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Arduino-Based Riot Control Robot for Crowd Management and Public Safety

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Abstract: ***Terrorism and violent riots continue to threaten public safety and security in India, leading to significant casualties among civilians and security personnel. Recent incidents in Jammu and Kashmir, Delhi, and Bangalore highlight the growing need for advanced technologies that can reduce direct human involvement during hostile situations. This paper proposes an Anti Terrorism and Riot (ATR) robotic system designed to assist security forces in crowd-control and anti-terror operations using controlled non-lethal mechanisms. The system integrates wireless communication and remote warning systems for real-time monitoring and operation [1]. An ATmega328P microcontroller and Bluetooth-based control are used in the prototype model. The robot is further protected with a waterproof and bullet-resistant metallic body to enhance operational safety and durability. The proposed framework aims to improve security force protection, minimize casualties, and support effective riot and terrorism management.***

Keywords: ATmega 328 PPU Microcontroller, Embedded C programming, HC-05 Bluetooth, Anti Terrorism, Riot (ATR) Robot, Ultrasonic Sensor & Nonlethal weapon system.

I. INTRODUCTION

Rapid technological development has transformed almost every sector, ranging from household automation to advanced space exploration. Among these advancements, robotics has emerged as one of the fastest-growing fields in recent years. Robots are now widely used in various applications, such as domestic cleaning, industrial automation, medical assistance, and planetary exploration missions. Modern robotic systems vary greatly in size and functionality, from microscopic nanobots to large-scale industrial robots used in heavy construction activities. In the defence, riot control and antiterrorism sectors, robotic technologies can significantly reduce risks to soldiers and civilians by performing operations in dangerous and inaccessible environments, including radioactive and hostile areas where human involvement is unsafe. Several robotic surveillance and spy systems have been developed previously, mainly for military applications. However, many of these systems suffered from limitations such as large size, high power consumption, limited battery life, and easy detectability. In addition, earlier systems lacked effective defence capabilities, reliable communication mechanisms, and internet connectivity. They were also vulnerable to physical damage and costly to deploy. The proposed system is designed to overcome these drawbacks by providing a compact, cost-effective, internet-enabled, and secure robotic framework with improved communication, surveillance, and protection capabilities.

II. FORMATTING THE TITLE, AUTHORS AND AFFILIATIONS

[1] Mert Demir presented an antiterrorism robotic platform integrated with electromagnetic weapon technology. The proposed system combines automated target detection, image processing, and artificial intelligence techniques to identify and track targets within the operational environment. The study mainly focuses on improving targeting accuracy and extending the operational range of the electromagnetic weapon system.

[2] Jianghong Wei described the design of an eight-wheeldrive antiterrorism robot intended for heavy-duty operations across different terrains[2]. The robot is remotely controlled and possesses stair-climbing capability due to its specially designed wheel-speed mechanism. In addition, the system incorporates field-scanning functions, bomb and landmine disposal mechanisms, and a projectile-control arrangement for handling hazardous situations. The robot is designed to support counterterrorism operations while minimizing risks to human personnel.

[3] B.You and co-authors developed a bio-inspired robotic system modelled after the characteristics of a police dog[3]. The robot integrates mobility and sensing features like those of trained canine units and is capable of receiving commands as well as transmitting images and video data to command centres. By combining biological inspiration with advanced sensing technologies, the system enhances situational awareness and operational precision in security-related applications.

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III. WORKING APPROACH

The proposed robotic system is equipped with a sensor module. This feature enables the robot to capture and transmit conflict or surveillance zones to the control station, thereby supporting real-time monitoring during critical situations. Military personnel often face significant risks while entering unfamiliar or hostile environments; therefore, the robotic platform can assist in preliminary area inspection before human deployment. In addition to defence applications, the system may also contribute to reducing criminal activities and improving operational safety for security forces.

A. Block Diagram and System Explanation

Arduino Uno is employed as the primary controller of the robotic system because of its simple programming environment and compatibility with embedded C-based development [4]. The robot utilizes an internet-enabled Bluetooth module and sensors that allows remote sensing over long distances, enabling continuous monitoring from different locations.

The prototype also incorporates a high-pressure water canon mechanism intended for emergency situations, which can be used as a non-lethal defensive measure during counterterrorism or crowd-control operations. The main objective of the system is to reduce human casualties and improve safety during hazardous missions. Proper implementation of such robotic systems can support military, police and law-enforcement personnel by minimizing direct exposure to dangerous environments.

In the demonstrated model, communication between the robot and the control unit is achieved through Bluetooth technology, providing an operational range of approximately 20–30 meters. However, the communication range can be extended through the integration of alternative wireless technologies such as RF modules, DTMF-based systems, or IoT-enabled communication networks.

The robotic platform offers several important applications in areas such as riot control, counterterrorism missions, firefighting operations, and exploration of radioactive or otherwise hazardous environments where direct human intervention may not be safe.

B. System Flow

The system flow illustrates the complete operational sequence followed by the robotic platform. Initially, the robot remains in standby mode until a connection request is received from the Android-based control application through the Bluetooth communication module.

After successful pairing between the mobile device and the robot, the control commands generated through the application are transmitted to the microcontroller. These commands are then processed and forwarded to the motor driver IC, L298N, which controls the movement of the geared motors attached to the robot's wheels [5]. Based on the received instructions, the robot performs the required directional movements such as forward, backward, left, or right motion. The robot continues executing the last received command until a new command is transmitted from the control application.

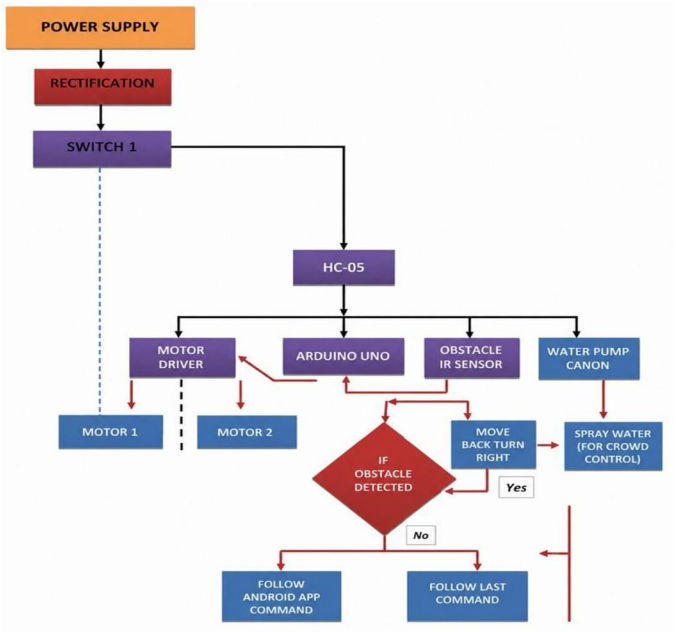


FIG. 1: Block Diagram

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The circuit diagram presents the detailed hardware interconnections among the various components integrated into the robotic system. It clearly specifies the pin configurations and wiring arrangements required for system implementation and reconstruction. In addition, the power supply connections for the Bluetooth communication module and other electronic components are properly illustrated to ensure reliable operation of the robotic platform[6].

IV. RESULTS

The developed riot control robotic system was successfully designed and tested for remote operation in security-related environments. Experimental results demonstrated that the robot could effectively perform directional movement commands, detect nearby obstacles using sensors, and respond accurately through Bluetooth-based wireless control. The integrated water cannon mechanism operated efficiently as a non-lethal crowd-control feature, showing the system's potential for handling emergency and riot situations. The prototype also maintained stable performance during continuous operation, confirming its reliability for real-time surveillance and public safety applications. Overall, the system achieved its objective of reducing direct human involvement in hazardous environments while improving operational safety and effectiveness**.**

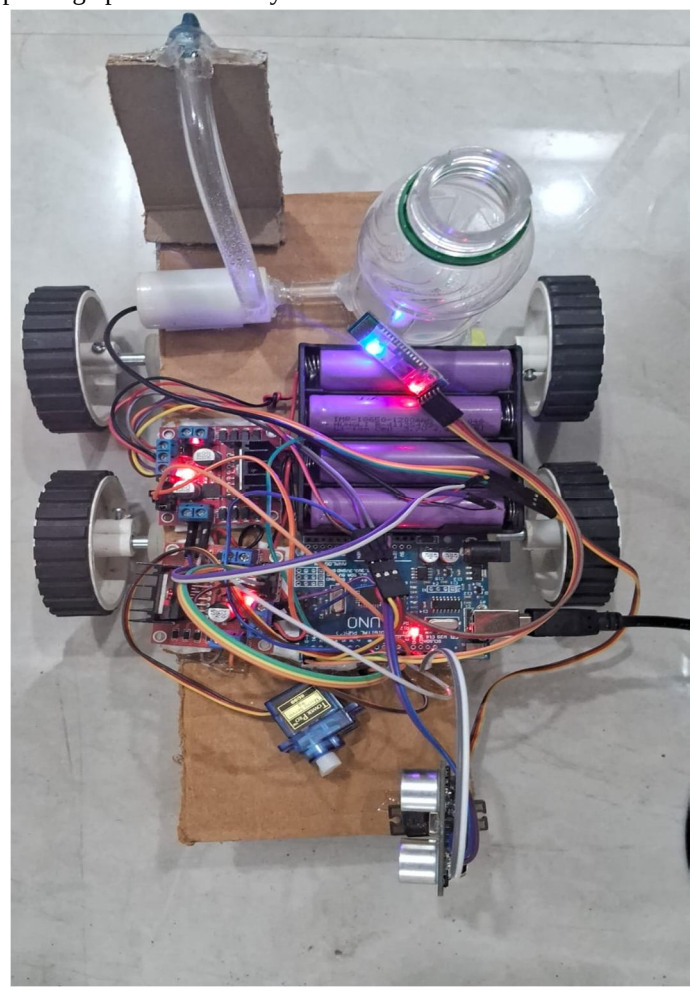


FIG: Result

V. CONCLUSION

The proposed anti-terrorism robotic system presents an effective and reliable solution for reducing human risk in hazardous and conflict-prone environments. The robot is designed using an Arduino Uno based control system integrated with Bluetooth communication, motor driver circuitry, obstacle detection sensors, and a water pump cannon mechanism for crowd-control and emergency operations. The developed system is capable of remotely controlled movement, obstacle detection, and real-time operational response, making it suitable for defence and security-related applications[7].

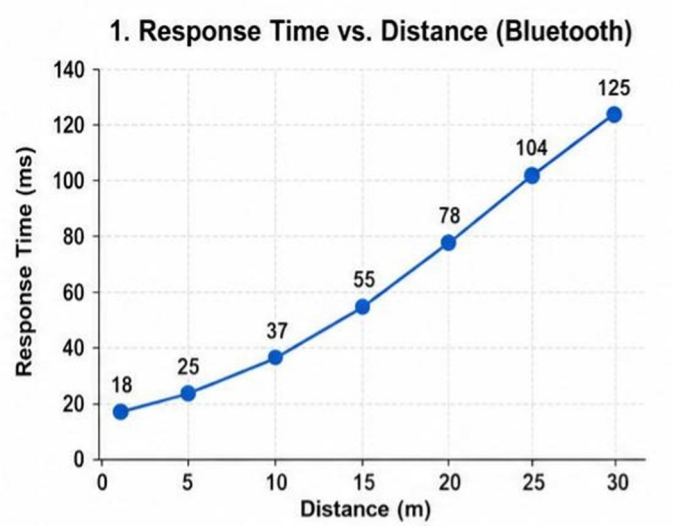


FIG. 2: Response Time vs Distance

The integration of wireless communication and intelligent control enhances the operational efficiency of the robot while minimizing direct human involvement in dangerous situations[8]. The use of IR sensors enables safe navigation by detecting obstacles during movement, whereas the water pump cannon provides a non-lethal mechanism for crowd management and emergency handling[9]. The robotic platform can be further enhanced by incorporating advanced technologies such as IoT communication, autonomous navigation, GPS tracking, artificial intelligence, and longrange wireless systems.

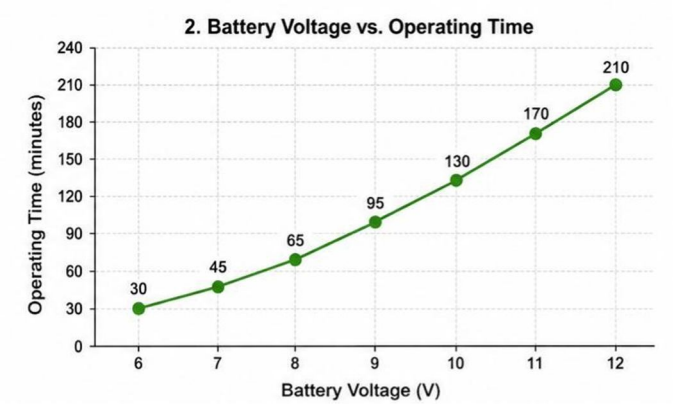


FIG. 3: Battery Voltage vs Operating Time

Overall, the developed robot demonstrates the potential of robotic automation in military surveillance, disaster management, rescue missions, industrial safety, and counterterrorism operations. The system contributes toward improving public safety, reducing human casualties, and increasing operational effectiveness in critical environments.

VI. FUTURE SCOPE

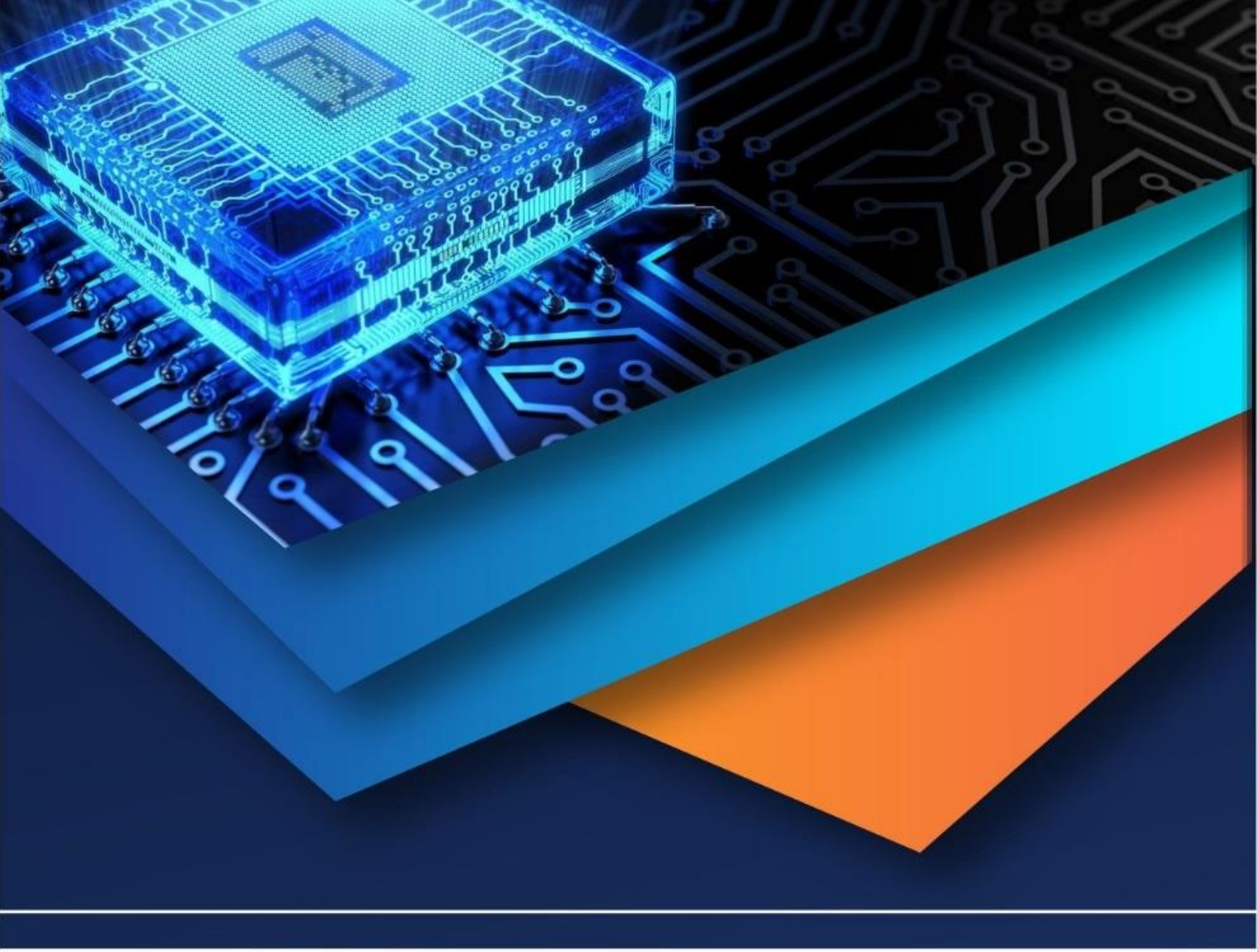
1) Integration of IoT technology for long-range remote monitoring and control.
2) Addition of GPS tracking system for accurate real-time location identification.
3) Implementation of Artificial Intelligence (AI) for autonomous navigation and smart decision-making.
4) Installation of live camera modules for improved surveillance and real-time video transmission.
5) Use of advanced sensors to enhance obstacle detection and environmental monitoring.
6) Upgradation of the robot's body for better performance in harsh and hazardous environments.
7) Expansion of applications in military operations, disaster management, and public safety missions.
8) Development of a more energy- efficient power system to increase operational time.

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