manpower-intensive and stressful. As a result, the operators can perform this task only for short periods. In addition, the task is monotonous and at times errors result due to operator inattentiveness. The humanitarian activity of removing antipersonnel land mines requires the use of robotic systems that put the operator at a distance to increase both operator’s safety and the mine removal rate. Although efficient mobile robotic systems are required for such applications, adequate sensor heads must be investigated first. Sometimes mine detectors are one-point detectors and thus they must be moved over large areas of ground, normally with the use of scanning manipulators. There has been a great activity in developing robotic systems for humanitarian de-mining for the last years. Many works have been devoted to the development of new sensors, detectors and include mobile robots (wheeled, tracked and legged robots). Some systems employ more than one type of sensor technology. These systems, while being very useful, are often expensive, complex and inflexible. The risk of mine clearance missions is primarily related to the lack of knowledge about the location of the mines, as well as the detection operations.

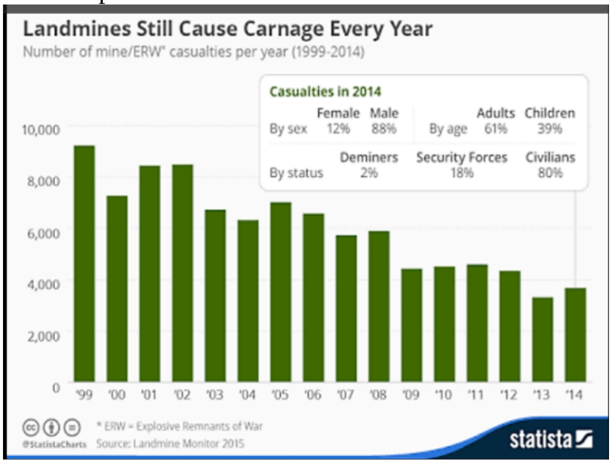



Fig. 1: Statistics of Deaths Caused By Landmines.

The goal now is to develop a fully automated system which is capable of locating the mines with the most bottom interference from human side. Robot path planning is a critical problem. This problem addresses how to find a collision-free path for a mobile robot from a start position to a given goal position while avoiding any obstacles and also a mechanism called the rocker-bogie mechanism with the help of which the robot can move over rough surfaces. The proposed robot is capable of autonomously detecting a mine detection sensor over natural ground surfaces and also giving us a live stream of video of where the robot is moving. Moreover, the robot is designed to operate remotely using transceiver radio frequency communication remote unit to communicate the robot for increasing the safety of the personnel performing mine detection.

## II. Objectives

### *A. Landmine Clearance*

A land mine detection robot is needed to be designed to employ in peace support operations and in the clearance of contaminated areas.

### *B. Wireless Control*

For the safety of the operator, the designed robot must be able to operate remotely; moreover, it is equipped with wireless data transmitting capabilities.

### *C. Low Cost & High Reliability*

The robot can be constructed in low cost of some hundreds of US dollars and less complex with high reliable structure.

## III. Block Diagram

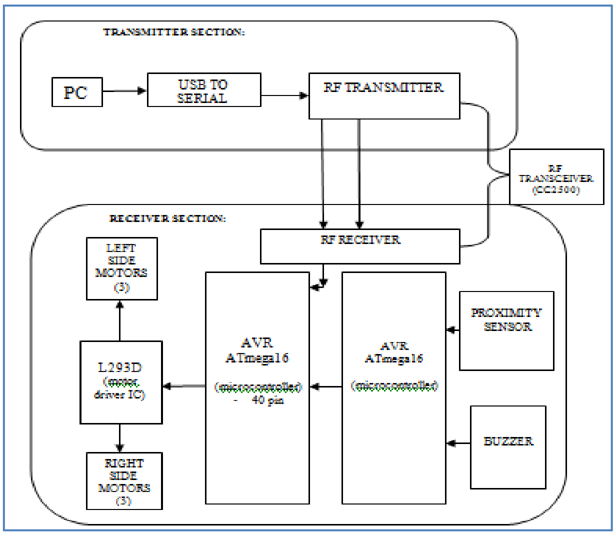



Fig. 2: Block Diagram of the System

- The robot will be controlled with the help of a computer/PC. MATLAB Programming will be used for this purpose (GUI).
- The USB to Serial block does the operation of connecting the PC to the Transmitter section of the RF Transceiver.
- We are using cc2500 as our RF Transceiver.
- RF Transceiver block consists of two components:
  - Transmitter
  - Receiver
- The Receiver from the receiver section accepts the commands from the manipulator or the controller and then gives the instruction to the microcontroller.
- ATmega16 is the microcontroller we will be using because of its various features mentioned further. The microcontroller is the heart of the robot and will be controlling all the other parts.
- Instructions are then given to the motor driving IC that is L293D.
- Motor driving IC controls two motors.
- There are a total number of 6 motors used for the Rocker-bogie mechanism. Each wheel has a motor attached to it. The motors are connected serially for all the motors to work. The robot will be moved accordingly.

## IV. Hardware Design

### A. *Circuit Diagram*

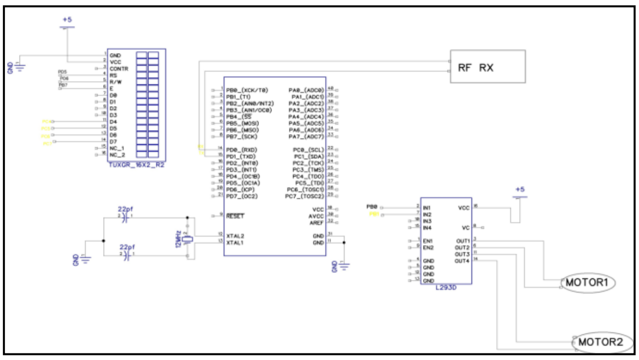



Fig. 3: Circuit Diagram

As shown in Fig. 3 ATmega16 microcontroller is a 40 pin IC. It has four ports: A, B, C and D. The RF Transceiver is connected at Port D at pins PD0 and PD1 because they are the transmitter and receiver pins of the microcontroller. 12 and 13 pins are the XXTAL1 and XTAL2 pins, which are basically used in the circuit for the crystal oscillator with 25 MHz frequency. Pins PB0 and PB1 of the microcontroller are connected to pins 2 and 7 of L293D that is the motor driver IC. Power supply is given at pin 10 at VCC of the microcontroller. Pin number 9 is the reset pin used for resetting the controller. Pins 31 and 11 of ATmega16 are given ground.

The motor driving IC, as mentioned earlier is the L293D. It's pin connections are as shown in Figure 2. Pins 2 and 7 of L293D are connected to the microcontroller at port B (PB0 and PB1). As it is a motor driving IC, the motors are connected at 3, 6, 11 and 14. These are the left side and the right side motors. VCC is given at pin number 16. While, pins 4, 5, 12 and 13 of L293D are grounded.

The power supply here will have an output of 5V while an input of 12V. It will be consisting of a transformer, a rectifier, two capacitors, and a regulator.

We haven't mentioned LEDs, but they can be used for indication when the mines will be detected. These LEDs will be connected at any ports of the microcontroller but mostly can be connected at port D as there are quite a number of pins available.

## V. Software Design

### A. *Programming*

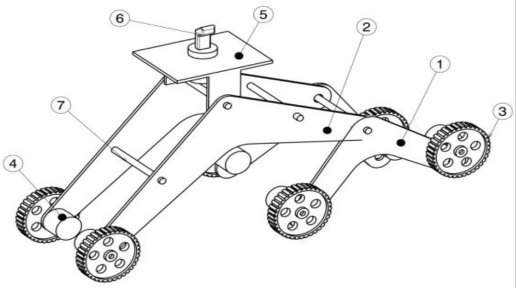
There are two programs used for the completion mentioned in this paper.

One is for the transmitter section. This programming is completely done in MATLAB. As the robot is controlled by the laptop, the GUI needs to be designed in MATLAB. It then behaves like a controller. Pushbuttons are developed in order to give instructions of moving forward, backward, left and right. There is a window for the video stream. Also, a radio button for enabling connection of the laptop and the robot is provided.

The other programming is completely embedded programming. This is the programming of the receiver section which includes the actual controlling that is the total movement of the robot.

## VI. STRUCTURE OF THE ROBOT




| Sr.No | Component Name | Quantity |
|---|---|---|
| 1 | Arm 1 | 2 |
| 2 | Arm 2 | 2 |
| 3 | wheel / Leg | 6 |
| 4 | Motor | 6 |
| 5 | Top Frame | 1 |
| 6 | Camera | 1 |
| 7 | Support Fixture | 4 |

Fig. 4: Structure of the Robot

Fig. 4 shows us the structure of the robot. This is basically how the robot looks.

The components of the robot itself are divided into seven parts. The parts are indicated using the index below the figure.

1) Component 1 is the Arm of the robot. There are 2 such arms of the robot. These arms are the front arms whose joints are enabled only on the rough surfaces as mentioned in the working in section 4. On the smooth surfaces these arms are stiff and work in a straight direction.
2) These are also arms. But these are longer and are the backward arms or the inner arms. These arms are not attached to any joints and are the major arms as they are always in use. The back and front arms are connected to each other at joints which play a major role in the robot.
3) Part 3 are the wheels which will be used majorly and only for moving the robot just like a vehicle. The dimensions of the wheels will be according to the robot size.
4) Part 4 is the motor. There are total six motors at the ends of the arms. The motors and the wheels will be connected back to back opposite each other. The motors are the important components of the robot as they will be controlling the robot completely.
5) Part 5 or component 5 is the top frame over which the camera for the video streaming will be mounted. In our project, we will be using a phone to directly stream the video to our PC. So, the top frame can also be used for holding or keeping of the phone. The top frame will be flat, but it can be designed as per our needs.
6) The IP webcam or the phone can be used as the camera. It will be mounted on the top frame as shown in the figure.
7) The last component is the support fixture. As the name suggests it will be supporting or we can say holding the components of the robot together. There will be 4 support fixtures. Three will be used for holding the arms and one for holding the top frame with the arms. These support fixtures extend the life of the robot as they prevent the breaking of the robot and also loosening of the component connections.

## VII. THE SYSTEM SPECIFICATIONS & CHARACTERISTICS

### *A. System Specification*

#### *1) RF Module*
- RF module operating range is 30 meter with onboard antenna.
- RF module operation temperature range: -40 to +85°c.
- RF available frequency at: 2.4 to 2.483GHz.

#### *2) ATmega16*
- Operating voltage of ATmega16 is 4.5 to 5.5 V.
- Speed grade for ATmega16 is 0 to 16MHz.
- High performance, low power consumption AVR 8 bit microcontroller.
- Single clock cycle execution.

#### *3) RF Transceiver*
- It is an FSK Transceiver module.
- It can be used in 2400-2483.5 MHz ISM/SRD band systems.
- It is based on 3 wire digital serial interface and an entire Phase-Locked Loop (PLL) for precise local oscillator generation.

#### *4) L293D*
- Motor driver IC.
- It is a 16-pin IC which can control a set of two DC motors simultaneously in any direction.
- An internally fitted diode. This diode is used for Transient Suppression.

#### *5) Motor*
- DC Motor PENTA
- ROBUST, SIMPLEST DESIGN
- Long Working Life
- 45-1500 W output power
- Ferrite Permanent Magnets

#### *6) Battery*
- Size 100(L) x 50(D) x 70(H)mm
- Charge current 720mA for 10-14 hours
- Discharge current 20 hr rate 350Ma

#### *7) Proximity Sensor*
- Size 4(L) x 1(R)cm
- Range 0.7 mm
- 12V power supply needed

#### *8) Buzzer*
- Compact
- Sound range – 50m

### *B. Robot Characteristics*
- The robot is able to detect 90% of landmines by using metal detector (Anti-personnel mines and Anti-tank mines).
- It has a new mine travel mechanism which helps the robot move on a rough surface or any kind of surface.
- For the safety of the operator, the designed robot operates remotely and equipped with wireless data transmitting capabilities.
- The robot travels in all the directions, steered using a differential drive steering type, detecting the possible buried mines, clearing 1.3-meter wide lanes in one pass.
- The robot can scan an area of 200 meter square per hour.

- The robot platform is designed to hold a phone which will be providing us with the facility of a video of the robot path using an app.

## VIII. FLOWCHART OF THE ROBOT SYSTEM

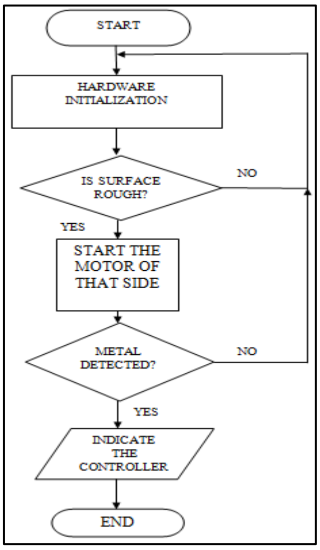



Fig. 5: Working of the Robot

Fig.5, gives a description of the flowchart which gives us the order in which the working of the project code will take place. The steps can be given in short as:

1) First step is always the start step.
2) Step 2 is the hardware initialization which will include steps such as setting the apparatus of the project including all the hardware parts like the controller the robot as well as setting it in a suitable environment with all the surroundings where the mine has to be detected.
3) In this step, we will be checking if the surface is rough or not. So basically it is a decision making step where the rough surface will be detected.

a) If the robot finds out that the surface is rough, the motors at the front end and the joints connected to them will be enabled so that the rocker-bogie mechanism can be used. In a way this robot will be able to move smoothly in all directions and on all surfaces without any difficulties.
b) If the surface is not rough, then only the motors will be enabled but not the joints as the robot now only has to move on a plain surface. Also, the working will be resumed to the second step which is the hardware initialization step.

4) After moving ahead this step also has a decision to be made. It has to check if the metal is detected.

a) If the metal is detected, the robot will stop and the sensor will be indicating the controller.
b) If not, the robot will continue moving forward.

5) In this step the metal has been detected by the robot and the robot now will indicate the controller, with the help of indicators such as buzzers. After this the mine can be diffused accordingly.
6) With this the operations of the robot will end.

## IX. ROBOT PATH PLANNING & OPERATION

To scan a certain area, the mine detection and extraction robot applies a scanning routine as follows:

- Starting from the origin point A, the robot travels in the direction specified b in the direction specified by the personnel handling the robot with the laptop.
- The instructions are given to the robot with the help of Graphical User Interfaced using MATLAB programming.
- The motors are driven by the motor driving IC (L293D).
- The motors are connected to each other in series.
- Once the magnetic sensor detects a mine, the sensor will stop scanning and then the robot comes to a standstill and sends out signals to the operator by beeping using the buzzer.

## X. CONCLUSION

It has been successfully proven through this proposed theory and concepts that a landmine exploring platform works perfectly. It will able to clear the path with 1m width at one go. The greatest advantage that this robot offers is the safety for the soldiers on war field. It will send the location of buried mine to the operators by using a video app. This means that if the operator or the soldiers follow the tire tracks, they are perfectly safe since the robot has already rolled over it. Thus, the proposed design for landmine detection and marking module had opened up a new area for the researchers to explore. Saving the lives and limbs of innocent civilians becomes one step closer. Also we have been using the camera connected to the laptop with the phone. So it will be easier to check the surrounding through the video.

## XI. FUTURE SCOPE

There is a huge scope of development in this theory and system. Many things can be improved and developed further. Development like:

- Many sensors can be used in a group so that the detection of the mines can be done for a long range.
- We can use LCDs for displaying different messages of the status of the robot as well as when the mine is detected.
- LEDs can be used for further high indication.
- Instead of using a phone app, we can use a complete camera.
- A major development that can be done is extraction of the mines by the robot using electromagnetic devices.

## ACKNOWLEDGMENT

This project was supported by Dr. D.Y.Patil Institute Of Engineering and Technology. We would like to thank our Principal, Dr. S.N. Mali, our H.O.D, Dr. S.R. Jog for giving us the opportunity of building this project. We thank our Internal Guide, Prof. Neelum Dave for supporting us throughout the development and making of this project. She has greatly assisted the project and given comments that has improved our system to a very high level. We would also like to show our gratitude to Kishan Malaviya, Ashish Vara and Bharat J, although any errors are our own and should not tarnish the reputations of these people.

## REFERENCES

[1] H. Najjaran, N. Kircanski and A. A. Goldenberg, "Landmine detection using an autonomous terrain scanning robot," NRCC-46424,2003.
[2] Nyein Chann, "Landmine detection and marking robot." Department of mechanical engineering national university of Singapore, Pp 01- 39, 2006/2007.
[3] Hajime Aoyama, Kazuyoshi Ishikawa, Junya Seki, Mitsuo Okamura, Saori Ishimura and Yuichi Satsumi, "Development of Mine Detection Robot System," International Journal of Advanced Robotic Systems, Vol. 4, No.2 pp 229 – 236, 2007.
[4] Liu Gangfeng, Zhu Lei, Han Zhenfeng, and Zhao Jie, "Distribution and Communication of Multi-robot System for Detection in the Underground Mine Disasters," Proceedings of the IEEE International Conference on Robotics and Biometrics December 19-23, 2009.
[5] K. Vidyasagar, U. Nageswar Rao, K. Suresh and MD, Abdul Farooq, "Landmine Detection Robot Using Radio Frequency Communication," Journal of Academia and Industrial Research (JAIR) Volume 4, Issue 2 July 2015.
[6] Nobuhiro Shimoi, Yoshihiro Takita, "Remote Mine Sensing Technology Using a Mobile Wheeled Robot," International Conference on Control, Automation and Systems. in KINTEX, Gyeonggi-do, Korea Oct, 27-30, 2010.
[7] Md. Shamsul Alam, Insan Arafat Jamil, Khizir Mahmud and Najmul Islam, "Design and Implementation of a RF Controlled Robotic Environmental Survey Assistant System".
[8] M.Muthiah, K.Nirmal, Rk.Sathiendran, "Low Cost Radio frequency Controlled Robot for Environmental Cleaning", 2015 International Conference on Circuit, Power and Computing Technologies[ICCPCT*]*, 2015, 978-1-4799-7075-9/15.