



## Review and Design Analysis of Robotic Vehicle used for Defense and Disaster Management

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### ABSTRACT

*The border areas need to be monitored and secured effectively and any security breach needs to be strictly monitored. The smart systems are being incorporated by Indian Defense systems now a days. The high security areas such as weapon arsenal etc. need to be monitored 24 x7 to prevent from unauthorized attacks. The proposed system deals with development of border security system to prevent unauthorized attacks. The proposed system consists of development of smart robotic vehicle which automatically safeguards the assigned area in surveillance mode. The developed smart system automatically targets the enemy when threat is detected and when the command to fire is received from the base station it automatically shoots the enemy. The proposed robotic vehicle is equipped with Landmine detection system. The Robot is also equipped with explosion detection system which will alert the base station. The Robotic vehicle is made autonomous so that once triggered from the base station it can perform effective safeguard of border areas without any human aid using Deep learning and Sensor based systems. The proposed system is Solar powered which will make it easy to charge using solar energy. The Robotic vehicle implements adaptive color changing system to map its color to the surrounding color using camera to camouflage itself which can prevent revealing its identity while spying.*

**Keywords:** Intelligent, Border Security, Target, Camouflage, Camera, Deep Learning, IOT, computer vision, Explosion, Land Mine, Solar, Autonomous etc.

## **1. INTRODUCTION**

Mobile robots are being used in military applications ranging from surveillance and monitoring to helping soldiers on the battlefield due to the promise of greater human safety. As new technological advancements are embraced, these robots' performance and capability rise at the expense of a more complex system. Despite the fact that many problems in robotics, such as kinematics, dynamics, and control of manipulators, are well-known, new problems related to mobile robot autonomy and intelligence, environmental uncertainty, and the complexity of coordinating robot-to-robot interaction and cooperation have recently emerged.

A flexible robotic platform is required to act as a test bed for the introduction of new hardware and software components as solutions to these difficulties are developed. Several robotic platforms have been created in the past using commercially available components to provide a reliable platform for a variety of applications. The platform described here, in contrast to other robots, was primarily created as a durable, yet adaptable outdoor platform with a range of modular parts, including an easily replaceable and accessible electronics bay. The system is designed with a web-based interface, free and open-source software, onboard navigation sensors, remote control, and redundant communication channels.

Any nation's security is greatly influenced by the protection of its borders. Effective border monitoring and security are required, and any security breach must be closely monitored. Indian military systems are currently incorporating smart systems. To stop uninvited attacks, high security areas like weapon arsenals etc. need to be watched 24 hours a day. The construction of a border security system to stop unauthorised attacks is the focus of the proposed system.

The proposed system consists of

development of smart robotic vehicle which automatically safeguard's the

assigned area in surveillance mode. The robotic vehicle used deep learning and sensor fusion to detect the unauthorized security breach and immediately informs the controlling end. If any unauthorized person is detected, the developed system used computer vision to track the coordinates of the person or enemy and sends the notification to the base station expecting a command to fire at the enemy. The developed smart system automatically targets the enemy when threat is detected and when the command to fire is received from the base station it automatically shoots the enemy. The proposed robotic vehicle is equipped with Landmine detection system. The robot can effectively detect mines using the metal detector provided on the Robot. This makes detecting the underground mines easy. The project also involves making the robot multitasked thus making it suitable for defence application. The Robot is also equipped with explosion detection system which will alert the base station if any explosion is detected. The proposed system also involves development of secure IOT protocol for communication between the robotic vehicle and the base station. The Camera with night vision system is also mounted on the Robotic vehicle to capture the live video feed and send it to the base station. The Robotic vehicle is made autonomous so that once triggered from the base station it can perform effective safeguard of border areas without any human aid using Deep learning and Sensor based systems. The proposed system is Solar powered which will make it easy to charge using solar energy.

## **1. OVERVIEW**

The proposed system consists of development of robot for border security. The proposed robotic vehicle can be used for surveillance as well as safeguarding our border using the IOT and Deep learning. The robotic vehicle

is Autonomous robotic vehicle. The robotic vehicle can be activated from the control panel and when triggered will be put up in surveillance mode. The robotic vehicle performs surveillance in the assigned area, continuously capturing the video feed from the on-board camera. The video feed is sent to the controlling end from where it can be viewed over the local network. The Video feed is processed by the raspberry pi using image processing techniques to determine the presence of the humans. If the human is detected, the system automatically commands the servo to target the position of human and move as the target moves. The same will be sent the control panel for verification and if the fire command is receiving the robotic vehicle also fires the target automatically. The figure below shows the line diagram of the project. The robotic vehicle also includes landmine detection system which can detect the land mines in the path of the robotic vehicle and alert the base station. The explosion sensor is also mounted on the robotic vehicle which will automatically detect the explosion and trigger the alert. The GPS system will send the live location of the robotic vehicle to the Base station which makes it easy to track.

detects the land mine in the path of the

### **1.1 CHARACTERISTICS OF ROBOT FOR BORDER SECURITY**

- A. Perform Autonomous surveillance
- B. Detect the humans automatically using deep learning
- C. Target the detect threat for shooting by using gun and turret mechanism
- D. Internet controlled control panel which can give trigger commands to the robotic vehicle to fire at the targeted enemy to develop a web application for view data using IOT
- E. Night Vision Wireless Video Surveillance system over IOT which helps the base station to remotely perform surveillance of the border areas.
- F. Land Mine detections system which

- robotic vehicle. Also detect the explosions in the path of the vehicle
- G. GPS based tracking system which can give the location details of the robotic vehicle to the base station.
  - H. Autonomous so that it can safeguard the borders effectively.
  - I. Solar powered.

## **Function 2: Landmine and Explosion Detection:**

### **1.2 TECHNOLOGY USED**

#### **HARDWARE TECHNOLOGY**

- Raspberry Pi 4
- ESP32 SOC
- Metal Detector Sensor
- Camera Module
- Night Vision Module
- GPS Module
- RTC
- Motors
- Motor Driver
- Flame Sensor
- Battery
- Servo Motors
- Laser Module
- LCD display
- Buzzer

#### **SOFTWARE TECHNOLOGY**

- Python IDLE
- WAMP server
- Arduino IDE
- ESPLOER IDE
- UBLOX U canter
- Brackets IDE

## **2. FUNCTIONS OF ROBOT**

### **Function 1: Autonomous navigation:**

The main feature of defence robots is their automated navigational capability. The system developed can perform autonomous navigation of the assigned area. The area given to the robot for border security can be covered by the robot by using autonomous navigation system which is implemented in this project. This not only helps the perform its operation with minimum supervision but also helps to perform its operations autonomously.

Soldiering is a dangerous occupation, and the tasks a soldier performs are generally more hazardous than those performed by others. Some of the riskiest activities a soldier must carry out while on duty include walking across minefields, detonating unexploded explosives, and clearing out enemy buildings. A land mine is an explosive device hidden under or on the ground that is intended to kill or cripple enemy targets when they move over, close to, or encircle it. These targets can be anything from soldiers to vehicles and tanks. The Robotic vehicle can effectively detect the land mines in its path thereby alerting soldiers so that any loss of life due to stepping on the landmine can be avoided. The Land mine detection is done using metal detector sensor which will check for landmines and if detected will alert the soldiers as well as ground station. The Explosion detection system uses explosion sensor for detection of the explosion and if explosion is detected the ground station alert will be triggered using IOT protocols to the ground station.

**Function 3: Human detection and Automatic Targeting and shooting system:**

The human detection and automatic targeting system is implemented using raspberry pi with camera module attached to the raspberry pi. The deep learning model is used to detect and track the motion of the humans in front of the robot, using the raspberry pi camera module. The raspberry pi camera module will process frame by frame data and if the human is detected will automatically inform the ground station. The targeting system will use turret gun to target the threat and also shoot the target using the gun mounted on the robot.

**Function 4: GPS tracking system:**

The GPS tracking system will fetch the real-world location data of the robot and update it to the developed ground station using IOT service. The GPS

notification system can help the ground station to track the exact location of

threat as well as the robot using the GPS location provided.

**Function 5: Video Surveillance system:**

The Camera present on the system will capture the video from the robotic vehicle and send to web application developed. The ground station developed will fetch the video from the robotic vehicle and display it in the control panel. The video surveillance can help to keep an eye on our enemies.

**Function 6: Ground station module:**

The ground station manages all the data coming from the robotic vehicle as well as send new data to control or trigger the robotic vehicle. The system is developed using PHP, HTML and bootstrap and is an web application module which can be used to control the Smart robot as well as view the video stream from the Robotic vehicle, the system can also be used to trigger the robotic vehicle and monitor the shooting state of the robotic vehicle using IOT.

### 3. ISSUES AND CHALLENGES FACED

Though the different solutions for the border security do exist, there is still a large literature gap in implementation on practical scale and the currently available solutions. The number of problems remain unsolved which will be discussed in the section below.

**Programming Issues:**

With limited knowledge of deep learning and machine learning implementation and learning curve is steep. The programming complexity exists and it is going to take more efforts and trials to solve the problems faced and to accomplish the objectives in the project.

**Material selection issues:**

Selection right hardware for the right task is another major issue faced while development of the border security. With limited hardware available in the market and power-hungry algorithms for deep learning tasks it is challenging to choose the best suitable hardware for the project.

**Issues faced with the existin solutions:**

The following table shows t literature review conducted and the ga between the same. The curre solutions and the issued faced with th same is given below.

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Table 1. Related work and Issues

<b>1.</b>	<p><b>Aim:</b> IOT based surveillance Robot Development for military applications</p> <p><b>Methodology:</b> This paper has the information for controlling the robotic system through internet web browser or android apps. This is only possible way when the raspberry pi connects with Internet connection. Some of the other sensor like Ultrasonic sensor are used to enhance the performance of the smart spy system. The raspberry pi and L293D driver is use to interface DC motor. Motor, Ultrasonic sensor and camera are the main interfacing device for security point of view because camera can able to send continuous picture or video information.</p> <p><b>Issues:</b> Can only perform surveillance and monitoring which is controlled manually using a webpage. This requires human operator and cannot detect or neutralize unexpected threats.</p>
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<b>2.</b>	<p><b>Aim:</b> Development of Intelligent surveillance system using machine vision</p> <p><b>Methodology:</b> A sentry robot named SGR-1, equipped with cameras, sensors and a subdues device, is designed for a long-range surveillance and suppression [3, 4]. It is largely composed of two modules, the tracking module and the detection module. While the detection module is composed of CCD and thermal video cameras</p>
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<b>g</b>	<p>for both day and night time use, the tracking module is composed of CCD camera, laser range finder, and IR laser illumination device. The detection module acts sequence touring that monitor. The multiple pre-set areas for specified time detecting targets. When the target is detected by detection module, the tracking module starts tracking the target, and the detection module resumes sequence touring as normal. In this way the combination of these two modules in SGR-1 allows it to detect and trace simultaneously. SGR-1 plays a central main role in device interconnect, which helps operators rapidly and accurately figure out the situation of intrusion alarm. SGR-1 moves the tracking module to have its camera aligned to a target detected by intelligent cameras or ground surveillance radars based on intelligent algorithms. A lethal weapon such as rifles, a non-lethal acoustic weapon, or a high power halogen lamp can be installed at the tracking module for suppression of targets.</p>
<b>g</b>	<p><b>Issues:</b> 1. Inability to take action on the detected threat. 2. Can perform surveillance and person detection effectively but fails to prevent additional security</p>

<b>3.</b>	<p><b>Aim:</b> To develop remote shooting system using captured images.</p> <p><b>Methodology:</b> The point of this project is to build up an implanted trespasser identification framework in border by utilizing IR sensor. There are numerous IR sensors being used today however the sensor that is utilized. will identify the Infrared beams that are transmitted from the human body. There is a need to use PI camera because, we are using PI Camera for finding / detection of intruders. We realize that in border there are numerous circumstances that happen, so at every point of time our soldiers can't watch the borders then intruders can enter our border by inadvertently and they may attack. At the point when an unknown person is detected in the scope of that IR sensor at that point</p>
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	it sends the flag to the raspberry pi and pi camera starts capturing the images. After capturing images, it will compare with database stored in the server, if image is does not match with any image, then robot will shootout that person. At that point the protect operation will be quick in identifying the people who are enter unknowingly. Robot will kill the opponents' life.
	<b>Issues:</b> No automatic targeting system implemented in the proposed solution which may results in missing targets while shooting

4.	<b>Aim:</b> To develop Intelligent border security system <b>Methodology:</b> Proposed system uses thermal imaging camera (FLIR) for detection of various objects and infiltrators. FLIR is assigned an IP address and connected through local network to the control centre. Software code captures video and subsequently the intrusion detection. A motor-controlled spotlight with infrared and laser gun is used to illuminate under various conditions at the site. System also integrates sound sensor to detect specific sounds and motion sensors to sense doubtful movements. Based on the decision, a buzzer and electric current through fence for further protection can be initiated. Sensors are be integrated through IoT for an efficient control of large border area and connectivity between sites.
	<b>Issues:</b> System uses sensors to detect the threat which is not accurate as sensors need to be calibrated and are prone to noise.
5.	<b>Aim:</b> Develop autonomous robot vehicles for border crossing detection. <b>Methodology:</b>

	In this work, a smaller, yet complex human tracking task by a mobile robot in a dynamic outdoor environment has been achieved by utilizing a SoS design approach. The detection of moving humans is performed using statistical background modelling and foreground detection on sequential images provided by a single fixed security camera in an outdoor location. The robot control is achieved through established communication formatted as XML messages containing positional data of a moving human target. A real-world application of such a SoS architecture includes border thread detection, where person crossing the border illegally can be tracked by autonomous border protection vehicles.
	<b>Issues:</b> Foreground method of human detection works in case of stationary cameras and is not effective to be mounted on robots.

7.	<b>Aim:</b> Development of Robot for spying and surveillance <b>Methodology:</b> In this present work, a Raspbian operating system-based spy robot platform with remote monitoring and control algorithm through Internet of Things (IoT) has been developed which will save human live, reduces manual error and protect the country from enemies. The spy robot system comprises the Raspberry Pi (small single-board computer), night vision pi camera and sensors. The information regarding the detection of living objects by PIR sensor is sent to the users through the web server and pi camera capture the moving object which is posted inside the webpage simultaneously. The
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	user in control room able to access the robot with wheel drive control buttons on the webpage. The movement of a robot is also controlled automatically through obstacle detecting sensors to avoiding the collision. This surveillance system using spy robot can be customized for various fields like industries, banks and shopping malls
	<b>Issues:</b> The PIR sensor uses passive infrared technology which is suitable when the sensor is stationary. The developed system doesn't include anything for safeguarding except for spying and surveillance.

8.	<b>Aim:</b> Autonomous Robot vehicle development using LabView <b>Methodology:</b> In this paper an Integrated Autonomous Vehicle (IAV) design is presented. The IAV is an automatic robot which has the capability to reach any corner of the security region without alarming the enemy. It can employ for suspicious bomb detection & demolition, threat detection etc. which is quite risky for soldier in the war field or border security region. This vehicle equipped with different on-board sensors, actuators, camera and Raspberry PI to accomplish the security activity. Raspberry PI monitors the controlling action of the robot which is programmed with LabVIEW (Laboratory Virtual Instrument engineering workbench) for efficient interaction and presentation.
	The proposed system cannot survive war field conditions as it is controlled using lab view and needs an additional system to connect the robot.

#### 4. CONCLUSION:

The unexpected attacks on the border and terrorist security breach at the border will cost the precious lives of our soldiers. This project can provide an automated robotic solution for surveillance and security of our border areas effectively. The system can perform effective surveillance of the high security areas and border areas by providing an IOT control over the control system provided. The application developed can be used to trigger the robotic vehicle as well as track the location and timings. Any threat identified including landmines and explosions are notified immediately to the ground control panel using IOT. The system implements automated targeting and shooting system which tracks for the presence of human using the camera mounted and if threat is found the same will be eliminated by automatically shooting the same.

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