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MILITARY WAR ROBOT

A BS Final Year Project by

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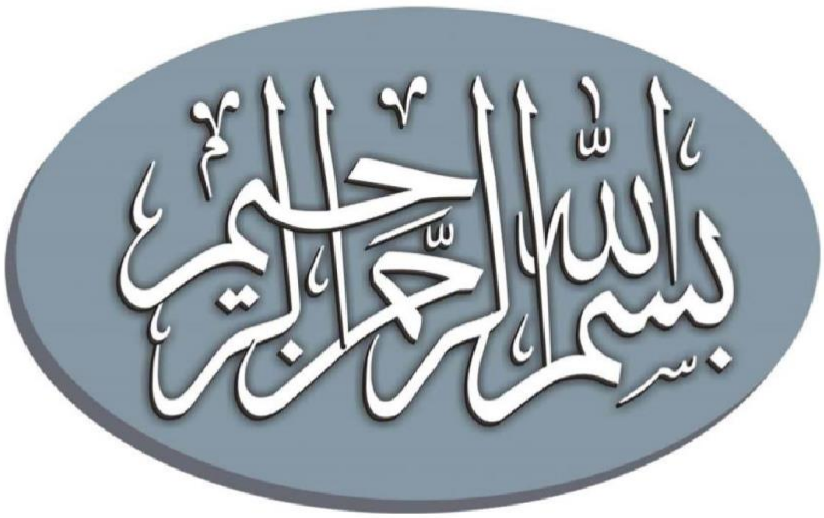

In the name of Allah (SWT), the most beneficent and the most merciful

A BS Final Year Project submitted to the

Department of Electrical and Computer Engineering

International Islamic University, Islamabad

In partial fulfillment of the requirements

For the award of the degree of

Bachelor of Science in Electrical Engineering

Declaration

We hereby declare that this work, neither as a whole nor as a part thereof has been copied out from any source. No portion of the work presented in this report has been submitted in support of any application for any other degree or qualification of this or any other university or institute of learning. We further declare that the referred text is properly cited in the references.

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Tools Used:

- Proteus
- MIT App Inventor
- MS Word
- MATLAB
- Arduino IDE

Abstract

This FYDP aims to investigate the design and development of military war robots. The use of unmanned ground vehicles (UGV) robotic systems in warfare has increased significantly in recent years, with countries investing heavily in the development of these technologies. Military war robots are automatic robots or remote-controlled mobile robots designed for military applications, from transport to search, rescue and attack. Specially designed to utilize them at the area, which have high risk. The proposed project will focus on exploring the various types of military war robots and their capabilities, as well as the ethical and legal implications of using autonomous robotic systems in warfare. The completion of this project will contribute to the development and recommendations for the safe and ethical use of military war robots in warfare. Ultimately, this project aims to promote the responsible use of autonomous robotic systems in military operations while mitigating the potential risks and ethical concerns associated with their use. They are used for surveillance, sniper detection, neutralizing explosive devices etc. Current robots that are equipped with weapons are tele-operated so they are not capable of taking life autonomously.

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List of Abbreviations

UGV	Unmanned Ground Vehicle
FYDP	Final Year Design Project
UAV	Unmanned Aerial Vehicle
IoT	Internet of Things
IED	Improvised explosive devices
AI	Artificial Intelligence

Chapter 1
Introduction

1.1 Motivation

We are three group members for FYDP. We were desired to join armed forces and attempted for it but not recommended, Alas! But the result didn't divert our love, patriotism and devotion for armed forces and for our country. So our mission is to serve them whether we are in field or across the field.

1.2 Project Overview

The military war robots can be traced back to the early 20th century, when the concept of using unmanned vehicles for military purposes began to emerge. The first notable remote-controlled explosive devices during World War I. These devices, known as "tele-tanks" were remotely operated vehicles equipped with explosives and used by the Russian military. they were not fully autonomous and required constant human control.

Military war robots are autonomous robots or remote-controlled mobile robots designed for military applications, from transport to search, rescue and attack. The robot is based on hybrid structure of UGV (unmanned ground vehicle).

Instead of independent AI, the robot is remote-controlled by human operators. The military doesn't usually use the term "robot" it calls them unmanned ground vehicles (UGVs) or unmanned aerial vehicle(UAVs). The robot that is equipped with weapons is tele-operated so it cannot capable of taking life autonomously.

1.2.1 Here is a brief overview how project works

Intelligence, Surveillance and Reconnaissance (ISR): Intelligence, Surveillance and Reconnaissance (ISR) are widely used in Combat robots. UAVs, UGVs, USVs, ROVs, AUVs, and others are extensively used in the ISR application. Small UGVs are used in the military sector mainly to provide battlefield intelligence. Currently, armed forces word wide no longer rely on human scouts and instead use small robots, which can remain almost invisible to the enemy. Search and Rescue Robots: Search and rescue robots are highly advantageous in war. They can manage to search, track, and rescue even in nuclear, biological, radiological, and chemical environments. In some cases, they can even work autonomously. Technologies is developing which can rescue soldiers from the battlefield with no risk to human life

Combat Support: Robots in the military are deployed in combat support, fire support, electronic warfare, battle damage management, strike missions, aerial refueling, etc. They also play a vital role in critical missions due to their enhanced capabilities and a certain degree of autonomy. Technological developments in army robots have led to equipping them with weapons to offer lethal capabilities in combat missions.

Wearable Support:

Wearable robots are thriving in the military and defense industry for helping human soldiers carry heavy pack loads efficiently. The combination of artificial intelligence and robotics provides automation to carry a bulk of supplies from one place to another.

1.3 Problem Statement

The inspection of the area with possibility of intruders or enemy can be dangerous. A professional team required to deal with this, which includes risk of human life. A very difficult, time consuming, highly risky and too much expensive task.

Therefore, the solution for this problem is to design a tele-operated robot which can reduce human efforts.

The major benefit is excluding risks and reduce human efforts. It is also a cheap solution as compared to human life.

Combat UGV is "Remote Control" as it provides real time control of the vehicle to the end user. The person controlling the vehicle shall decide what to do next after examining the surrounding environment of the vehicle.

Fabrication of the project providing gun firing mechanism.

1.4 Project Objectives

UGVs can be used for many applications where it may be inconvenient, dangerous or impossible to have a human operator present.

Atmosphere sensor used to detect any kind of gas or smoke.

A gun is used to eliminate the enemy.

It consists of cameras which is used for Visual aid on enemy area.

A robotic arm is used for carrying purposes.

A hardware type project which could be deployed in the field.

1.5 Brief Project Methodology

UGV Design: Designing the UGV with a hybrid structure that combines mobility, durability, and adaptability to various terrains.

Tele-Operation System: Developing a robust tele-operation system to enable real-time control of the UGV by human operators. This will involve designing intuitive control interfaces and ensuring low-latency communication between the operator and the UGV.

Sensor Integration: Integrating sensors, cameras, and other necessary equipment to provide ISR capabilities and enhance situational awareness.

Weapon System Integration: Incorporating a gun firing mechanism onto the UGV to enable controlled and precise weapon deployment under human operator guidance.

Testing and Validation: Conducting rigorous testing to ensure the UGV's performance, reliability, and safety in various operational scenarios.

Documentation and Reporting: Documenting the design, implementation, testing, and results of the project in a comprehensive report.

1.5.1 Methodology Chart

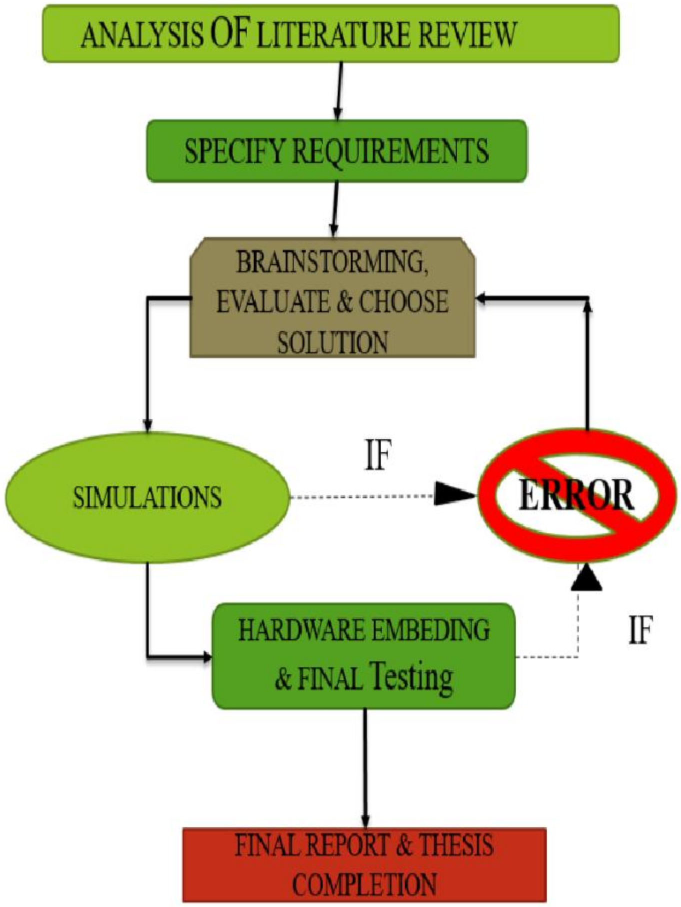


Figure 1

1.6 Report Outline

Introduction:

Background and purpose of the report.

Brief overview of military war robots.

Importance of incorporating a robotic arm in military war robots.

Design and Specifications:

Overview of the military war robot's overall design.

Key features and capabilities of the robotic arm.

Size, weight, and mobility considerations.

Integration with existing military technologies and systems.

Functionality and Operations:

Primary functions and tasks performed by the robotic arm.

Control mechanisms and interfaces for operating the arm.

Range of motion and flexibility of the arm.

Safety protocols and measures to avoid collateral damage.

Applications and Benefits:

Roles and missions where the robotic arm is particularly useful.

Enhancements in situational awareness and target acquisition.

Support in logistics, maintenance, and engineering operations.

Advantages in hazardous environments and high-risk tasks.

Challenges and Limitations:

Potential technical limitations and constraints.

Power and energy requirements for the robotic arm.

Environmental considerations and adaptability to various terrains.

Training and skill requirements for operating the robotic arm.

Chapter 2
Literature Review

2.1 Background of Project/Topic

The military war robots can be traced back to the early 20th century, when the concept of using unmanned vehicles for military purposes began to emerge. The first notable remote-controlled explosive devices during World War I. These devices, known as "teletanks" were remotely operated vehicles equipped with explosives and used by the Russian military. they were not fully autonomous and required constant human control.

The emergence of artificial intelligence and advancements in robotics during the late 20th and early 21st centuries revolutionized the capabilities of military war robots. These advancements allowed for greater autonomy and decision-making capabilities in unmanned systems. The introduction of sophisticated sensors, such as cameras, LIDAR (Light Detection and Ranging), and other detection systems, enabled robots to perceive and understand their environment, making them more adaptable to complex battlefield situations.

2.2 Related Work/Projects

John Smith, the author provides a comprehensive review of hybrid vehicles and their significance in achieving sustainable transportation. The paper delves into the history of hybrid vehicles, starting from their early development to the advancements made in recent years. It explains the functioning of hybrid vehicles, highlighting the various drivetrain configurations such as series, parallel, and series-parallel hybrids. Furthermore, the paper addresses the challenges faced by hybrid vehicles, such as battery technology and the need for charging and fueling infrastructure. The future prospects of hybrid vehicles are also explored. Overall, this research paper provides valuable insights into the current state and potential of hybrid vehicles in the context of sustainable transportation.

In this research paper, Ahmed Ali, Fatima Malik, and Muhammad Hassan present the design and control of a robotic arm for industrial applications. They first provide an overview of the existing research on robotic arms, highlighting the key features and applications of different types of robotic arms. They then describe the design of their own robotic arm, which consists of five degrees of freedom and is driven by servo motors. The paper discusses the materials used for the construction of the robotic arm and provides details of its mechanical structure. They also describe the electronic control system of the robotic arm, including the microcontroller and motor drivers.

The deployment of military war robots raises various ethical, legal, and strategic implications. Arkin (2016) examined the ethical considerations associated with autonomous military robots, including issues of lethal force and human supervision. The research by Cakmak et al. (2014) focused on the challenges and future directions of human-robot interaction (HRI) in military applications, addressing concerns related to trust, collaboration, and decision-making. These studies underscore the importance of comprehensive frameworks and policies to govern the ethical and legal dimensions of military war robots.

Military war robots have diverse applications across different operational domains. One prominent application is in surveillance and reconnaissance missions. Dey et al. (2016) explored the use of autonomous robots for gathering intelligence and conducting real-time situational analysis in hazardous environments. Additionally, Kumar and Shukla (2020) highlighted the role of military robots in explosive ordnance disposal (EOD) tasks, emphasizing their potential to reduce risks to human personnel.

2.3 Project Contribution

As the above mentioned projects, they have limited scope. By keeping the sight on future as the fuel is demolished in coming years, we combine the idea of robotic arm and hybrid vehicle embedding our own idea to embed a gun, sensor and Machine learning (ML) algorithm to detect a man and giving it a command as it is tele-operated so that it cannot shoot autonomously. An Unmanned Ground Vehicle (UGV) is a vehicle that operates while in contact with the ground and without an onboard human presence. Mechanical arms is to automate the process of placing goods or products onto pallets. By automating the process, palletizing becomes more accurate, cost- effective, and predictable. The Gun is used for military purposes and detect the spy with the help of camera.

Combat (UGV), and can be used for a wide range of applications such as reconnaissance, surveillance, target acquisition, logistics, and combat. Many aspects of this of Combat Robots involve artificial intelligence and machine learning, robots can be equipped with human senses, such as vision, touch, and the ability to perceive temperature.

2.4 Summary

This project presents a future-oriented perspective on the integration of a robotic arm and hybrid vehicle for military applications. It begins with a background section, tracing the historical development of military war robots from early remote-controlled explosive devices to artificial intelligence and robotics in the late 20th and early 21st centuries.

It emphasizes the significance of hybrid vehicles in achieving sustainable transportation, exploring their history, drivetrain configurations, and challenges. It discusses the design and control of a robotic arm for military applications, covering its mechanical structure and electronic control system. The sensors used in projects give a UGV human like senses to detect and aware.

Building upon these existing works, the project contribution section outlines a novel idea to integrate a robotic arm, hybrid vehicle, and tele-operated gun, incorporating sensors and machine learning algorithms. The goal is to create an Unmanned Ground Vehicle (UGV) with advanced capabilities such as detecting individuals and enabling tele-operated shooting under human control.

Chapter 3
System Design and Implementation Details/Design Procedures

3.1 System Design

The system architecture of the military war robot with an Arduino as main controller. At first it is connected with Esp-32 which is responsible for wireless communication and hybrid vehicle driving control.

Secondly it is connected with robotic arm can be used to manipulate objects in the battlefield, such as removing obstacles, handling explosive devices, or disarming improvised explosive devices (IEDs). They provide a safe and controlled method for dealing with potentially dangerous objects or situations.

A gun mechanism is also connected to Arduino, by web cam install at front can be used to detect target and gun is tele-operated so that it can shoot autonomously.

The environmental sensor is installed so that it can detect any kind of gas or smoke.

3.1.1 System Architecture/Flow Diagram

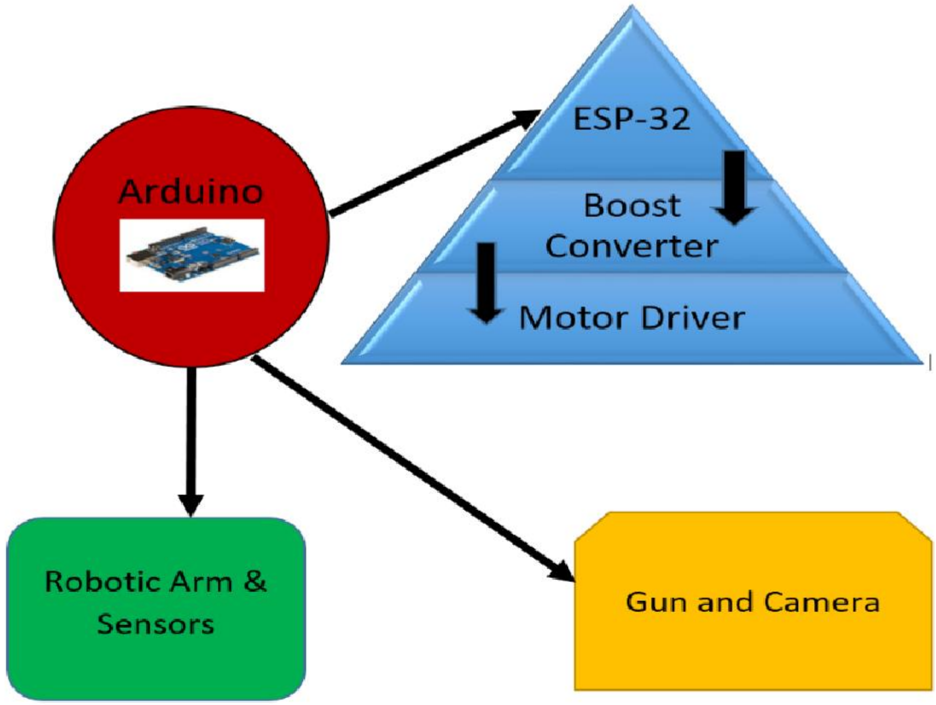


Figure 2

3.1.2 Block Diagram:

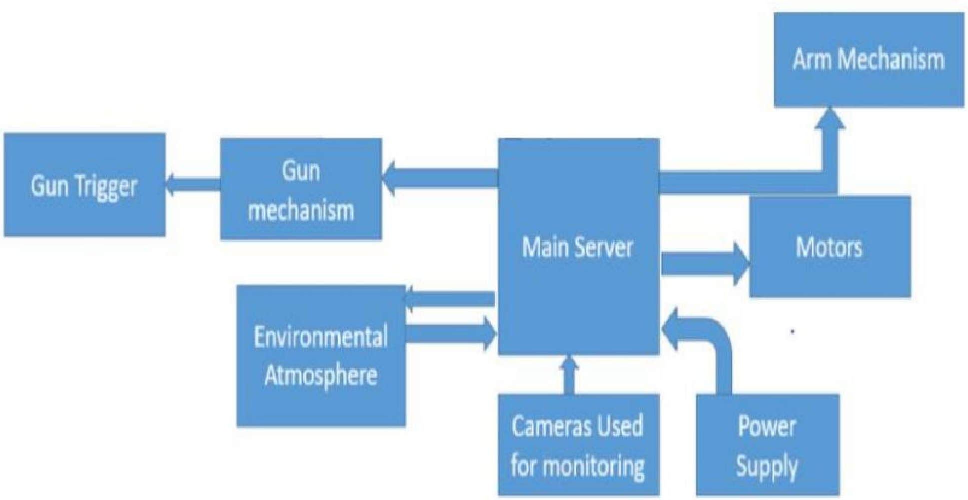


Figure 3

3.1.3 Requirements/Requirements Analysis

Mission and Operational Objectives: Clearly define the mission and operational objectives of the military war robot with a robotic arm. This could include tasks such as reconnaissance, surveillance, target acquisition, or weapon deployment. Identify the specific roles and responsibilities the robotic arm should fulfill in support of the robot's overall mission.

Payload and Arm Capability: Determine the payload capacity and range of motion required for the robotic arm. Consider the weight and size of objects the arm needs to manipulate, as well as the required precision. Evaluate the necessary degrees of freedom, reach, and lifting capacity to meet the operational requirements.

Weapon Integration: Specify the integration of military weapons with the robotic arm. Identify the types of weapons to be integrated, such as firearms, grenade launchers, or specialized tools. Define the arm's ability to stabilize, aim, and fire these weapons accurately and safely, considering factors like recoil management and target tracking.

Environmental Adaptability: Assess the environmental conditions in which the military war robot with the robotic arm will operate. Consider factors such as temperature extremes, dust, water resistance, and ruggedness requirements. Specify the arm's ability to function reliably and effectively in these challenging environments.

Control and Interface: Define the control system and interface requirements for operating the robotic arm. Determine whether the arm will be operated remotely or autonomously. Specify the control interface, including the type of input devices and the level of operator feedback required to ensure precise control over the arm's movements.

Safety and Risk Mitigation: Identify safety measures and risk mitigation strategies for the robotic arm's operation. Consider aspects such as collision avoidance, emergency stop functionality, and fail-safe mechanisms. Define safety protocols to protect operators, nearby personnel, and the arm itself during operation.

Power and Energy Management: Analyze the power requirements of the robotic arm, including the power source, energy storage, and power management systems. Consider the duration of operation, battery life, and the ability to recharge or replace power sources in the field.

Communication and Integration: Specify the communication requirements for the robotic arm, including data exchange with the control station and other subsystems of the military war robot. Determine the necessary protocols, bandwidth, and encryption measures for secure and reliable communication.

Maintainability and Support: Define the requirements for maintenance, repair, and support of the robotic arm. Consider aspects such as ease of access for maintenance, availability of spare parts, and training requirements for personnel responsible for arm maintenance and troubleshooting.

Testing and Evaluation: Determine the testing and evaluation criteria to assess the performance of the robotic arm. Define metrics for completion, accuracy, correctness, and other relevant factors based on the mission objectives. Plan for rigorous testing to validate the arm's performance in simulated and real-world scenarios.

By conducting a comprehensive requirement analysis, the specific needs and objectives of a military war robot with a robotic arm can be identified and translated into detailed specifications. This analysis lays the foundation for the design, development, and implementation phases of the robotic arm system.

3.2 Methodological/Implementation/Experimental Details

Design Process

Initial concept development and requirements gathering.

Iterative design and prototyping stages.

Incorporation of feedback from military experts and stakeholders.

Finalization of the robotic arm design and integration with the war robot.

Robotic Arm Components:

Selection of materials and actuators for the arm.

Joint mechanisms and range of motion considerations.

Gripper or end effector design and functionality.

Integration of sensors for perception and feedback.

Control System:

Overview of the control architecture for the robotic arm.

Integration with the war robot's central control unit.

Control algorithms and programming for arm movement.

Safety features and emergency shutdown mechanisms.

Testing and Evaluation:

Test scenarios and objectives for assessing the robotic arm's performance.

Test environment and conditions (indoor, outdoor, simulated combat).

Measurement and data collection methods during testing.

Analysis of results and comparison against design specifications.

3.2.1 Hardware/Development Setup

Computer Hardware: It's need a powerful computer system capable of handling the computational demands of robot development. A high-performance workstation or server with a fast processor is recommended.

Microcontrollers and Processors: Arduino as a microcontroller and ESP for communicational process are suitable for controlling the various subsystems of the robot, such as the locomotion system, robotic arm integration, and weapon systems.

Sensors: Integrate an environmental sensor and web cam to provide the robot with perception capabilities. Choose sensors based on the specific requirements of the war robot.

Actuators: Select actuators for the robot's mechanical components, such as motors, servos, and hydraulic or robotic arm systems. These actuators enable the robot to perform movements, manipulate objects, and potentially engage in combat.

Communication Systems: Establish reliable communication systems to transmit commands and receive data from the robot. Here in the proposed design it uses wireless communication (WIFI) through ESP.

Power Supply: Ensure a robust and efficient power supply system for the robot. Depending on the size and complexity of the robot, you may need batteries, power management systems, and charging stations. In military applications, it's crucial to consider power efficiency and redundancy for extended operations.

Prototyping Tools: Equip your development setup with prototyping tools such as breadboards, soldering stations, oscilloscopes and multi-meter. These tools facilitate the rapid prototyping and testing of circuits, components, and mechanical parts.

Development Boards and Kits: Utilize development boards and kits in fyp lab and control lab that provides a comprehensive platform for programming, testing, and integrating various hardware components. Examples include Arduino boards, ESP, or specialized robotics development kits.

Figure 4

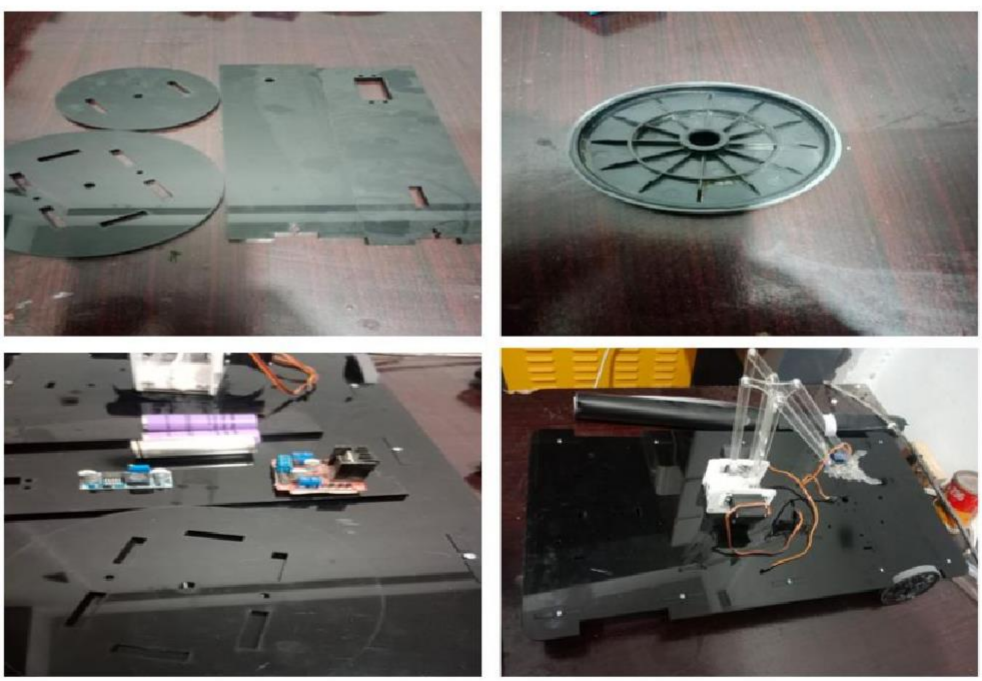


Figure 5

Figure 6

3.2.2 Hardware Details

Arduino UNO:

The heart of an Arduino board is its microcontroller, which is responsible for executing the program and controlling the connected hardware components.

Arduino boards have a set of digital input/output (I/O) pins that can be used to read signals or control devices. These pins can be configured as either input or output. Additionally, Arduino boards also have analog input pins for reading analog signals.

The Arduino development environment provides a user-friendly environment (IDE) for writing, compiling, and uploading code to the Arduino board. It uses a simplified version of the C/C++ programming language.

ESPN- 32:

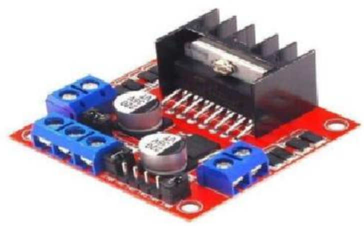
ESP32 can perform as a complete standalone system or as a slave device to a host MCU, reducing communication stack overhead on the main application processor.

ESP32 can interface with other systems to provide Wi-Fi and Bluetooth communication.

Boost Converter:

The boost converter is used to step-up an input voltage to some higher level, required by a load. It is a type of DC-DC (Direct Current to Direct Current) converter that increases the output voltage level from a lower input voltage. Boost converters can increase the battery voltage to drive high-voltage components. Boost converters offer higher efficiency and better voltage regulation compared to linear voltage regulators, making them a popular choice for voltage step-up applications.

Motor Driver:



Motor drivers acts as an interface between the motors and the control circuits. A motor driver is an electronic device or circuit that controls the speed, direction, and other parameters of an electric motor. It acts as an interface between the motor and the controlling system, such as a microcontroller or a control circuit.

DC Motors:

A DC motor is any of a class of rotary electrical motors that converts direct current DC electrical energy into mechanical energy. It's most common types rely on the forces produced by induced magnetic fields due to flowing current in the coil. Nearly all types of DC motors have some internal mechanism, either electro-mechanical or electronic, to periodically change the direction of current in part of the motor, e.g. stepper motors, dc geared motors and shunt motors.

Robotic Arm:

Robotic arms are used for object manipulation, allowing war robots to pick up, move, and interact with objects in there surroundings. This capability valuable for tasks such as handling equipment, opening doors, or operating machinery. It is made up of two or more joints according to requirement.

Web Cam:

A webcam is a video camera which is designed to record or stream to a computer or computer network. They are primarily used in video telephony, live streaming and for security purposes.

Here it is used for live monitoring and visual aid.

3.2.3 Software/Tools

MIT INVENTOR APP

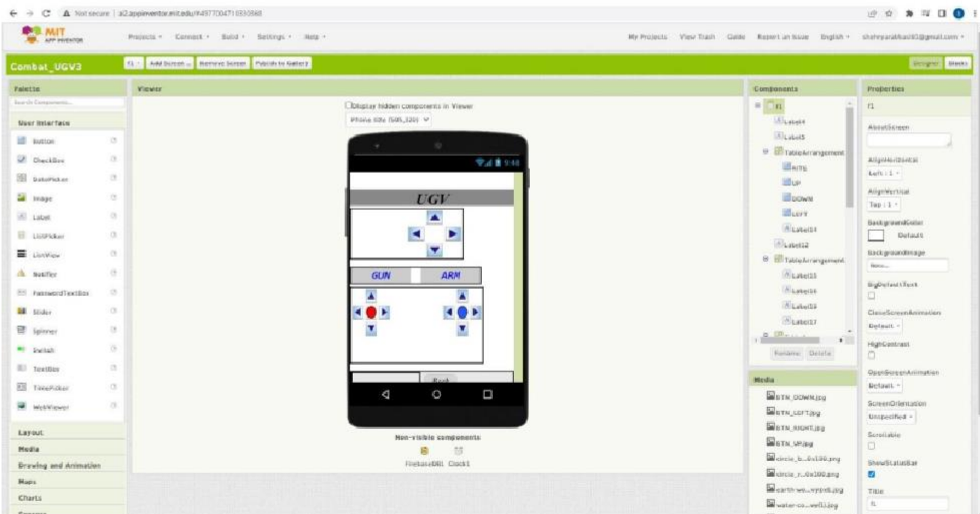


Figure 7

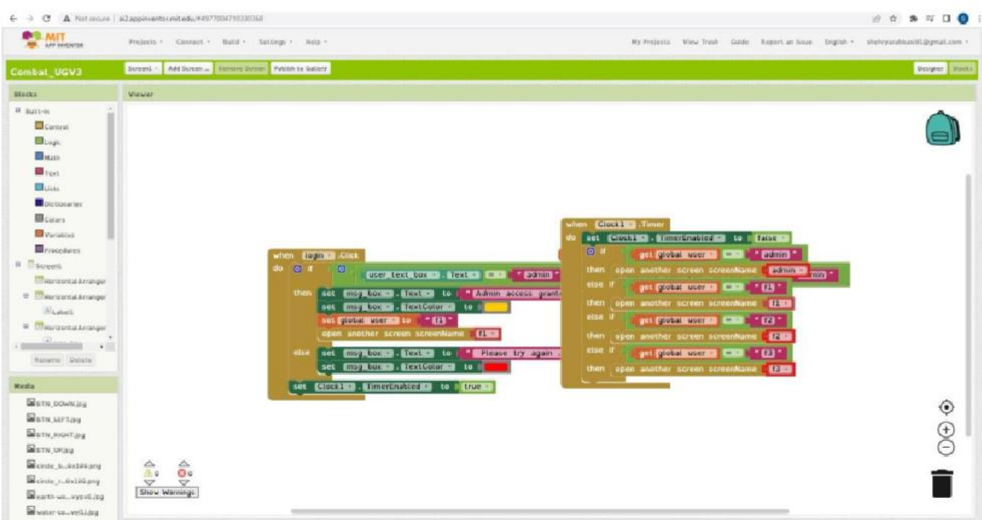


Figure 8

3.3 Algorithms/Simulation Details/Codes

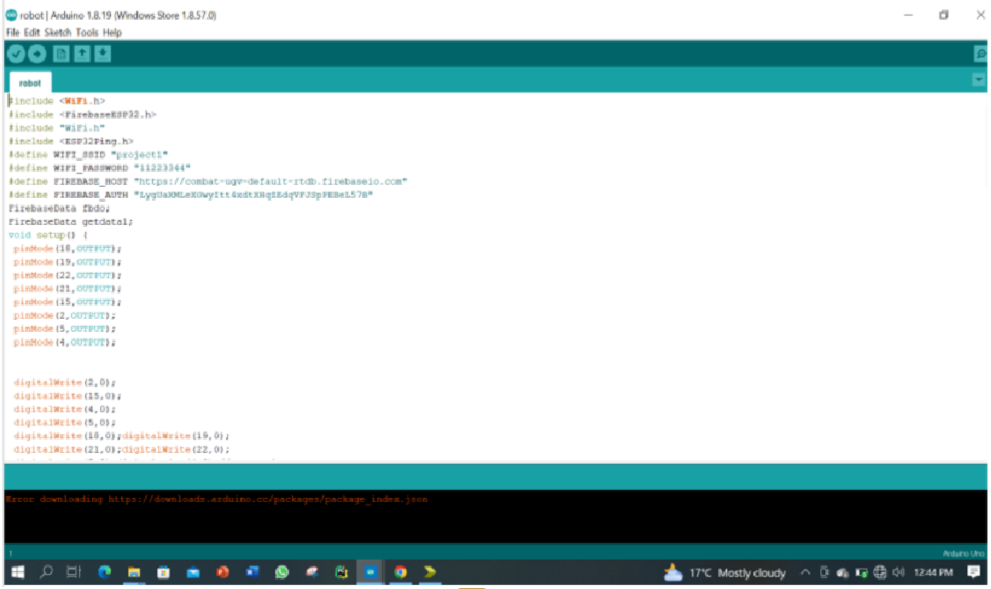
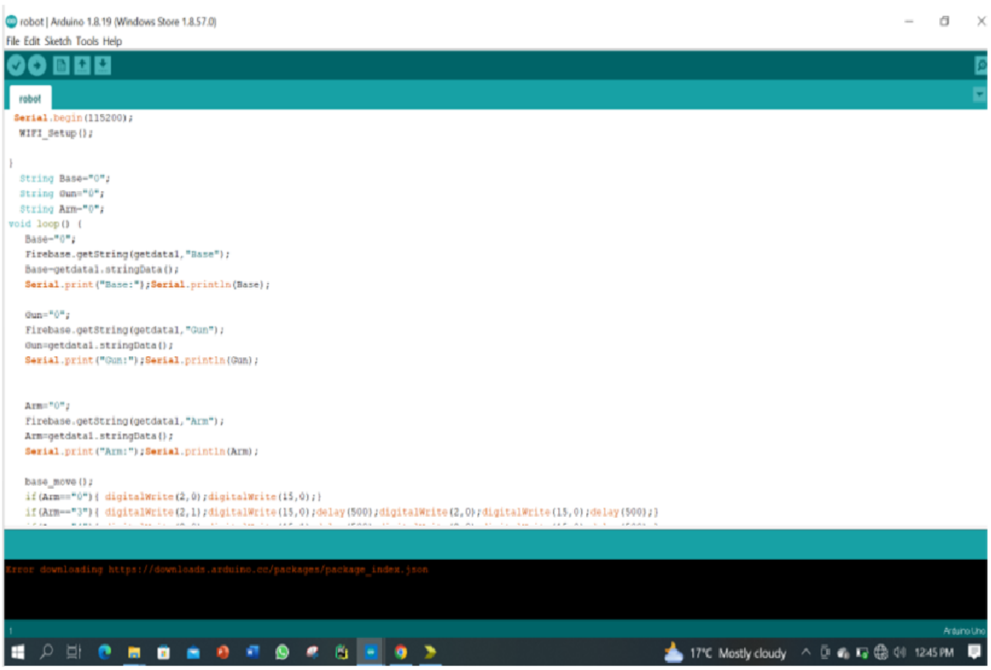


Figure 9



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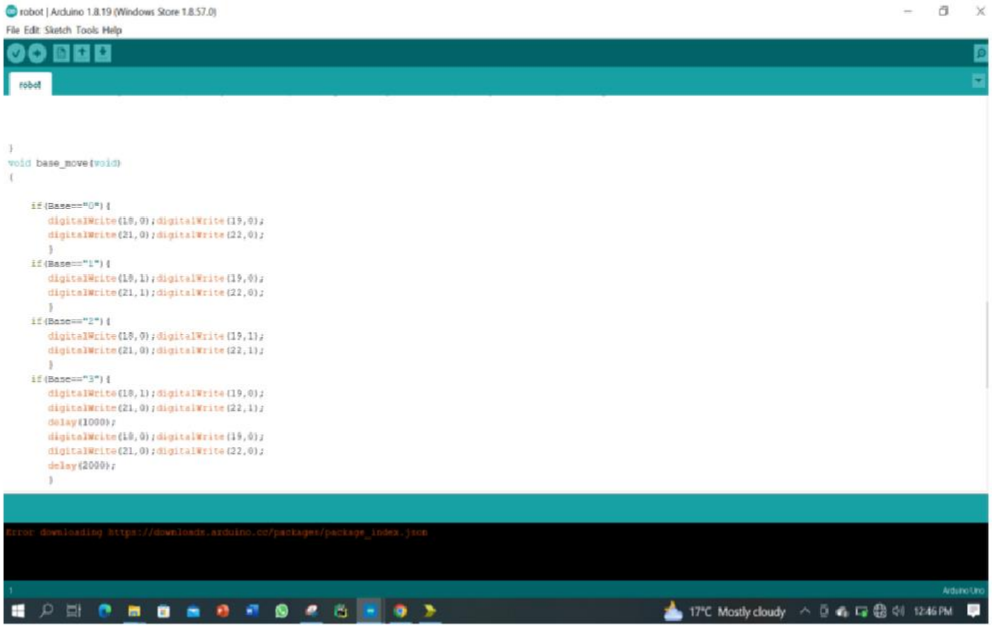
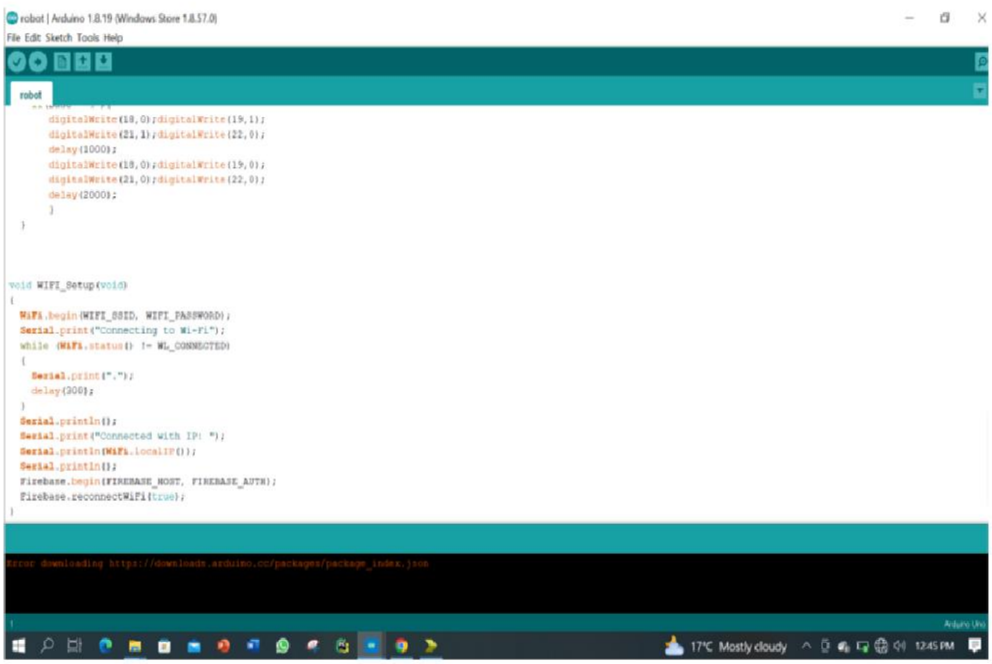


Figure 11



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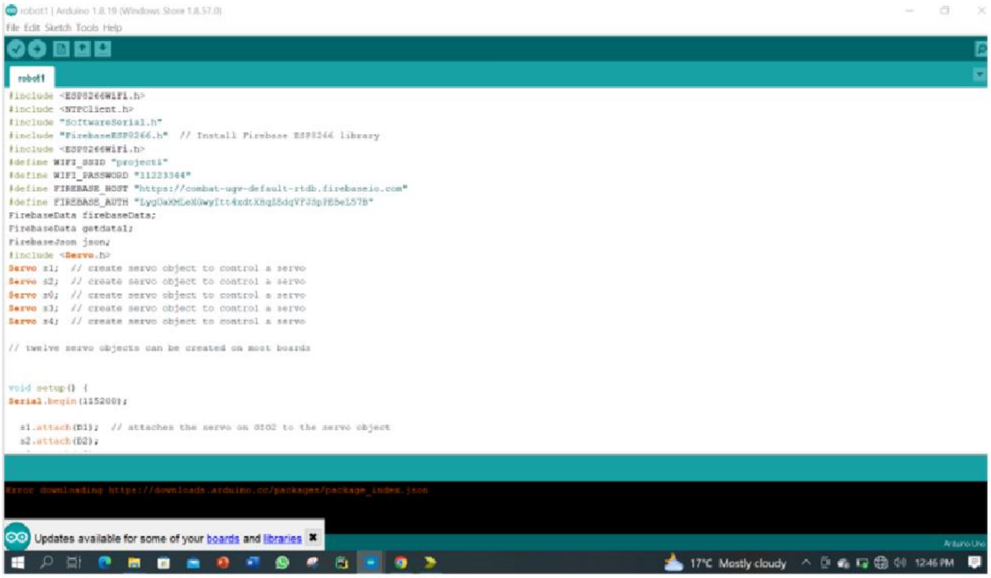

Figure 13

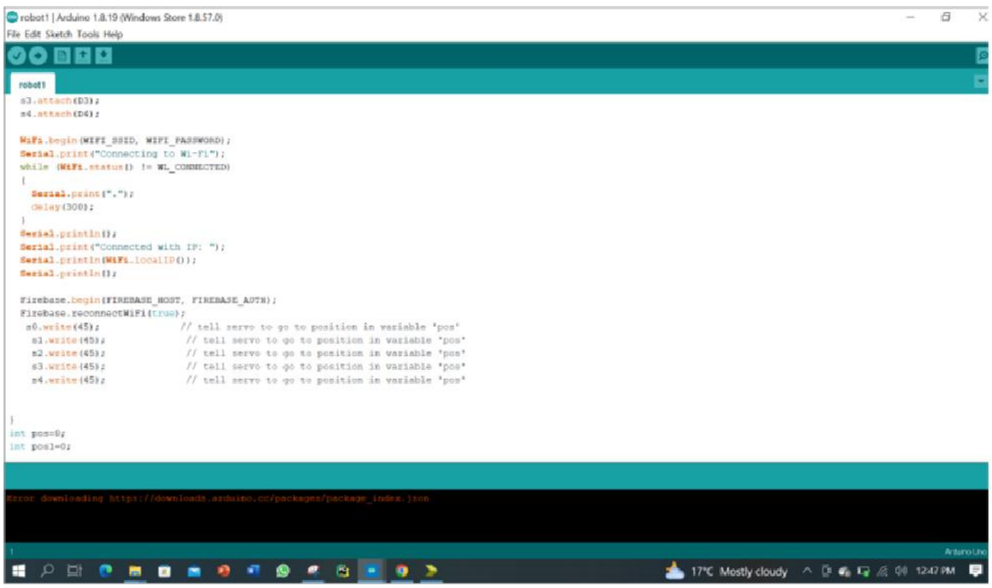

Figure 14

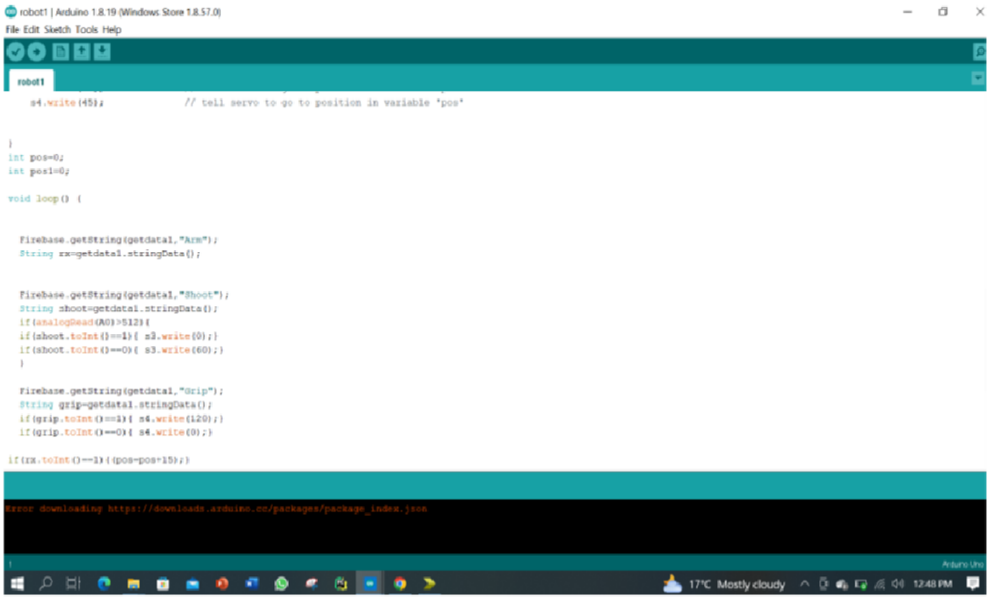

Figure 15

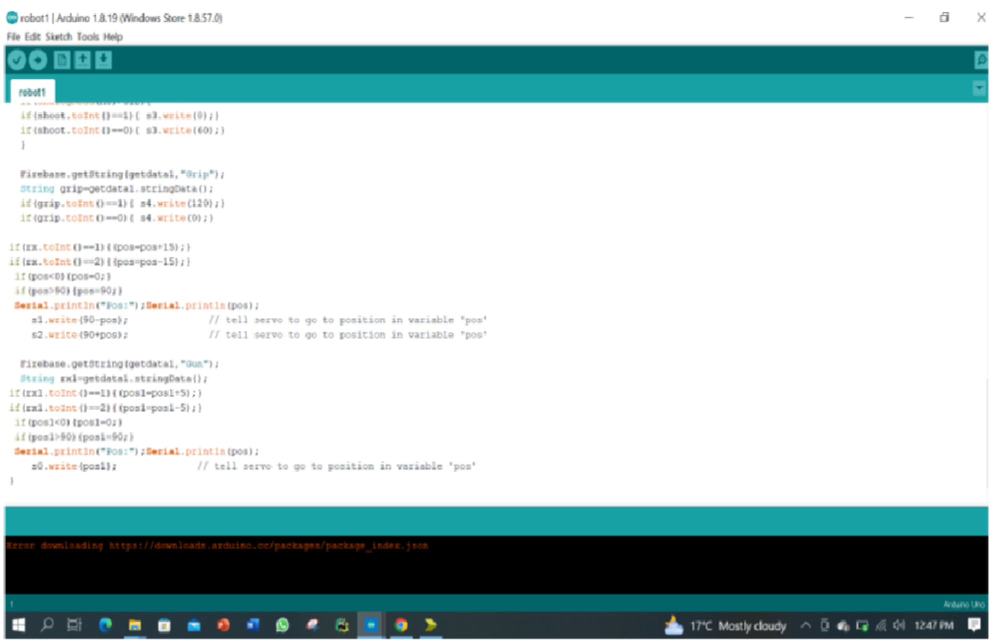

Figure 16

3.4 About Format of Table

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Functionality Table:

Components	Operation	Description
Data link protocol	communication	Wireless communication
Camera	Visualization	Visual aid on enemy/ area
GUN	Shooting	Able to shoot up to specific range
Smoke sensor	Detection	Able to detect Smoke
Motors	Movement	Rotates gun, arm and drive robot
Data link protocol	communication	Wireless communication

Table 1

Robotic Arm Control Capabilities:

Function	Range of Motion	Payload Capacity
Lifting	0-90 degrees	500 gm
Rotating	0-270 degrees	500 gm
Extending	0-1 ft	500 gm
Precision Movement	1-5cm	-
Tool Attachment	Quick Release	-

Table 2

Chapter 4
Testing and Validation/Discussion

4.1 Testing

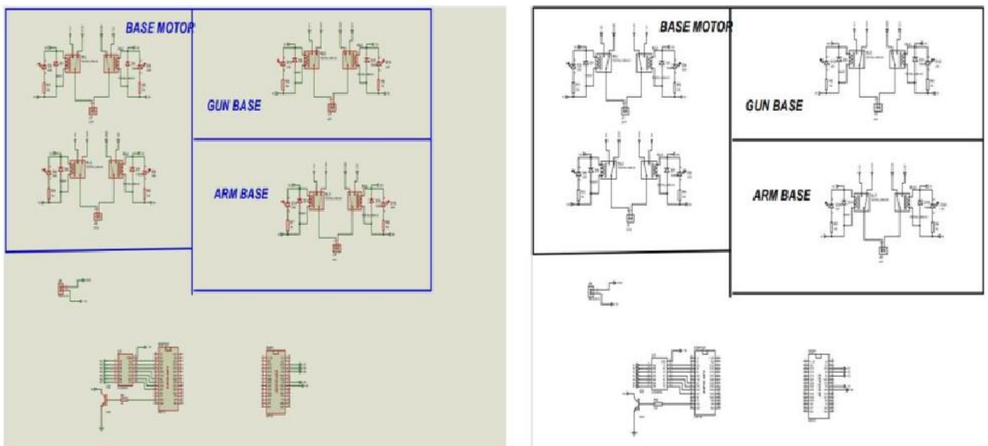

Figure 17

This provides a brief testing for base, gun and arm lifting and rotation.

4.1.1 Prototypes:

Figure 18

Figure 19

4.1.2 Test Cases

Hybrid Structure Synchronization:

At early it faced a problem for motor synchronization for base. This problem is overcome by adjusting all motors value at real time database. The structure speed is also very slow, so it is also by adjusted by increasing value in real time database of MIT app inventor.

Robotic Arm Control:

Check that all joints and motors are calibrated properly. Again it faced the same problem the rotation of robotic arm is not accurate, It is adjusted in Arduino ide environment by using stepper motors for precise rotation. Test the arm's ability to handle different loads within its specified payload capacity. Integrate the robotic arm with the robot's overall system, ensuring proper mechanical alignment, electrical connections, and software integration.

4.2 Results/Output/Statistics

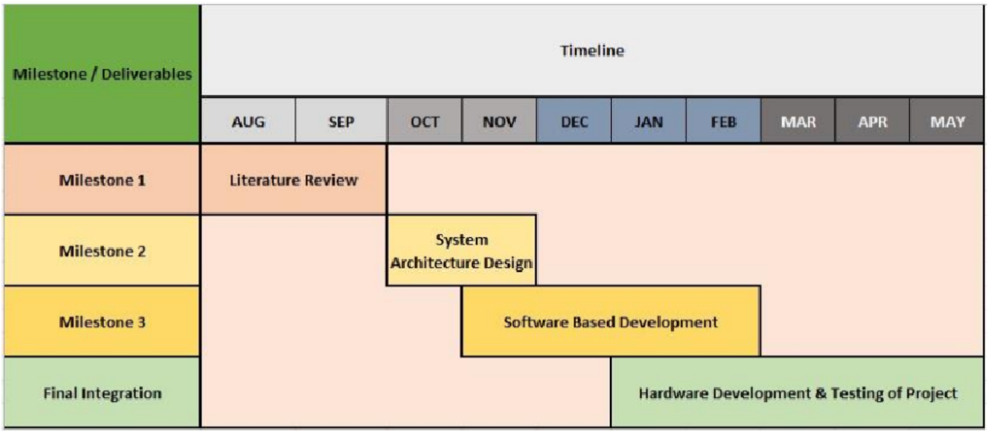

Figure 20

4.2.1 Completion

Task Success Rate: During field trials and operational scenarios, the robot's ability to complete assigned tasks is measured. This metric provides an overall success rate, indicating the percentage of tasks successfully completed by the robot and its robotic arm.

Object Manipulation: The arm's effectiveness in manipulating objects is evaluated. This includes tasks such as lifting, carrying, placing, or interacting with various military equipment and supplies. The successful completion of these tasks demonstrates the arm's capability to perform precise and reliable object manipulation.

Weapon Integration: The integration and functioning of military weapons with the robotic arm are examined. The stability and accuracy of firing, including the ability to aim, stabilize the weapon, and engage targets, contribute to the assessment of completion in weapon-related tasks.

4.2.2 Accuracy

Positional Accuracy: The arm's ability to reach predefined positions accurately is assessed. This includes evaluating the deviation from the target location, ensuring precise movements and alignments.

Gripping Accuracy: The arm's gripping mechanism is evaluated for precision in grasping and releasing objects securely and without damage. The accuracy of gripping contributes to the arm's ability to effectively manipulate objects of various shapes and sizes.

Weapon Firing Accuracy: In the case of weapon integration, the accuracy of the arm's stabilization and aiming mechanisms is crucial. The ability to aim and fire military weapons accurately minimizes collateral damage and enhances operational effectiveness.

4.2.3 Correctness

Motion Planning: The arm's adherence to defined motion planning algorithms is evaluated. This includes assessing the arm's ability to generate smooth and obstacle-free paths while avoiding collisions with objects or personnel.

Compliance with Safety Measures: The arm's compliance with specified safety parameters is assessed. This involves verifying that the arm operates within defined safety limits, preventing unintended movements, and prioritizing the safety of nearby personnel and equipment.

Adherence to Command and Control: The robot's ability to accurately interpret and execute commands from the control station is evaluated. This metric measures the arm's response to commands, its compliance with operational protocols, and its proper execution of assigned tasks.

Chapter 5
Conclusion and Future Recommendations

5.1 Conclusion

In conclusion, the project focused on the design and development of a tele-operated Combat Unmanned Ground Vehicle (UGV) with a gun firing mechanism for military applications. The UGV showcased several key features and functionalities, including intelligence, surveillance, and reconnaissance (ISR) capabilities, search and rescue operations, combat support, and wearable support.

Through the implementation of a hybrid structure design, the UGV demonstrated mobility, durability, and adaptability to various terrains. The tele-operation system allowed for real-time control by human operators, enabling them to make informed decisions based on the vehicle's surrounding environment.

The integration of sensors and cameras enhanced the UGV's ISR capabilities, providing valuable battlefield intelligence and improving situational awareness for military personnel. Additionally, the gun firing mechanism provided controlled weapon deployment under human operator guidance, contributing to combat effectiveness.

The UGV's ability to navigate hazardous environments and its support for search and rescue operations were significant highlights. It proved instrumental in reducing risks to human life, particularly in nuclear, biological, radiological, and chemical environments.

Furthermore, the inclusion of wearable support technology alleviated the physical strain on human soldiers, enabling efficient carrying of heavy loads and enhancing overall operational performance.

The project's outcomes demonstrated the feasibility and potential of tele-operated UGVs in military operations. It emphasized the importance of leveraging robotics and AI technologies to minimize risks, improve efficiency, and enhance the capabilities of armed forces.

Moving forward, further embedded design and development should be conducted to enhance autonomous features, refine the tele-operation system, and explore additional applications of UGVs in the military sector.

Overall, this project has contributed to the advancement of military robotics and showcased the potential for tele-operated UGVs to serve as valuable assets in supporting armed forces across various operational domains. By reducing human efforts and excluding risks, these UGVs have the potential to revolutionize military operations and contribute to the safety and security of our country

5.2 Future Recommendations

Prioritize the implementation of robust safety and security measures to prevent unauthorized access, ensure secure communication, and protect the UGV and its operations from potential cyber threats or malicious attacks.

Seek feedback from military personnel and operators through rigorous field testing and evaluations. Incorporate their insights and experiences to further refine the UGV's design, functionality, and operational effectiveness.

Implementing autonomous features to enhance the UGV's capabilities, such as obstacle avoidance and path planning algorithms.

Expand the UGV's capabilities beyond ground operations. Explore the integration of aerial drones or unmanned aerial vehicles (UAVs) to provide a comprehensive and integrated solution for both ground and aerial reconnaissance, surveillance, and combat operations.

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Annexure ‘A’
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