6 Axis Or 5DOF Real Time Bomb Diffusing Robot

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ABSTRACT

The persistent global threat posed by explosive devices necessitates the continual development of advanced, reliable methodologies for their safe handling and disposal. This project presents the design and implementation of a remotely controlled mobile robot equipped with a ***6-axis/5-DoF robotic arm*** *for real-time bomb diffusion and disposal. The system is engineered to operate in high-risk zones, such as military areas or sites of terrorist activity, thereby safeguarding the lives of trained bomb disposal experts and the public.*

The robotic platform features a robust, all-terrain chassis for enhanced mobility in challenging environments and a high-definition wireless camera system that provides live video feedback to the human operator at a safe distance. The core of the system is the articulated robotic arm, which, with its 5 or 6 degrees of freedom, offers the necessary dexterity and precision to perform delicate tasks like cutting specific wires or manipulating suspicious objects without direct human contact.

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Keyword :- *Explosive Ordnance Disposal (EOD)Robot, Robotic Manipulator/Arm, Degrees of Freedom (DOF), Real-time Control/Operation, Remote Control/Teleoperation, Hazardous Environments*

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1. INTRODUCTION

The increasing threat of explosive devices, including improvised explosive devices (IEDs) and unexploded ordnance (UXO), poses a grave challenge to security forces globally. Traditional bomb disposal methods often require direct human intervention, placing personnel at extreme risk of injury or death. To mitigate these dangers, advanced bomb diffusing and disposing robots have been developed, enabling the neutralization of explosive threats remotely. These robots are designed to enhance safety, efficiency, and operational success while reducing the need for human operators to enter hazardous zones.

Bomb disposal robots, such as the one developed for the Indian bomb squad, incorporate cuttingedge technology, including high-definition cameras, robotic arms, and advanced sensors to facilitate precise handling and real-time monitoring of explosives. The robot in this project is specifically designed to detect and neutralize explosive threats, including the manual identification and removal of specific-colored wires using a five- degree-of-freedom (5DOF) robotic arm. A containment chamber ensures that any blasts are safely contained, preventing damage to surrounding areas. With its advanced mobility and autonomous capabilities, this robot is capable of navigating challenging terrains, confined spaces, and even urban environments, making it a versatile tool in modern bomb disposal operations.

The integration of artificial intelligence (AI) and machine learning significantly enhances the robot's decision-making capabilities, allowing it to analyze and respond to explosive threats in real-time. As technology advances, robots like this one will continue to improve in precision, autonomy, and adaptability, revolutionizing bomb disposal operations and ensuring safer outcomes for human personnel.

1.1 Problem statement:

The rising frequency and sophistication of explosive threats worldwide pose a severe risk to lives, infrastructure, and national security. Traditional bomb disposal methods require direct interaction with explosive devices, putting human personnel at significant risk. The need for an advanced, autonomous, remotely operated bomb diffusing and disposing robot is critical to mitigate these dangers and improve the speed and effectiveness of explosive ordnance disposal (EOD) missions. This project aims to develop a robotic system that can efficiently detect, assess, and neutralize explosive threats with minimal human involvement, addressing challenges such as precise manipulation, real-time threat analysis, and robust mobility in complex environments.

1.2 Objectives:

- **Enhance Personnel Safety:** Develop a robotic system that minimizes human exposure to explosive threats by enabling remote bomb detection and disposal operations.
- **Improve Precision and Efficiency:** Incorporate advanced robotic arms, sensors, and AI-driven decision-making to ensure accurate and effective explosive disposal.
- **Enable Real-Time Monitoring:** Integrate high-resolution cameras and communication systems for real-time surveillance and assessment of potential threats.
- **Support Multi-Agency Use:** Develop a versatile system suitable for military, law enforcement, and emergency response teams to address various explosive threats.
- **Facilitate Controlled Detonation:** Incorporate mechanisms for safe detonation or neutralization of explosive devices with minimal collateral damage.

2. LITERATURE SURVEY

- M. Cianctietti, A. Arienti, B.M. Follador, B.Mazzalai, P.dario Inspired by the Octopus, they made an interesting robot model due to its high dexterity, different movements and very complex behavior. In this experiment, the extension, shortening, bending and extension etc. used to direct the movement of the actuator. They examined the basic features and patterns of octopus arm movements, which are They concluded that the proposed concept for the base of the robot arm, inspired by octopus muscle hydrostatics, was successfully implemented on the model and the corresponding model was modified and implemented.
- Ravikumar Mourya, Amit Shelke, Saurabh Satpuite, Sushant Kakade, Monoj Botre The main objective of the studies is to design and implement 4DOF pick and place robotic arms. They concluded that CAD tools such as Creo1.0 and Auto CAD were used to create the best model. A theoretical analysis of inverse kinematics is performed to determine the position and orientation of the end effector.Ansys software was used for statistical analysis.
- Professor S.N.Teli, Akshay Bhalerao, Sagar Ingole, Mahesh Jagadale. Proposed project is to design and manufacture a pneumatic arm to pick up and place cylindrical objects. They concluded that the lever was controlled by a control defect and a control valve. The rotation and movement of the arm is done by a cylinder using a helical groove mechanism. Total weight is 25 kg. The model must carry at least 10 kg.
- S. Premkumar, K. Surya Varman, R. Ballamurgan, Objective Testing of Coordinated Grip Mechanism and Vacuum Mirror Mechanism Working on a Pick-and-Place Robot Arm. These robots can perform tasks such as holding, sucking, lifting, placing, and placing in a single robot arm.It will reduce cycle time, optimum time, operating cost, space consumption. It is user-friendly and effective in glass transport systems.
- SC Gutierrez, R. Zotovic, M.D. Navarre, M.D. report The goal of their project is to create a lightweight robotic arm at low cost. They decided to use plastic fiber material and design it using a water absorption technique so that it would not affect the overall weight of the arm. Local reinforcements should be included during the construction of the arm shell. Mast light duty gearboxes are used with harmonic drive type, but the light gear needs to be disassembled to prevent it from being replaced due to bad couplings.
- M. Tuithaf, only L. Harder. It is not safe for robots to interact with humans, especially children, at the moment, so four degrees of freedom robot arms were developed .
- M. Pellicciari, G. Berselli, F. Liaj, A. Verganana. presents a method for reducing the overall effort of a pick and place robot arm. First, electromechanical models of series and parallel manipulators are derived, and then energy-optimized trajectories are calculated by continuous time measurement. As you can see, it is not always beneficial to make as few transactions as possible. Energy consumption for work as a function of working time. Future work includes improving the engine model and developing an online programming algorithm.

- Mohd Ashiq Kamaril, Yusuff, Reza Ezucin Samin, Babul Salam, Kader Ibrahim, development report of the wireless mobile robot arm. A wireless PS2 controller is used to control selection and display functions. The development of this robot is based on the Arduino Mega platform. Check the speed, distance, lift of the load arm to understand its performance. Robots must overcome problems such as putting or picking things away from the user, picking up and removing dangerous things quickly and easily.

3. METHODOLOGY

Phase1: Planning and Requirements Analysis Phase

This initial phase defines the project scope, objectives, and constraints.

- Hazard Assessment and Concept of Operations (CONOPS): Identify potential threats (e.g., IED types, terrain, environment) and define how the robot will be used in the field. The primary goal is to maximize human safety by enabling remote operation.
- System Requirements Definition: Specify functional requirements such as the required dexterity (5 or 6 DOF arm), payload capacity, maximum operating distance (range of wireless communication), speed, power requirements, and ability to operate in various terrains.
- Feasibility Study: Determine the technical feasibility and budget, including selection of core components like microcontrollers, motors, sensors, and communication modules.

Phase2: Design Phase

The design phase translates requirements into a detailed system blueprint.

- Mechanical Design & Modeling: Design the mobile base (e.g., wheeled or tracked for all-terrain capability) and the robotic arm mechanism using CAD software (e.g., SolidWorks). Mathematical modeling of the arm's kinematics (Denavit-Hartenberg parameters) is essential for precise control.
- Hardware Selection & Circuit Design: Select specific components like high-torque servo motors, motor drivers (e.g., L298N IC), cameras (for visual feedback), sensors (e.g., metal detectors, gas sensors, current sensors), batteries, and wireless communication modules (e.g., Wi-Fi, RF link).
- Software Architecture Design: Design the control system, which typically involves a ground control station and an onboard processing unit (e.g., Raspberry Pi or Arduino). The architecture must support real-time data transmission (video, sensor data) and command reception.
- User Interface (UI) Development: Design an intuitive remote control interface, often using joysticks or hand gesture control, to ensure ease of operation by non-roboticists in high-pressure situations.

Phase3: Development and Prototyping Phase

This phase involves building the system components and integrating them.

- Fabrication: Manufacture the physical components of the robot base and arm, often using techniques like 3D printing for rapid prototyping and metal for high-stress parts.
- Assembly and Wiring: Assemble the mechanical frame and install all electronic components, ensuring proper wiring and power distribution.

- Programming and Algorithm Development: Write the software/firmware for the microcontrollers and main processor. This includes:
    - Motor control algorithms using Pulse Width Modulation (PWM) for speed and direction

Phase4: Testing and Validation Phase

Rigorous testing is crucial in a hazardous application to ensure reliability and safety.

- Module Testing: Test individual components (motors, sensors, camera, wireless link) to ensure they function according to specifications.
- Integration Testing: Verify seamless interaction between the hardware, software, and communication systems.
- Performance Analysis: Conduct controlled experiments to test performance parameters such as:
- User Acceptance Testing (UAT): Involve EOD experts to test the robot in simulated real-world scenarios and provide feedback.

Phase5: Deployment and Maintenance Phase

The final stages involve transitioning the robot to operational use and ensuring ongoing functionality.

- Deployment: Move the tested robot into the operational environment with trained personnel.
- Training: Provide comprehensive training to operators and maintenance staff.
- Maintenance and Upgrades: Establish a maintenance schedule. The modular design should allow for future upgrades (e.g., adding more AI features, better dexterity, enhanced communication range) based on field experience and evolving threats.

3.1 BLOCK DIAGRAM

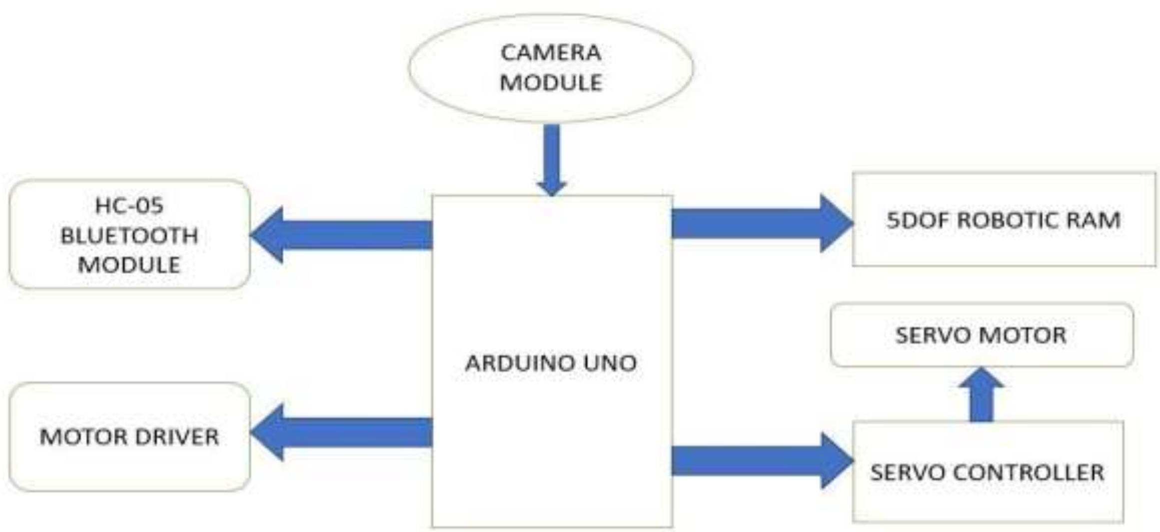

Fig1: Block diagram

3.2 WORKING PRINCIPLE

A 5-degree-of-freedom (DOF) or 6-axis bomb disposal robot operates on the principle of remote manipulation to safely handle and dispose of explosive devices, minimizing risk to human life. The core working principles involve remote control, real-time feedback, and precise robotic arm movement facilitated by multiple joints. The primary principle is teleoperation: a human operator controls the robot from a safe distance using a remote control unit or ground station system. This control system sends commands to the robot's onboard microcontrollers and motor drivers, which in turn move the vehicle and the robotic arm with precision.

4. HARDWARE AND SOFTWARE REQUIREMENT

4.1 HARDWARE REQUIREMENTS

- Mechanical Structure: Includes the chassis, robotic arm (5DOF), wheels, and end_x005F_x0002_ effector (gripper).
- Actuators: Motors (DC, Servo, Stepper) that provide motion.
- Sensors: Ultrasonic Sensor (for distance measurement)
- Microcontroller/Microprocessor: Arduino (UNO) or ESP32
- Control System: Manual control via Bluetooth and Motion control using PID algorithm
- Power Supply: Battery-operated (Li-Ion or Lead Acid) And Power management for different
    - Subsystem

4.2 SOFTWARE REQUIREMENTS

- Arduino IDE: Used for programming and uploading code to ESP modules.
- Embedded C / C++: Programming language used to develop the system logic.
- Serial Monitor: For debugging and viewing sensor outputs during testing.

Fig2: Arduino ide

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main() into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution.

A minimal Arduino C/C++ sketch, as seen by the Arduino IDE programmer, consist of only two functions:

- setup(): This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.
- loop(): After setup() has been called, function loop() is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

5. CONCLUSIONS

5.1 Future Work

- Upgrade to Wi-Fi/4G for long-range control
- Add AI object detection for wire/component recognition
- Make it foldable or lightweight for easier transport
- Implement self-righting mechanism for rough terrain
- Explore solar or hybrid power for outdoor operations

5.2 Extension Possibilities

- Combine with drones for aerial + ground surveillance
- Use in minesweeping, riot control, or chemical handling
- Convert into a modular educational robotics kit
- Develop a mobile app for control, diagnostics, and monitoring

6. REFERENCES

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