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Unmanned Ground Vehicle Bomb Disposal Robot

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ABSTRACT :

This study showcases Various experts worldwide have developed an unmanned ground vehicle bomb disposal robot, which is a safe and reasonably priced tool for emergency rescue assistance. The development of a 6 DOF articulated robotic arm installed on a movable platform will enable the bomb disposal squad to securely dispose of bombs at a distance. A computer can control the robot's entire functionality wirelessly. The actuator of the arm is a DC servo motor, which is driven by a PWM signal produced by a microprocessor. The mathematical modeling of a six degree-of-freedom robotic arm and the complete prototype development process are the subjects of this report. Development of the circuits and architecture are discussed independently.

Unmanned Ground Vehicles (UGVs), particularly Bomb Disposal Robots, have emerged as indispensable assets in modern military and civilian operations. These highly specialized machines are designed to mitigate the risks associated with bomb disposal tasks, protecting human lives and infrastructure. Equipped with advanced sensors, manipulators, and mobility systems, Bomb Disposal Robots exhibit remarkable capabilities in navigating hazardous environments, detecting explosives, and executing delicate disposal procedures with precision. Their autonomous or remote-controlled operation allows for effective deployment in various scenarios, including urban settings and hostile terrains, where human intervention would be perilous. Through continuous technological advancements, UGVs continue to evolve, enhancing their performance, versatility, and adaptability to increasingly complex threats. As a result, Bomb Disposal Robots play a crucial role in safeguarding communities, critical infrastructure, and military personnel worldwide, underscoring their significance in modern security and defense strategies.

Keywords — Unmanned Ground Vehicle, bomb disposal robot, MCU, Robotics, RF, Wi-Fi

INTRODUCTION :

Robots are becoming more and more necessary in human lives since they can carry out regular tasks with amazing speed, accuracy, and expertise despite the degree of complexity. Robotics technology has advanced to the point where it can now recognize human behavior patterns and respond in accordance with those patterns to complete tasks even in the absence of the human worker. In order to boost efficiency in the various tasks that the robots undertake in place of humans, language is implemented on them, and numerous cutting-edge electrical gadgets operate in tandem with them. Research on life-threatening tasks such as bomb disposal has been taken into consideration as robotics has advanced in various fields.

There are two primary facets of developing robots such as disarming bombs with minimal human-bomb interaction and preserving vital evidence of bomb material for use in technology tracing and creator identification. Given the numerous civil wars and subsequent terrorist attacks worldwide, law enforcement agencies now find it exceedingly dangerous to disarm bombs by hand. The professionals who typically perform this work also make every effort to avoid contact with other individuals. It is always necessary to watch over and defuse the device remotely. As a result, robots are frequently required to support the bomb disposal teams. This is the only reason you should be working on this project. Many lives can be saved by a robot that disposes of explosives. It possesses enhanced agility, dexterity, and speed, matching that of an in-person explosive ordnance disposal technician.

PROBLEM DEFINITION

Problem addressed by the Unmanned Ground Vehicle (UGV) Bomb Disposal Robot revolves around the hazardous nature of bomb disposal tasks and the inherent risks posed to human life and infrastructure. Traditional methods of bomb disposal often require human intervention, exposing personnel to potentially life-threatening situations. Moreover, the complexity and unpredictability of explosive devices demand precision and expertise, further increasing the danger. In response, the development of UGV Bomb Disposal Robots aims to mitigate these risks by providing a remotely operated or autonomous platform capable of navigating hazardous environments, detecting explosives, and executing disposal procedures with precision and efficiency. By removing humans from the immediate vicinity of explosive devices, these robots enhance safety for personnel while ensuring the effective handling of explosive threats.

Objectives

The primary objective is to reduce the risks to human life by providing a remotely operated or autonomous platform for handling explosive devices, thereby minimizing the need for direct human intervention in hazardous environments.
The robot has designed to efficiently detect, identify and dispose of explosive devices ensuring precise and controlled procedures that minimize the potential for detonation and collateral damage.

UGV Bomb Disposal Robots are engineered to operate effectively in diverse terrains and scenarios, including urban environments, rugged landscapes, and hostile areas, thereby extending their utility across a wide range of operational contexts.

These robots enable remote operation by human operators, allowing them to control the robot from a safe distance while maintaining real-time situational awareness through onboard sensors and cameras.

Some UGV Bomb Disposal Robots are equipped with autonomous navigation and decision-making capabilities, enabling them to carry out predefined tasks without continuous human oversight, thereby improving operational efficiency and reducing workload for human operators.

Incorporating advanced sensor technologies such as cameras, lidar, and chemical sensors, UGV Bomb Disposal Robots aim to enhance detection capabilities, enabling the identification of explosive threats with high accuracy and reliability.

The robot's manipulator arm is designed for precise and dexterous manipulation of objects, allowing for safe handling and disposal of explosive devices, as well as execution of delicate procedures such as cutting wires or disabling triggering mechanisms.

Facilitating seamless communication between the robot and human operators, UGV Bomb Disposal Robots ensure timely exchange of information and instructions, enabling coordinated and effective bomb disposal operations.

Providing comprehensive training programs and technical support for operators and maintenance personnel, ensuring proficient operation and maintenance of the robot throughout its operational lifespan.
The development and refinement of UGV Bomb Disposal Robots involve ongoing research and development efforts aimed at enhancing their performance, reliability, and capabilities in response to evolving threats and operational requirements.

Problem Identification

The development of Unmanned Ground Vehicle (UGV) Bomb Disposal Robots addresses critical challenges in modern security and defense strategies. One primary issue is the inherent danger posed to human bomb disposal technicians during the handling and neutralization of explosive devices. These technicians face significant risks, including injury or death, when approaching and disarming explosive threats manually. Moreover, the complexity and variability of explosive devices further exacerbate these risks, with some devices featuring intricate triggering mechanisms or hidden components. Accessibility to certain environments, such as confined spaces or rugged terrains, presents another challenge, limiting the effectiveness of traditional bomb disposal methods.

Additionally, the time-sensitive nature of bomb disposal operations necessitates rapid response times, which may not always be feasible with manual approaches. Situational awareness is crucial for successful bomb disposal, yet factors such as limited visibility or compromised communication channels can impede the ability of technicians to assess the situation accurately. By addressing these challenges, UGV Bomb Disposal Robots offer a solution that enhances safety, efficiency, and effectiveness in neutralizing explosive threats while reducing the reliance on human intervention in hazardous environments.

LITERATURE SURVEY

In October 1921 first two-wheeled unmanned vehicle was manufactured. It was controlled wirelessly through the radio. In 1930’s Russia made “Tele tanks” which were armed vehicles controlled by radio from other tanks and they were used in the winter war. The British produced radio control variant of its Matilda II infantry tank during 1941, which was used in World War II. Its common name is "Black Prince," and it was utilized for

demolition missions or for deflecting anti-tank gun fire. The first major development was in 1960 by DARPA which included TV sensors, cameras and computer programmes to monitor its direction of motion.

In this work, Sainadh Jasthi, Ponnammal P, Aditya Shashank Neti, and Akhil Cherukuri discussed an unmanned Self-controlling ground vehicles have been discussed. These self-controlled individuals can handle any emergency situation that today's warriors may encounter. As self-controlled robots are handy in working with position tracking of terrorist parallelly with soldiers. This vehicle works autonomously with given GPS co-ordinates and also gains the climatic conditions. So, it has been successfully built a prototype of self-controlled vehicle having GPS antenna, magnetic compass, and path planning and obstacle detection algorithm. As they are planning to control the vehicle by using arm controlled or gesture-controlled mode. Also, they can consider of using camera live feed for it.

P. Kim, J. Park, Y.K. Cho et.al performed work on as is the collaboration between UAV and UGV for geometric data collection and 3D visualization. And discuss about UAV and UGV are used in collaboration for collecting superior geometric records important for construction activities. This presents a brand-new 3D data architecture in dynamic jumbled environments by UGV and UAV. Firstly, UAV is deployed to collect images of site and creating 3D terrain including obstacle information. Using all this information mesh grid is created and this all information is shared with UGV for optimal path planning. As a result, this collaboration decreases human effort and provide different interventions.

METHODOLOGY

The methodology for designing and developing an Unmanned Ground Vehicle (UGV) Bomb Disposal Robot involves several key steps, including:

Requirement Analysis: Begin by identifying the operational requirements and constraints for UGV Bomb Disposal Robot. This includes understanding the types of explosive threats it will encounter, environmental conditions, terrain challenges, operational range, and payload capacity.

Conceptual Design: Generate conceptual designs for the UGV Bomb Disposal Robot based on the identified requirements. Consider factors such as mobility platforms (e.g., wheeled, tracked, legged), sensor systems, manipulator arms, communication systems, and autonomy levels (e.g., teleoperation, semi-autonomous, fully autonomous).

Prototyping: Develop prototypes of the UGV Bomb Disposal Robot to test and validate the conceptual designs. This may involve building physical models, simulating robot behaviors in software, and conducting feasibility studies to assess performance and functionality.

Sensor Integration: Integrate a suite of sensors into the UGV Bomb Disposal Robot to enable detection, localization, and identification of explosive threats. Common sensors include cameras, lidar, chemical detectors, radiation detectors, and thermal imagers.

Manipulator Arm Design: Design and integrate a manipulator arm onto the UGV Bomb Disposal Robot for precise and dexterous handling of explosive devices. Consider factors such as reach, payload capacity, degrees of freedom, and end-effector options (e.g., grippers, cutting tools, disruptors).

Autonomy Development: Implement autonomous capabilities into the UGV Bomb Disposal Robot to enable it to navigate, localize, and interact with its environment without human intervention. Develop algorithms for obstacle avoidance, path planning, localization, and decision-making based on sensor feedback.

Human-Robot Interface: Design an intuitive human-robot interface for operators to control and monitor the UGV Bomb Disposal Robot during mission operations. This interface should provide real-time feedback on robot status, sensor data, and mission progress.

Testing and Evaluation: Conduct comprehensive testing and evaluation of the UGV Bomb Disposal Robot in controlled laboratory settings and realistic field environments. Assess its performance, reliability, safety, and effectiveness in detecting and neutralizing explosive threats.

Iterative Refinement: Iterate on design and functionality of UGV Bomb Disposal Robot based on testing results and user feedback. Continuously refine and optimize the robot's capabilities to enhance its performance and address any identified shortcomings.

Deployment and Training: Deploy the UGV Bomb Disposal Robot for operational use in relevant environments, such as military operations, law enforcement activities, or humanitarian demining efforts. Provide comprehensive training for operators and maintenance personnel to ensure proficient operation and maintenance of the robot.

SYSTEM METHODOLOGY

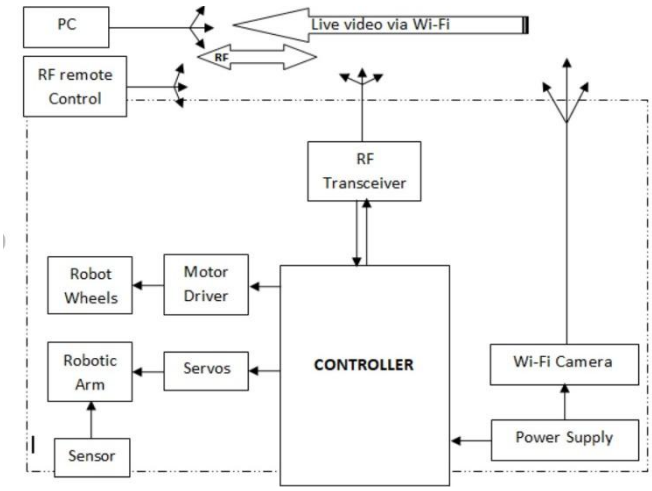


Fig. 1. Block Diagram

The block diagram of the unmanned ground vehicle bomb disposal robot is an advanced robotic system designed for bomb disposal operations. The robot's control unit consists of a PC and a robot control system (CONTROLLER), which processes and executes commands. The communication block enables wireless communication between the robot and the operator through the RF Transceiver, and provides a live video feed via the Wi-Fi Camera. The robot platform is equipped with wheels for mobility, a motor driver for motor control, and a power supply to power the robot.
The robotic arm can execute accurate motions and manipulations since it is driven by servos and has feedback and sensing devices installed. The robot can be remotely controlled by the operator using the RF remote, guaranteeing effective and safe bomb disposal procedures. All things considered, the unmanned ground vehicle bomb disposal robot is an extremely complex and sophisticated device that blends state-of-the-art technology with sensible design to offer a dependable and efficient solution for bomb disposal operations.

The vehicle consists of a central controller, which manages the robot's movements, communication, and control systems. The controller is equipped with a processor, memory, and sensors for data acquisition. It can also communicate with external systems via wireless communication interfaces or wired connections. The robot's body consists of wheels, motors, and a driver system. The wheels provide traction for the robot, while the motors are responsible for powering the wheels. The driver system, typically a differential drive system, enables the robot to move in different directions. The robot's arm is equipped with servos for precise control and manipulation of the arm. The arm is designed to handle and dispose of explosives and IEDs safely and securely.

The robot's sensors and cameras allow it to identify, classify, and mark the bombs or IEDs. These sensors may include infrared cameras, thermal imaging cameras, or laser rangefinders for detecting and classifying explosives or IEDs. The robot may also have sensors for detecting physical obstacles and navigating the environment. The robot's power supply provides the necessary power to the. controller and the other components of the robot. It may be a battery system or a portable power generator. The communication system allows the robot to receive commands from a remote operator or another system and report its status or location. This system may include radio transceivers, Wi-Fi cameras, or other communication interfaces. Overall, the bomb disposal robot is a sophisticated and highly specialized piece of equipment designed to perform its mission effectively and safely. It utilizes advanced technologies and systems to detect, classify, and dispose of explosives and IEDs in a controlled and controlled manner.

System implementation

The circuit diagram for an unmanned ground vehicle (UGV) bomb disposal robot serves as the blueprint for its intricate electronic system. At its core, the diagram delineates the connections and components crucial for the UGV's operation, ensuring seamless communication and control. The diagram typically includes power distribution systems, motor controllers, sensors, and a central processing unit. Power distribution circuits manage the flow of electricity from the UGV’s power source to various subsystems, safeguarding against electrical overload.

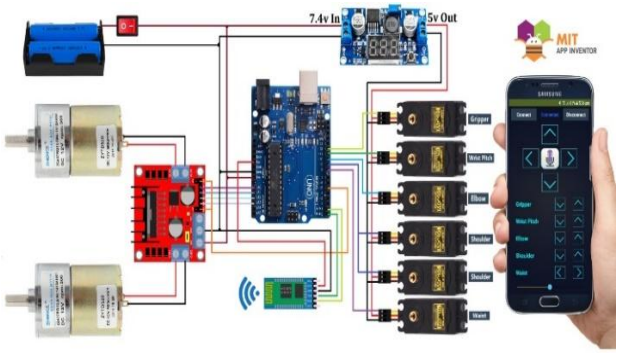


Fig. 2. Circuit Diagram

Motor controllers regulate the movement of the UGV's wheels or limbs, enabling precise navigation and manipulation in hazardous environments. Sensors, such as cameras, infrared detectors and proximity sensors, current information regarding the robot's surrounds, empowering to detect and respond to potential threats. The CPU acts as the brain of the UGV, orchestrating the integration of sensor data, executing pre-programmed commands, and facilitating remote control functionality. Together, these components form a comprehensive circuit diagram that underpins the UGV's capabilities, ensuring its effectiveness in safely disposing of explosive devices and navigating challenging terrains. The collected data undergoes real-time analysis to identify abnormal trends or pollution events. Machine learning algorithms may be employed to enhance the system's ability to recognize patterns and anomalies, improving its accuracy in pollution detection.

Components

Robotic Arm

Typically affixed to a base, robotic arms get their name from their resemblance to a human arm. The arm has several joints that function as axes to provide varying degrees of mobility. An arm with robotics has greater range of motion the more rotational joints it has. Four to six joints are used in the majority of industrial robotic arms, giving them an equal number of rotational axes for movement. Robot controller, end-of-arm tool, actuators, sensors, power systems, vision systems, and software components are some of the components of a robotic arm, in addition to rotary joints.

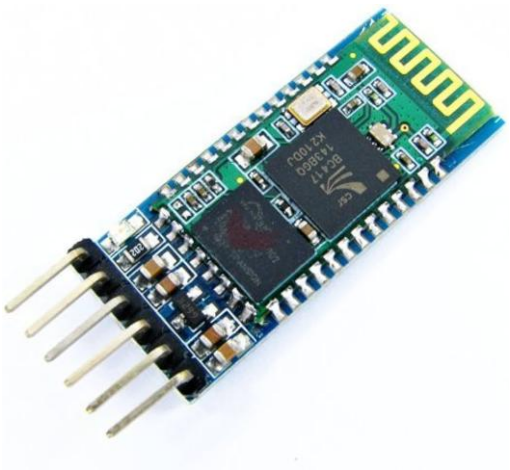
In unmanned ground vehicle (UGV) bomb disposal robots, robotic arms serve as indispensable tools for executing intricate tasks safely and remotely. Their primary role revolves around the careful handling and manipulation of explosive devices, allowing the robot to approach, inspect, and disarm potential threats without endangering human personnel. Equipped with specialized tools such as grippers, cutters, and cameras, these robotic arms enable the robot to perform a wide range of tasks related to explosive ordnance disposal (EOD), including wire cutting, detonator disabling, and controlled detonations.
Whether breaching barriers, navigating confined spaces, or handling hazardous materials, the robotic arm's versatility enhances the UGV bomb disposal robot's capabilities, ensuring effective threat neutralization while minimizing risks to human operators.

Fig. 3. Robotic Arm

Bluetooth Module

Short-range data sharing between devices is made possible via the Bluetooth wireless communication protocol. As a bridge between devices and the Bluetooth network, Bluetooth modules perform this role. For the purpose of facilitating communication and connectivity between gadgets like PCs, smartphones, Internet of Things devices, and more, they use radio waves. Secure, dependable, and low-power wireless connectivity is offered by Bluetooth modules, which function on particular frequencies in the 2.4 GHz spectrum.

Fig. 4. Bluetooth Module



Bluetooth connectivity streamlines maintenance and updates by enabling remote diagnostics and software upgrades. Engineers can troubleshoot issues and make necessary adjustments without the need for physical access to the robot, ensuring efficient operation and minimizing downtime. Overall, Bluetooth modules play a crucial role in UGV bomb disposal robots, enabling enhanced functionality, communication, and operational efficiency in hazardous environments.

Arduino Uno R3

A detachable, dual-inline-package (DIP) ATmega328 AVR microcontroller serves as the foundation for the Arduino Uno R3 microcontroller board. Six of the 20 digital input/output pins are can be utilized as analog inputs and six as PWM outputs. It can have programs loaded onto it from the user-friendly Arduino computer application. The Arduino Uno R3 can interface with a wide array of sensors, actuators, and communication modules, enhancing the robot's perception and interaction with its environment. For instance, it can integrate sensor data from ultrasonic range finders, gyroscopes, accelerometers, and GPS modules to facilitate precise navigation and situational awareness. Moreover, the Arduino Uno R3's GPIO (General Purpose Input/Output) pins enable connectivity with actuators such as motors, servos, and robotic arms, enabling the robot to manipulate objects, breach barriers, or perform delicate tasks such as bomb disposal with precision. Arduino Uno R3's versatility, programmability, and compatibility with a wide range of sensors and actuators make it a valuable asset in UGV bomb disposal robots.

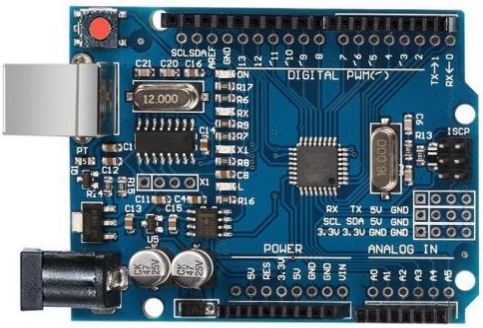


Fig. 5. Arduino Uno R3

DC DC buck convert

DC-DC buck converters serve several important purposes in unmanned ground vehicle (UGV) bomb disposal robots, enhancing their performance and efficiency in various ways. These converters are crucial components for managing power distribution and ensuring that the robot's electrical systems receive the appropriate voltage levels. In a UGV bomb disposal robot, where power efficiency and reliability are paramount.

Fig. 6. DC DC buck convert

DC-DC buck converters play a critical role in UGV bomb disposal robots by providing efficient voltage regulation, power management, compact design, temperature regulation, and battery efficiency. These converters contribute to overall performance, reliability, and functionality of robot, enabling it to carry out its mission effectively in hazardous environments while maximizing operational autonomy. DC-DC buck converters play a pivotal role in UGV bomb disposal robots, empowering them with efficient power management, robust performance, and enhanced mission capabilities in challenging environments.

FINAL PROTOTYPE

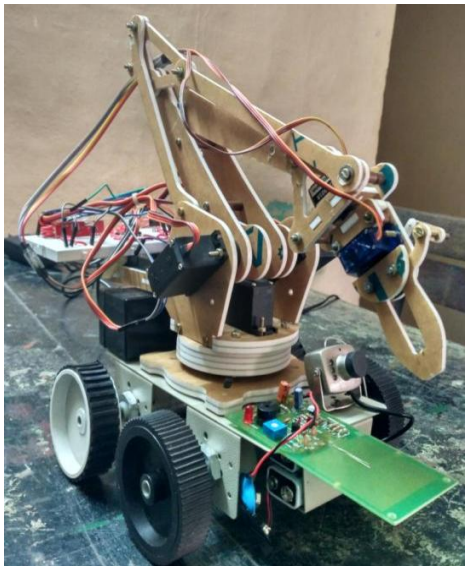


Fig. 7 Prototype

CONCLUSION

The Unmanned ground vehicle bomb disposal robot project has culminated in a transformative advancement in security and safety measures. Through relentless innovation and collaboration, the team has successfully developed a highly efficient and reliable robot capable of safely neutralizing explosive threats in various environments. Equipped with state-of-the-art technology and precise control mechanisms, the robot has demonstrated its effectiveness in minimizing risks to human life while effectively mitigating potential hazards. With its successful deployment and proven performance, this project marks a significant milestone in the ongoing efforts to enhance security protocols and protect communities worldwide. As a result, the Unmanned ground vehicle bomb disposal robot stands as a testament to the power of technological innovation in safeguarding lives and maintaining peace and security in an increasingly complex world.

As the project draws to a close, its legacy serves as a testament to the ingenuity and dedication of the individuals organizations involved, laying the groundwork for continued advancements in defense technology and counterterrorism strategies. Ultimately, the UNMANNED ground vehicle bomb disposal robot project not only represents a significant achievement in engineering and innovation but also embodies a commitment to protecting lives and promoting global security in an ever-evolving threat landscape.

Future Scope

The Unmanned ground vehicle bomb disposal robot project encompasses a broad range of possibilities for innovation and impact in the field of security and defense. As technology continues to advance, there are several key areas where the project can expand and evolve. the future scope of the project extends to exploring new applications and deployments of the robot in various operational environments. This could include integrating the robot into larger unmanned systems or networks to enable coordinated and collaborative operations with other autonomous vehicles or drones. Additionally, there may be opportunities to adapt the robot for use in other hazardous or high-risk scenarios, such as search and rescue missions in disaster zones or reconnaissance missions in hostile environments.

Collaboration with stakeholders across different sectors, including military, law enforcement, and emergency response agencies will be necessary in order to fully realize the Unmanned ground vehicle bomb disposal robot project. By working together, researchers, engineers, and end-users can co-create solutions that address the specific needs and challenges faced by these organizations, ultimately enhancing their capabilities and effectiveness in ensuring public safety and security.

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