HBRP PUBLICATION

Research and Reviews: Advancement in Robotics
Volume 3 Issue 1
DOI: http://doi.org/10.5281/zenodo.3725684

Design of Unmanned Ground Vehicle for Landmine and Bomb Detection using Software Defined Radar

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ABSTRACT

Landmine is a device which will explode as a result of action applied on it like delivering pressure upon it. It is buried under earth to destroy the objects like soldiers, vehicles and tanks when they move over or near to the landmine. This project includes a solution for detecting and defusing the land mine safely without any casualties. Unlike already existing projects or models, this project got something new and innovative. UGV operates semi-automatically (means, vehicles can perform some function even without a soldier/operator. Using A.I based algorithms) for actions like movement, detection, picking, counter strike and diffusion. So in this paper we demonstrate our idea by building a prototype of proposed solution. Also we explain the methodology we adopted to reach the final result.

***Keywords:** UGV (Unmanned Ground Vehicle), AI (Artificial intelligence), SDR (Software Defined Radar)*

INTRODUCTION

In the past decade, robotic systems have made an impact in every industry. But there are still some socially relevant problems which are not yet resolved. So this paper is a proposed solution for detecting landmine and explosives to help the compactant/EoD officers. Before going into deep let's discuss what all are the impact of landmine. Is it a threat to society? What are all the possible types of landmines? We explain all these in our general background.

GENERAL BACKGROUND

The landmine or bomb blast affected more than 70 countries around the world between1999 to 2009. More than 70,000 casualties were recorded within this period. Landmine is ofcourse a threat to society. The most affected were locals who lived nearby war zones / landmine prone areas.

Some states in India still have active landmines which are installed by maoist/ terrorists to destroy their enemies.

Impact of the landmine explosion was severe. The children who play nearby and people who do agriculture in these areas are dangerously affected.

Removal of landmine is a critical problem faced by many countries around the world, and the attempt would be a suicidal mission.

So since this is a robotic era we are using a robotic system to resolve this critical problem without any risk or casualties except the cost for rebuilding the robot in case of an explosion happens.

There are different kinds of landmines so approach each and every landmine will be different from each other. So just a robotic

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system would not be enough to resolve this issue so we need machine learning and artificial intelligence to play a vital role in this project. In the next section we will discuss about proposed system.

PROPOSED SYSTEM

UGV is a solution for detecting and defusing the land mine safely without any casualties. Unlike already existing projects/models, this project got something new and innovative. UGV operates semi-automatically (means, vehicles can perform some function even without a soldier/operator using A.I based algorithms) for actions like movement, detection, picking, counter strike and diffusion.

UGV can be remotely operated using NRF Command controller or can be automatically choose its best route using algorithm. Either way the vehicle is capable of doing the following functions/task.

- Detect the landmine Bomb using detectors radars which is attached to its chassis.(auto - adjustable calibrate using sensors)
- Robotic arms digs out the landmine
- UGV Uses CV vision to identify the landmine type and make a decision using decision parameters
- UGV also have a plotting feature which plot a white border (each side) to show the safe path for tanks and combatants tofollow
- UGV also have a feature to mark the landmine spot and make it explode by planting a detonator near to the mine.(only used for some complexmines)
- UGV also contains a counter strike feature which is operated manually using RC Controller.
- When a communication signal is lost the vehicle has a backup option to operate in A.I mode.

SYSTEM LOGIC FLOW DIAGRAM

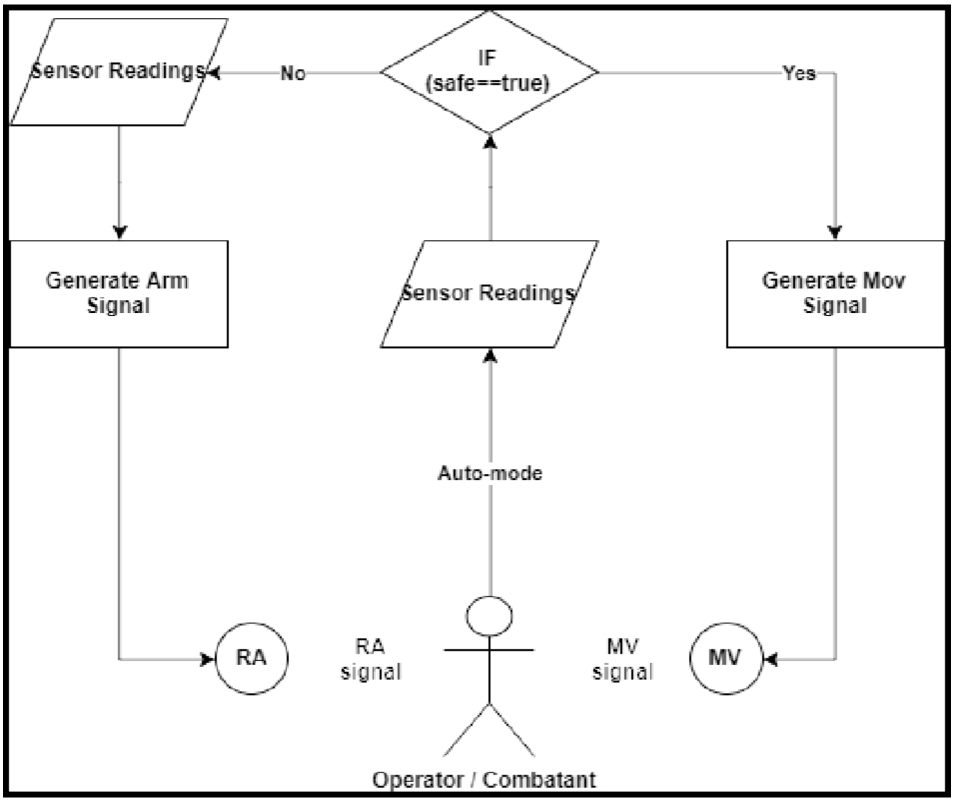

***Fig.1:**-Command Module Logic*

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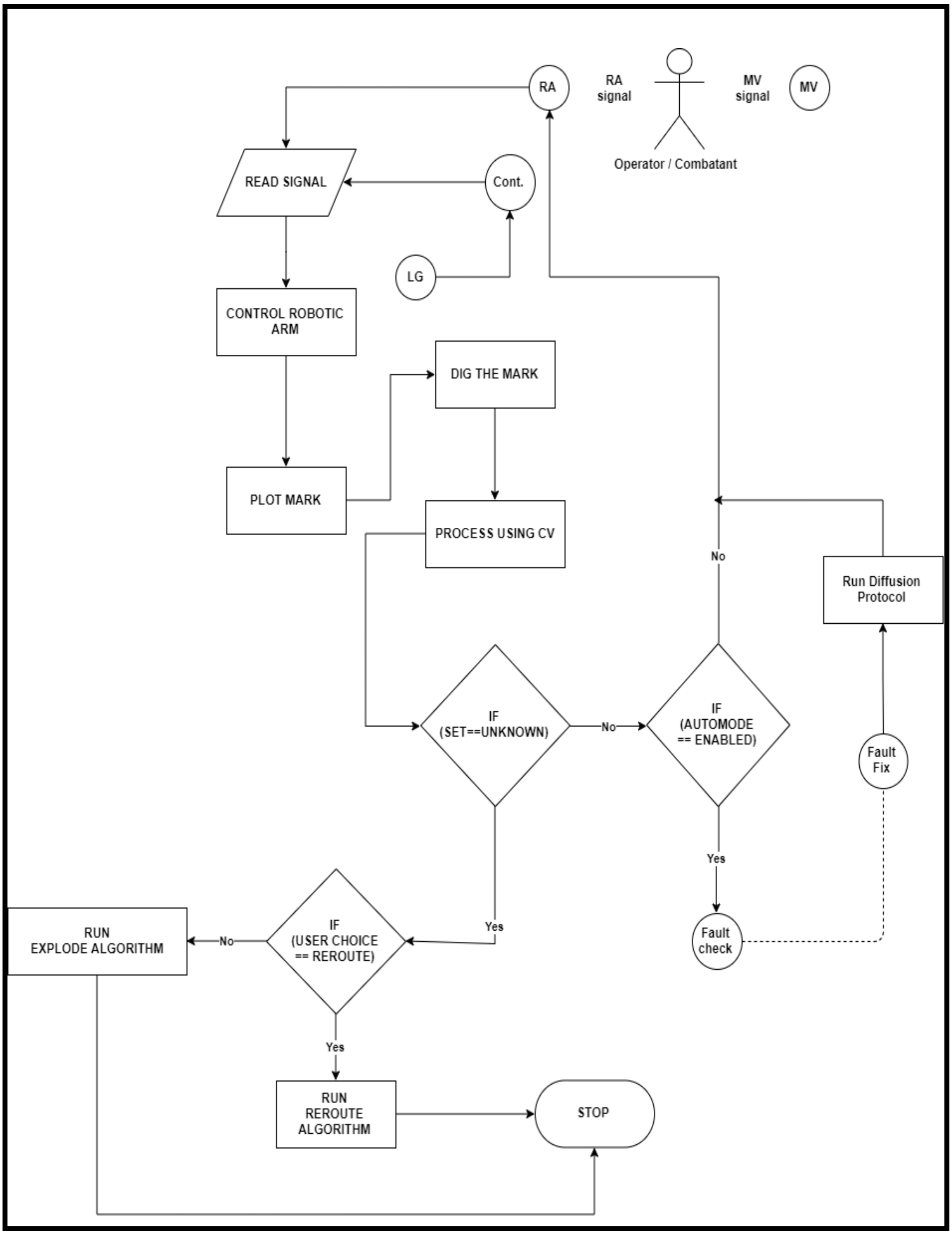

Fig.2:-*Detection & Diffusion Logics*

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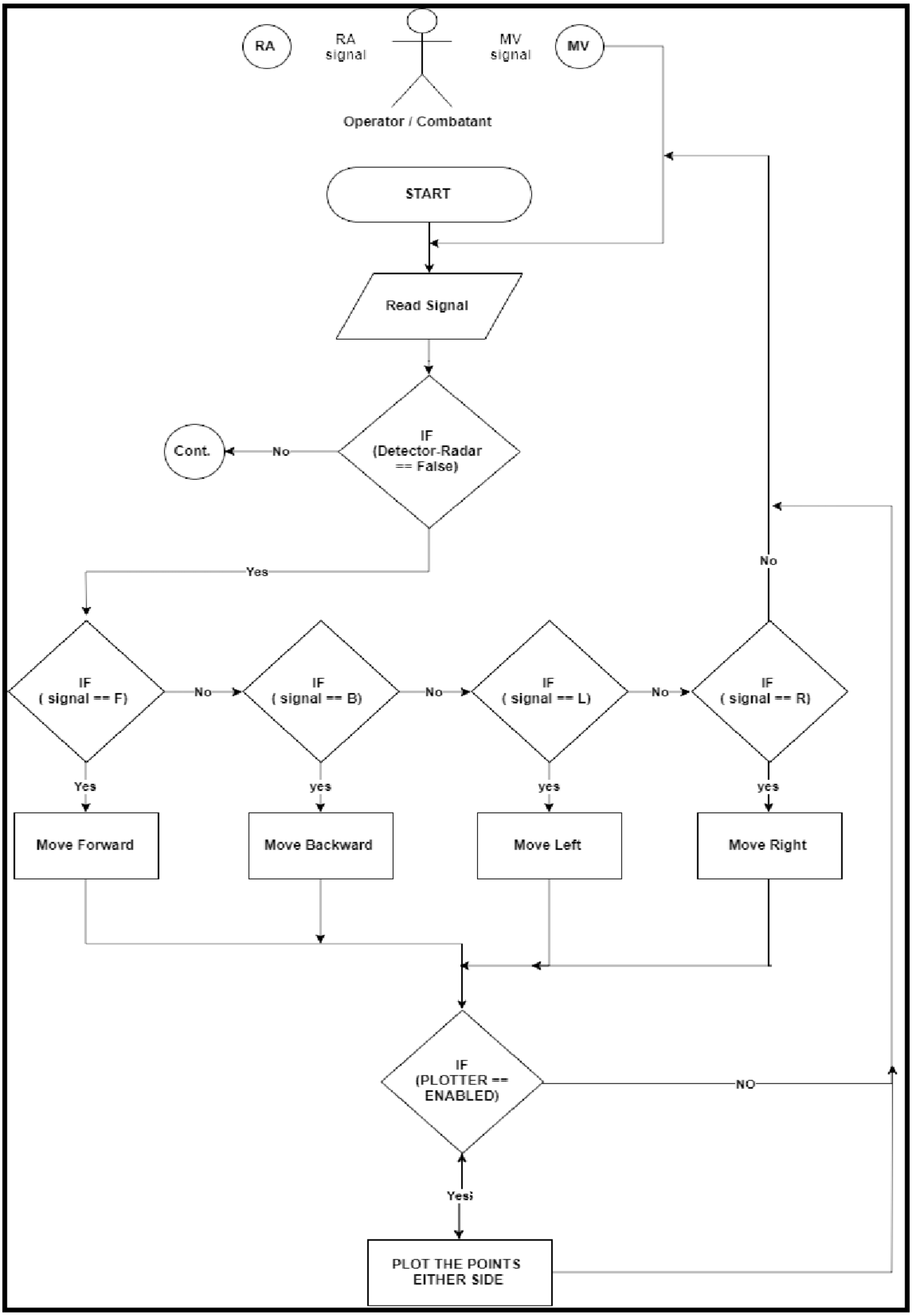

Fig.3:-Movement Logics

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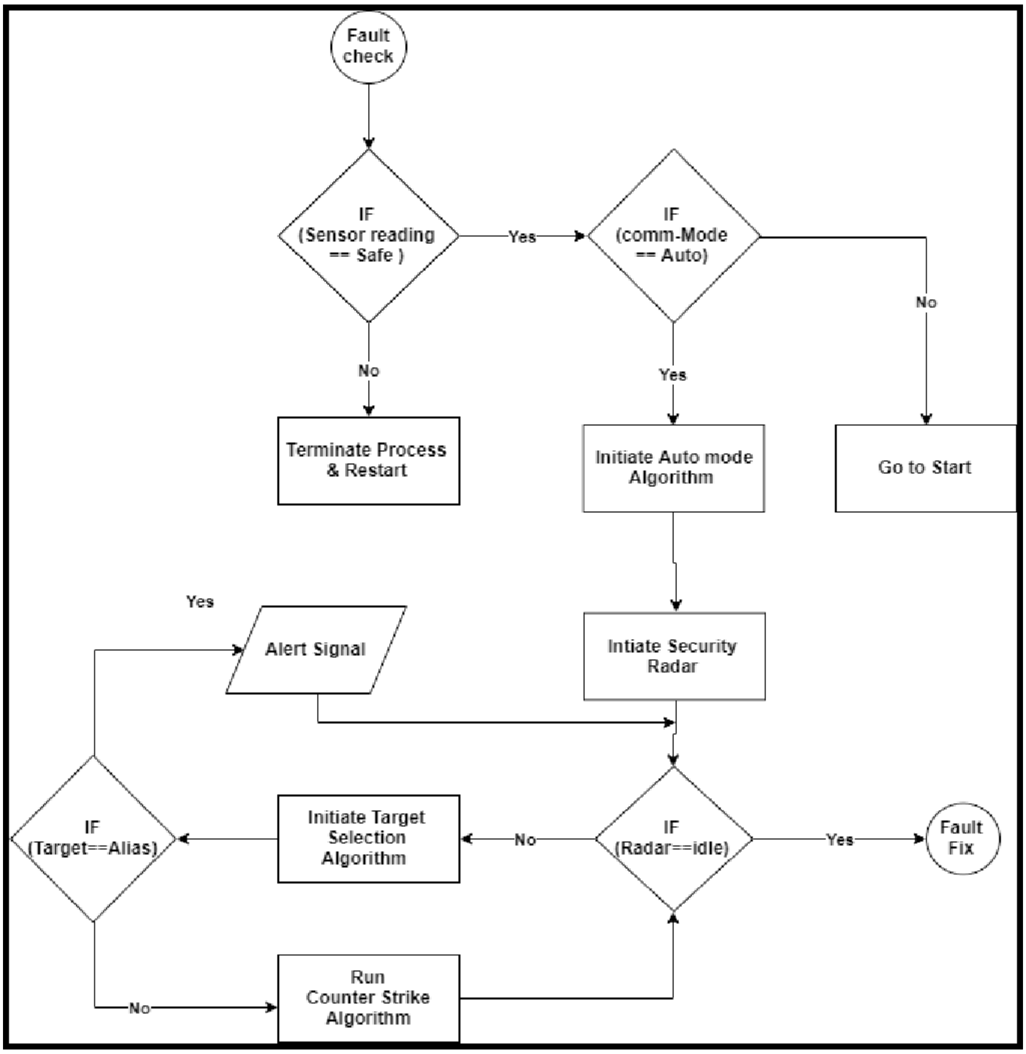

***Fig.4:**-Fault-check & alert protocols*

METHODOLOGY

U.G.V can be controlled via a command module console which is installed on a host computer which sends user command/ cheat code (ENCRYPTED) from console to Command Module.

Command module is responsible for transmitting the signal from console to U.G.V using NRF Technology.

Once the U.G.V receives the signal the U.G.V Decrypt the signal and executes the code as per the defined function.

There are many possibilities and actions based on incoming signals let's discuss each and every case.

Case 1: If the signal was movement signal the function checks if the path was safe or not safe with the help of detector & Computer vision (using camera attached in front).

Case 1.1: If the signal readings are normal then the path was safe. The movement function can be activated

Case1.2: If the signal readings are not normal then the path is not safe so the movement should be restricted and the alert protocol should be executed.

Case2: If the bomb was identified the diffusion logic is applied

Case2.1: Get the status of incoming signal if the no signal is coming then it means connection is lost so automatic algorithms have to be executed to diffuse the

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landmine. This process is done using A.I algorithms.
Case2.2: Get the status of incoming signal if the signal is active do as per the instruction of operator.
Case 3: If the mode is automatic, a certain level of fault check should be done to make the U.G.V able to make the right decision.
Case 4: From fault check if decision can't be made then the exit the code and execute alert protocols.

WORKING PRINCIPLE

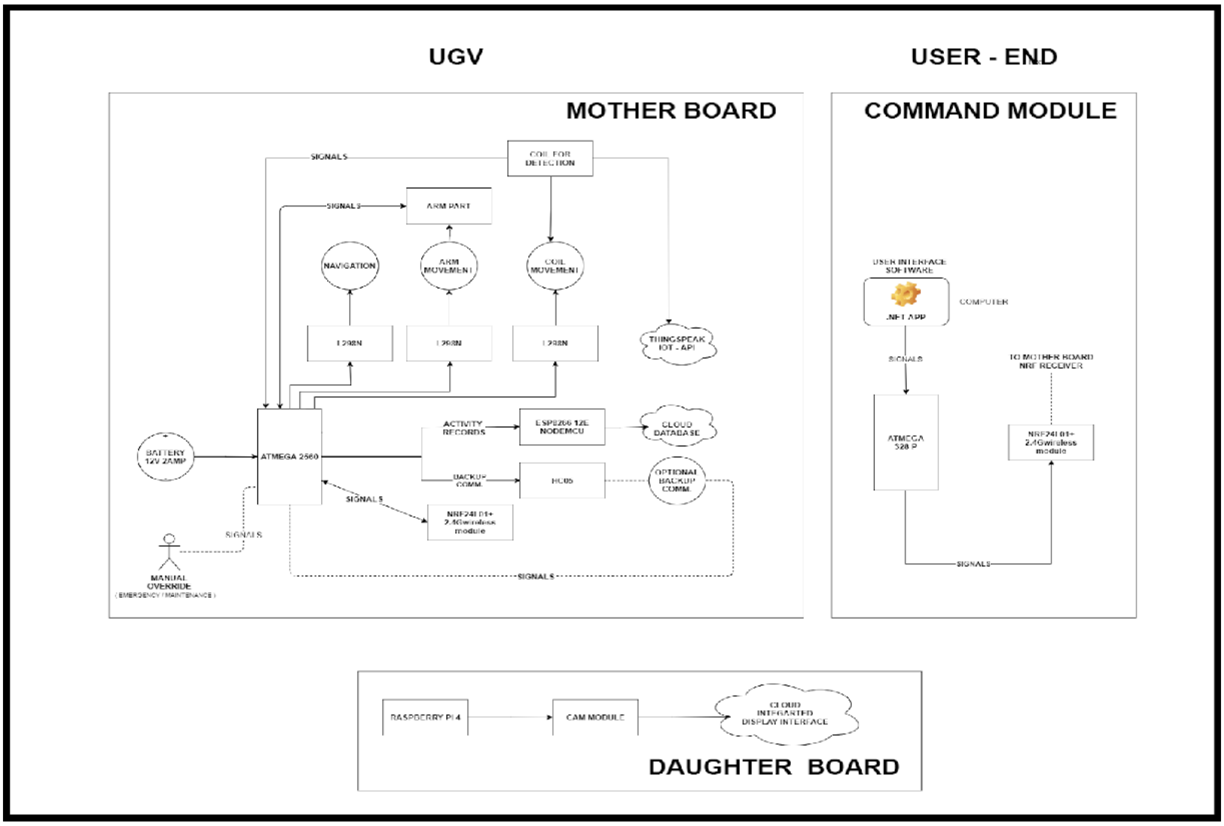

__Fig.5:__-Block diagram for proposed system

SIGNAL CONSIDERATION

Case 1: At first the U.G.V search for incoming signals. If the signal is not yet received from communication error in this scenario the UGV will execute the automatic algorithm which is already preprogrammed. In this mode U.G.V will also activate alert protocol, fault check algorithms.
Case2: if the signal is regained/ received the will verify and send signal to corresponding modules as interrupt signals using function invoke

Signal Work Flow Based on Manual Override is Given Below:

1. At first the user will send an input signal based on cheat codes using a command module interface which is a made of windows visual studio and.net programming
2. From the User interface the signal was sent to Atmega328 microcontroller using Serial UART network protocol connection.
3. Once the signal was received by atmega 328 the input signal is converted into encrypted format {Hexcode} and sent via NRF transmitter as data packet. Data packets contains following information.

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TX address	RX address	Data (Hexcode)	Hotkey

4. The signal is scanned and the data packet is received by mother board using the NRF receiver. And data packet is send to Atmega2560 Microcontroller
5. {Encrypted} Data packet is decrypted to process the user signal. Once the signal was identified the motherboard program will verify the signal.
6. Depending upon the input signal the corresponding functions are performed the command module at the user end. The will consider it as the lost signal.
7. If the signal is for movement the program will invoke movement functions including forward(),left (),right(),backward(),tilt_left(),tilt_righ t() corresponding function will invoke L298N module which is a motordriver/controller which works in H bridge concept.
8. If the signal is for arm program will invoke arm functions which include each DOF based argument passing to the Towerpro MG995 servo motor attached to the Robotic arm bracket.
9. Based on signal from detector module the signal can be considered or can be mark for review or can be revoke by executing the alert protocols.

LANDMINE DETECTION

Landmine is detected by 3 methods. Each method have its own purpose U.G.V carries these 3 method for making right decision. They are given below:

Metal Detector Coil:

Using magnetic induction principle the bomb/landmine which is metallic can be identified.

The constant high voltage is passed through coil (AWG wire) of 56 turns and10 cm coil inner diameter. Due magnetic induction there will be pulse variation in output analog signal. This analog signal is recorded using an analog reader of Atmega microcontroller and corresponding decision is made based on signal graph. Signal graph is shown below

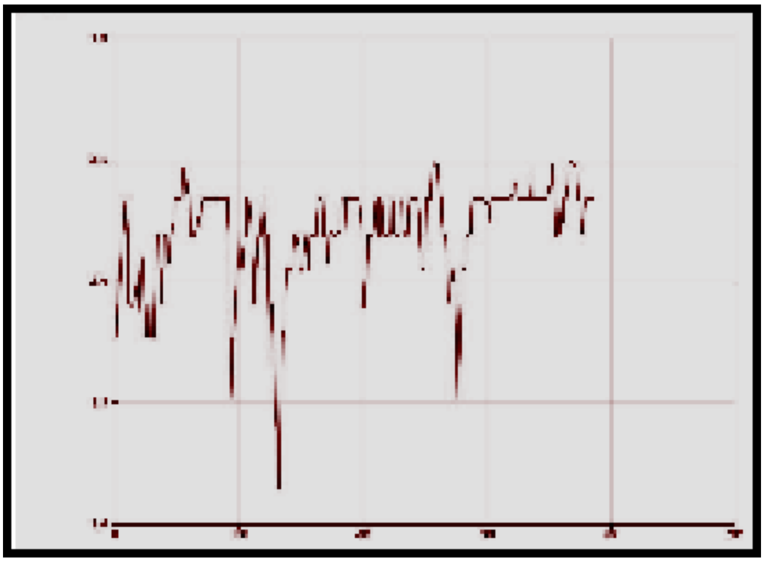

Fig.6:*-Analog reading in Serial plotter*

Computer Vision

Using computer vision/object detection technique the landmine can be identified which is on the ground (not concealed underground). This module is embedded in the Daughter board. microprocessor is used to process the image captured (at real time) using a webcam or ESPcam.

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Once the object is identified as a threat an interrupt signal is passed to microcontroller using serial UART Communication network protocol.

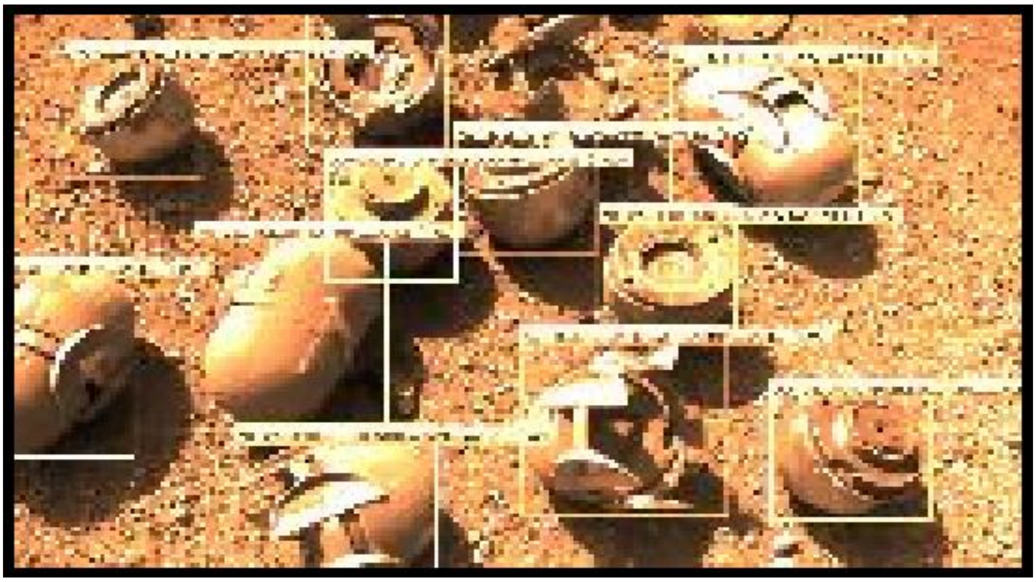

Fig.7:-*Computer vision technique using OpenCV*

GPR & SDR Technique
Using Ground Penetrating RADAR technique we can detect all metallic to non metallic landmines which are concealed under the ground. The technique uses a software defined RADAR (SDR) to map the signals and make a decision out of output analog readings.

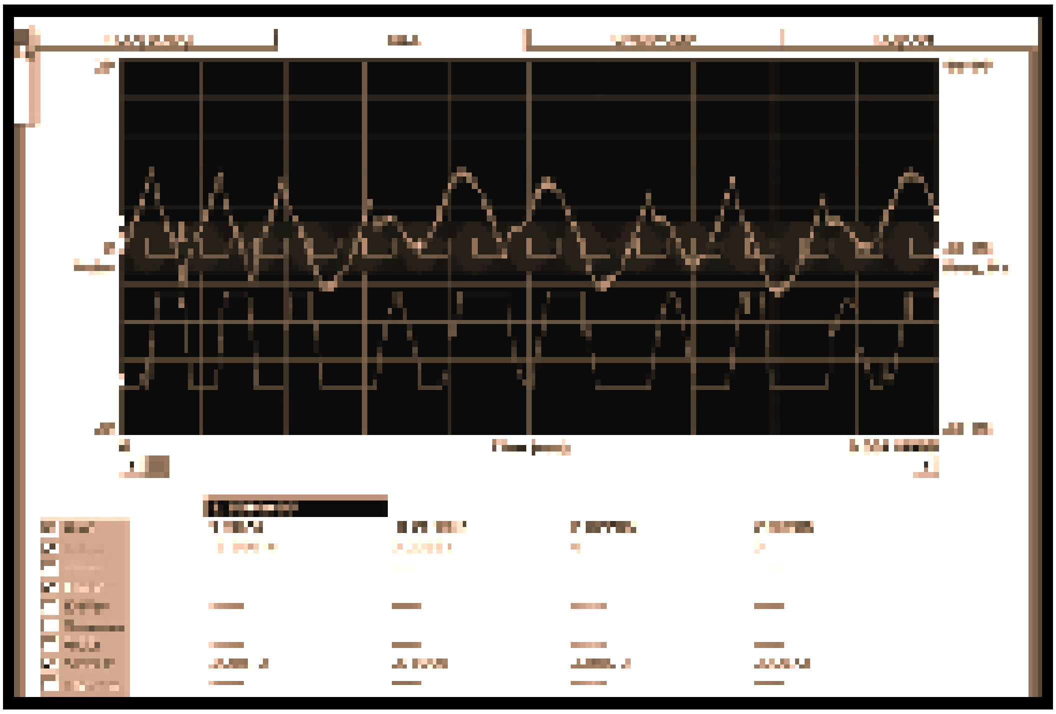

Fig.8:-*Software Defined RADAR user Interface for manual analysis*

IMPLEMENTATION
To implement the prototype of U.G.V we need the following modules and schematics are given below.

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Module List
Atmega2560 Microcontroller
Atmega328 Microcontroller
Raspberry pi 4
ESP Cam
AWG Copper Wire (30 Gauge)
Robotic Arm- End effector, Bracket, angle bars, ball bearings
150 Rpm 12 v DC motor
Towerpro MG995 Servo motor
L298N Motor Shield
SR04 Sensor
HC05 transceiver
nRF24L01+ Transceiver
ESP826612E

Fig.9:-*Modules list for prototyping*

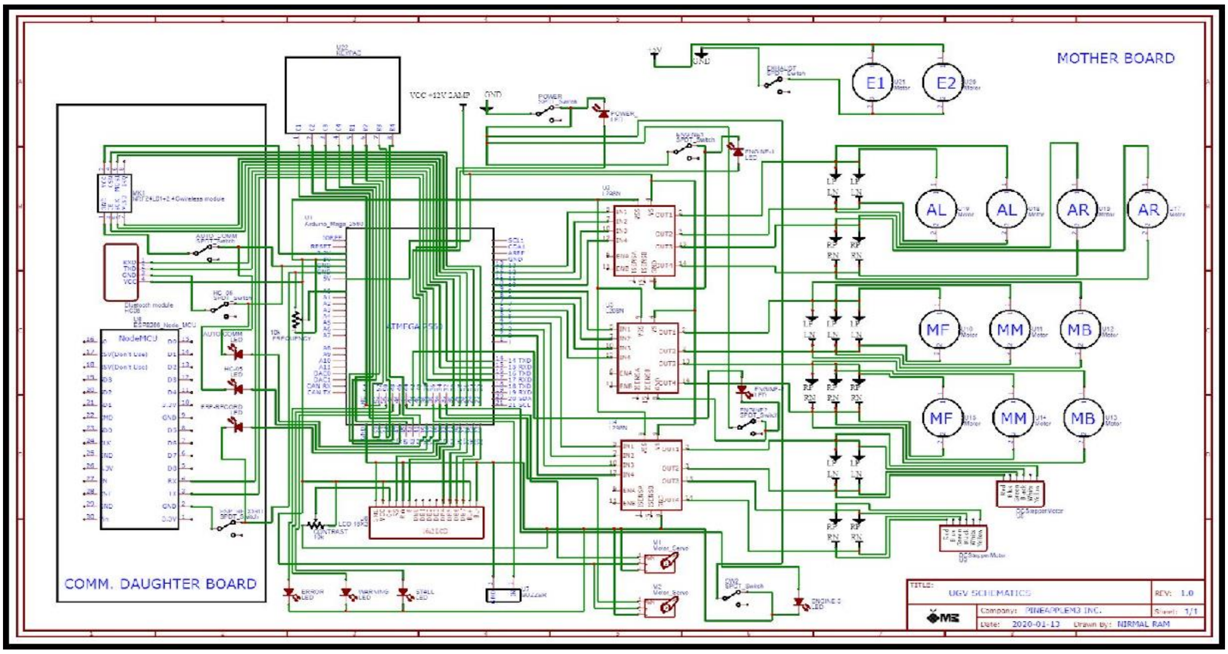
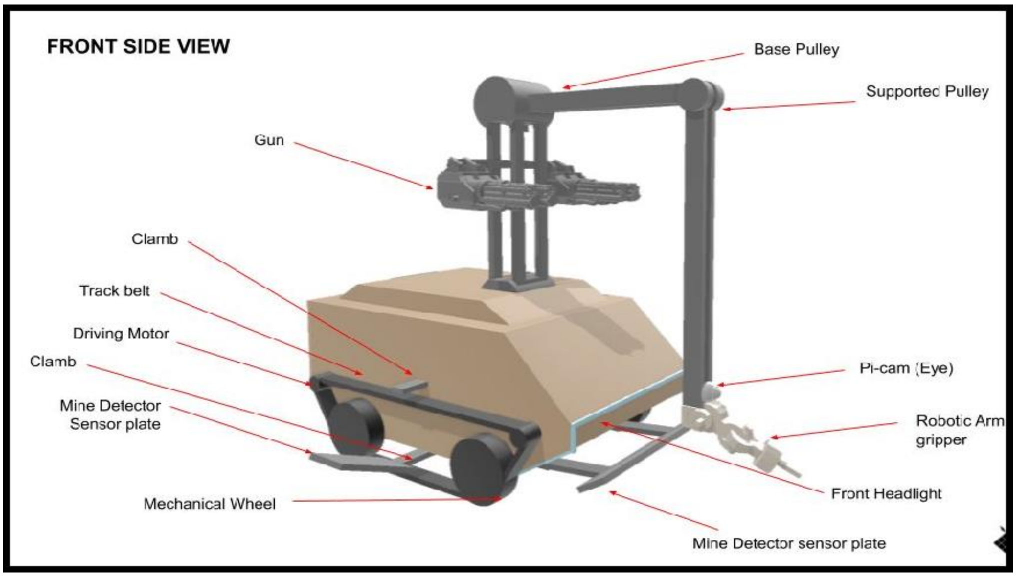


Fig .10:-*Wiring Schematics of Motherboard & Daughter Board*



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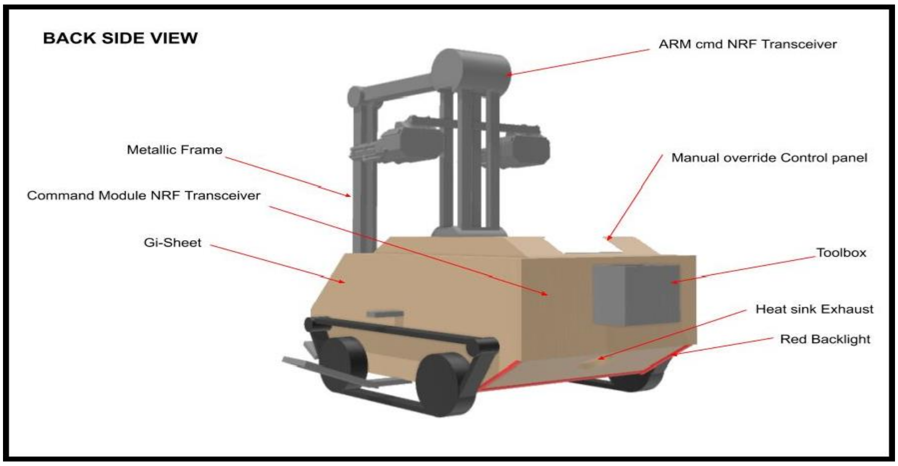

Fig.11:-*Prototype front view & back view design of U.G.V*

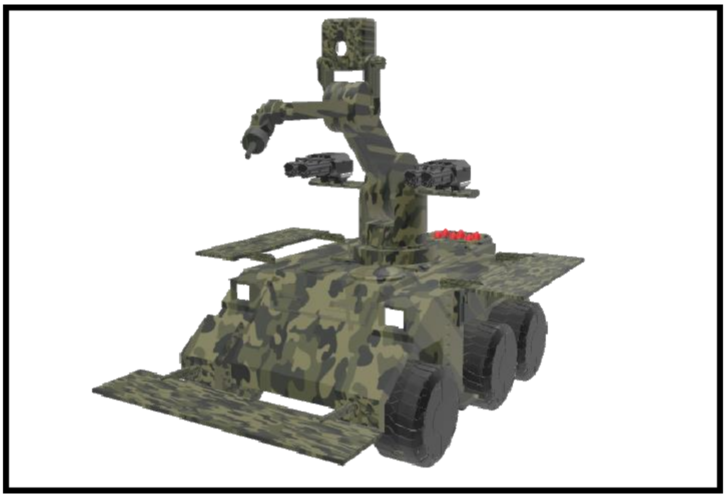

Fig.12:-*Final design of U.G.V*

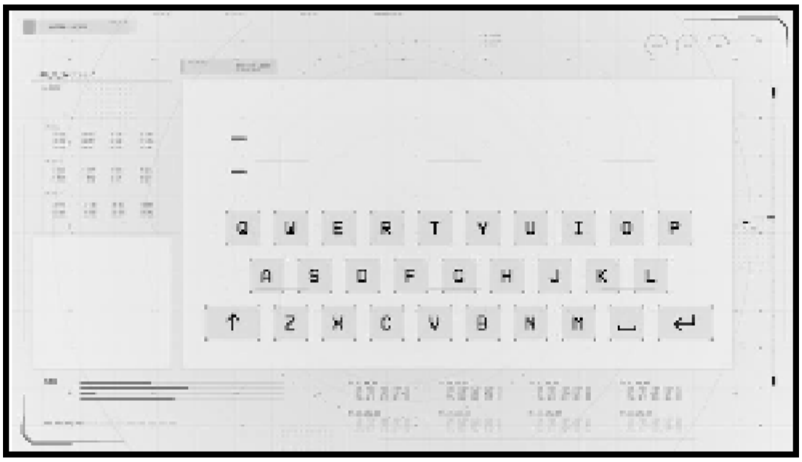

Fig.13:-*Command module console interface (VB application)*

CONCLUSION

This project is designed for military uses. In recent years, larger attention has been paid to the intensive use of temporary mines, primarily by non-state armed teams. These landmines are devices which extremely explosive which is also known as IEDs or can be referred as body traps especially to the soldiers. It harms the vehicles, tanks, soldiers that pass over or

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near to the landmine. There is different types that fall in the categories such as presence, proximity sensing and those which will explode due to the direct contact that are prohibited whether or not they were designed in an exceedingly manufacturing plant or elsewhere because offensive components are belong to this landmine to have the extreme harmful state. This project is in a position to resolve these issues faced by modern military personnel because of landmine and casualties.

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Cite this article as: Nirmal Ram, Mohammed Fasin AF, Sonu Sebastian, Namitha Gopinath, & Dr Rajeshwari. M. (2020). Design of Unmanned Ground Vehicle for Landmine and Bomb Detection using Software Defined Radar. Research and Reviews: Advancement in Robotics, 3(1), 1–12. http://doi.org/10.5281/zenodo.3725684