Bomb Disposal Robot with Live Video Streaming

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ABSTRACT

The main objective behind this Project is to develop a robot to perform the act of surveillance human activities using wireless night vision camera and Robots can be manually controlled using IOT android application. The robot consists of night vision wireless camera which can transmit videos of the human. The purpose of this robot is to roam around and provide audio and video information from the given environment and to send that obtained information to the user with metal detection. In this project, one can control the robot with the help of mobile. This robot will collect data from remote place and able to send those data to a remote IoT cloud database. We can control the movement of the robot by sending instructions via IOT app from our android phone. a multipurpose Robotic vehicle moves Forward, Left, Right, Backward and Stop directions which can be constrained by ESP32 In proposed system we are going to designed a low-cost Microcontroller Based Android controlled Robot. The robot will move forward, backward, left and right direction by following the instructions given from the mobile. This system can be helpful for various purposes. Our project aims to provide a robotic vehicle equipped with a wireless camera having night vision capability for remote monitoring/spying purposes with metal detect alerts. The night vision camera allows for transmitting real time night vision video even in dark environments. Whatever is recorded by the camera can be viewed in PC for reference.

Keywords: Robotic Surveillance, Wireless Night Vision Camera, IoT Control, Metal Detection, ESP32 Microcontroller.

1. INTRODUCTION

Our project focuses on developing a robotic vehicle integrated with a wireless camera that supports night vision, aimed at enabling remote surveillance and spying. The night vision capability ensures real-time video transmission even in complete darkness. The video footage captured can be viewed on a computer for monitoring purposes. This system is particularly helpful in military operations, anti-terrorism activities, and other high-risk zones. It may also be deployed in forests or harsh terrains where it is difficult for people to navigate during nighttime. The robot can be remotely guided using an Android smartphone, offering simple and user-friendly control. The movement—forward, backward, left, and right—is triggered by commands sent via an Android application. These signals are received by a module connected to an 8051 microcontroller. When the microcontroller gets the command, it activates the motors through a motor driver IC. The robotic unit is controlled effortlessly through any Android phone. It give a convenient interface to operate the bot. The Android device communicates over a reliable IoT connection. At the vehicle's end, an IoT receiver interprets these commands to manage the motion. The camera equipped with infrared technology makes it possible to carry out effective monitoring in areas with no light. This can be used in areas human cannot enter safely. Also it works well in covert operations during night.

Cloud robotics is a rapidly developing area that combines the strengths of cloud computing with robotic systems. In this study, a system has been designed using an autonomous robot capable of sensing various environmental parameters like temperature, humidity, air quality, and GPS data, which are then uploaded to the cloud for storage. The robot is operated by an Arduino microcontroller and uses an ESP-CAM module to interact with the cloud. A private cloud infrastructure is established through OpenStack, offering Infrastructure as a Service (IaaS) for data handling. The gathered information is stored on a centralized cloud server to monitor changes in the environment at the targeted location.

2. LITERATURE REVIEW

After reviewing numerous research papers and articles, we identified several that proved valuable in shaping and improving our project design. In the paper Military 2*020* Spying Robot by Sarmad Hameed, Muhammad Hamza Khan, and Naqi Jafri, it is emphasized that carrying out massive operations in war zones is highly dangerous. In border areas, it becomes difficult for soldiers to simultaneously protect themselves and monitor enemy activities. In such scenarios, deploying a robot becomes a more efficient and safer alternative, potentially replacing human soldiers in certain tasks.In Spying Robot with Night *Vision Camera* by Aaruni Jha, Apoorva Singh, and Ravinder Turna, the authors describe how a robot transmits signals to an RF receiver via a transmitter from a base station. The robot captures real-time videos, including in darkness, due to the presence of LED lights. These lights are discreet enough to go unnoticed by enemies, allowing covert recording in sensitive regions. Similarly, in the work by Priyanka Yadav and Swati Gawhale, they concluded that such robotic systems are effective in wartime for gathering critical intelligence that could potentially disrupt enemy strategies. By analyzing the collected data, defense personnel can prepare adequately and respond effectively to unforeseen attacks.

When it comes to robot navigation, the challenges are generally categorized into global and local navigation, based on the environmental knowledge available. In global navigation, a complete map of the environment is known in advance, allowing the robot to plan a path that avoids obstacles. For instance, one method uses predefined maps to calculate a suitable route. In contrast, local navigation operates under uncertainty or partial knowledge, relying on sensors to detect surroundings and avoid collisions in real-time.

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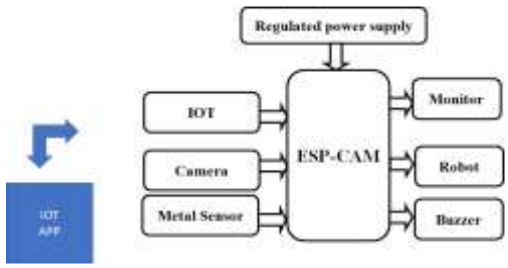
The artificial potential field method is a widely recognized approach for obstacle avoidance. Krogh introduced a generalized potential field model, while Kilm and Khosla applied harmonic potential functions. Additionally, Krogh and Fang explored dynamic sub-goal generation using real-time feedback. Over the years, the potential field method



(PFM) has become increasingly popular in mobile robotics. The concept of imaginary forces guiding a robot was first suggested by Andrews and Hogan, as well as Khatib. In these frameworks, obstacles exert repulsive forces and the goal exerts an attractive force. The combination of these forces determines the robot's path.These techniques has been proven to be very effective in real-world navigation challenges. However, sometime the robot may get trapped in local minima due to conflicting forces. Research is still ongoing to refine this approach and make it more robust for complex environments.

The resultant force **R** dictates both the direction and velocity of the robot's movement. One of the primary reasons for the popularity of this method is due to its straightforward implementation and effectiveness. A paper introduces *Histogram In-Motion Mapping (HIMM)*, an innovative technique for constructing real-time maps while the robot is actively moving. HIMM organizes data into a 2D histogram grid that is continuously updated through rapid motion-based sampling using onboard range sensors. This dynamic sampling strategy is especially effective for handling imprecise and noisy data, like those from ultrasonic sensors, while keeping computational requirements low. With fast mapping capability, the robot can immediately leverage this data in real-time obstacle avoidance procedures. This integrated method offers two main advantages: quick and precise mapping, and secure navigation toward a target destination.

Real-time obstacle detection is one of the core challenges in ensuring the functionality of mobile robotic systems. Most robots include some form of collision prevention, ranging from basic techniques that simply halt the robot upon obstacle detection, to more advanced systems that allow the robot to reroute around the obstacle. The latter requires a more sophisticated logic, since it considers the size and shape of objects in its path. In the proposed system, ultrasonic sensors are repeatedly scanned while the robot is in motion. When an object is detected through an echo, the related grid cell's value is increased. A stationary object will eventually register a high value in a specific grid location, while random errors result in sporadic low readings and does not accumulate significantly. Despite the known inaccuracies of ultrasonic sensors, this technique results in a dependable model of the robot's surroundings.

The Internet of Things (IoT) has various definitions, but at its core, it refer to a system where devices communicate with each other using machine-to-machine (M2M) protocols. This interaction allows the seamless collection and transmission of data. IoT has already led to automation across numerous industries and has made the collection of large-scale data more accessible. Regarded as a key element of the Fourth Industrial Revolution, IoT is already being used in smart parking, precision farming, and efficient water resource management. Extensive research has also explored IoT's potential in developing intelligent infrastructures such as traffic flow reduction, bridge monitoring, accident-prevention vehicles, and smart electrical grids. Even though these sectors differ from healthcare, they confirm the potential of applying IoT principles in medical domains as well. Existing frameworks from various industries have shown that tracking devices remotely while compiling and reporting real-time data is not only feasible, but also practical. This offer a solid foundation for developing intelligent, IoT-driven healthcare applications in future.

3.METHODOLOGY / SYSTEM DESIGN

For our bomb disposal robot project, we adopted a systematic and hands-on methodology, combining mechanical, electrical, and software components into a cohesive system designed for reliable remote operation and live video streaming. We began by conceptualizing the overall structure of the robot, sketching initial design layouts for the chassis, mobility system, and robotic arm. Using these sketches as a guide, we fabricated the base of the robot with a robust metal frame, cutting and assembling the parts ourselves to ensure the platform was sturdy and could handle uneven or unpredictable surfaces during field operations. For mobility, we installed tracked wheels powered by two high-torque DC gear motors, which were mounted on custom motor brackets and connected to a motor driver module we configured and tested for smooth forward, backward, and turning movements. The robotic arm, which we designed and built from lightweight materials, was equipped with multiple servo motors providing precise articulation to grasp and move suspicious objects. Each servo motor was carefully wired and programmed to respond to control signals sent from the main Arduino microcontroller. To integrate live video streaming, we selected and mounted an ESP32-CAM module at an elevated position on the robot, ensuring it provided a clear and unobstructed view of the surroundings. This camera module was programmed to stream real-time video over a Wi-Fi network, allowing the operator to view the feed on a smartphone or computer screen. For controlling the robot remotely, we used a joystick interfaced with the Arduino, which was programmed to interpret the operator's commands and send corresponding signals to the motor driver and servo controllers. The entire system was powered by a rechargeable battery pack, and we custom-built a power distribution setup with voltage regulators to ensure each component received stable and appropriate power levels. As part of the system design, we also focused on securing all wiring neatly within the chassis to prevent interference or damage during movement. After assembly, we conducted multiple test runs in controlled environments, monitoring the robot's ability to traverse different surfaces, manipulate objects using the robotic arm, and transmit clear and stable live video. Our approach ensured that every aspect of the hardware and control system worked in harmony, resulting in a fully functional bomb disposal robot capable of safe and efficient remote operation.

In the hardware and system design of our bomb disposal robot project, we implemented a centralized control architecture based around the **ESP32-CAM module**, which acted as the brain of the system and integrated multiple hardware components for effective bomb detection and disposal operations. At the core of the system, we connected a **regulated power supply**, which we designed and configured to provide stable voltage and current levels, ensuring the reliable operation of all connected components without fluctuations or power loss during operation. From the ESP32-CAM, we established connections to several key modules. One connection was made to an **Internet of Things (IoT) interface**, which we programmed and configured to transmit sensor data and video streams to a dedicated **IOT App**, allowing the remote operator to receive real-time updates and control signals. The **camera module** on the ESP32-CAM provided continuous live video streaming, giving the operator a clear view of the robot's surroundings and potential threats, enhancing situational awareness and enabling precise control from a distance.

We also integrated a **metal sensor** into the system, which we installed and wired directly to the ESP32-CAM to detect the presence of metallic objects or explosives. This sensor's output was used to trigger specific responses in the system, such as activating the **buzzer module**, which we configured to emit an audible alert whenever a suspicious object was detected, notifying both the operator and any nearby personnel. Additionally, we established direct control pathways from the ESP32-CAM to the **robot movement system**, which consisted of tracked wheels driven by DC gear motors. This allowed us to send movement commands from the remote operator through the IOT App, processed by the ESP32-CAM and translated into precise motor actions. To provide a visual interface at the control station, we connected a **monitor** to the system, which displayed the live video feed and real-time data from the camera and sensors, giving the operator an integrated view of the robot's operations and environment.

Throughout the project, we ensured that each module was properly connected and tested to ensure seamless communication and coordination within the system. The flow of information from the **regulated power supply**, through the **ESP32-CAM**, and to each functional component such as the camera, metal sensor, buzzer, robot actuators, and monitor was carefully optimized to minimize delays and maximize reliability. Our design allowed the operator to control the robot remotely via the **IOT App**, receiving immediate video feedback and alerts from the system, making our robot a capable and efficient solution for hazardous operations like bomb detection and disposal.

4.HARDWARE DESCRIPTION

In our project, we focused on constructing a sturdy and reliable hardware system for our bomb disposal robot, making sure that each component was carefully chosen and assembled to meet the needs of hazardous environment operations. We began by designing the robot's base using a **metal chassis**, which we personally cut, drilled, and assembled to ensure it provided both stability and durability for the platform. To ensure mobility over rough surfaces like rubble and uneven ground, we installed **tracked wheels** powered by two **DC gear motors**, which we mounted securely using custom brackets we fabricated. These motors were connected to a **motor driver module**, which we configured and tested to provide smooth and responsive movement in all directions. For the manipulation of suspicious objects, we built a **robotic arm** from scratch using lightweight aluminum and plastic components. This arm was fitted with multiple **servo motors** that we programmed and calibrated to achieve precise movements, allowing the robot to lift, grip, and maneuver objects as required. On the top of the robot, we mounted an **ESP32-CAM module**, which we integrated into the system to provide a live video feed. We powered the entire system using a **rechargeable battery pack**, and we designed and soldered a **custom power distribution board** to ensure that voltage was properly regulated for each component. The control system was built around an **Arduino UNO**, which we connected to the motor driver and servos using clear and organized wiring that we hand-soldered and tested. To ensure smooth communication between the operator and the robot, we configured a **Wi-Fi network**, allowing real-time video streaming from the ESP32-CAM to the operator's device and control signals from the joystick to the robot. Each piece of hardware was physically installed, secured, and tested by us, ensuring that the robot could perform effectively in the field. Our hands-on work with the mechanical assembly, electronic wiring, and system integration resulted in a fully functional bomb disposal robot capable of remote operation and live video streaming.

5.Complete Development Process and System Functionality

The development process of our bomb disposal robot was structured in several critical stages, starting from initial design conceptualization to complete hardware and software integration. We first defined the system requirements, focusing on creating a robot capable of safe, remote-controlled operations with live video streaming and real-time metal detection. Using this blueprint, we fabricated the mechanical structure, ensuring durability and stability through a precisely cut and welded metal chassis. We integrated a high-torque motor system to drive the robot's movement, controlled via a motor driver connected to an Arduino-based microcontroller. The robotic arm, built from lightweight materials and fitted with multiple servo motors, was designed for accurate object manipulation. The ESP32-CAM module was configured to provide seamless live video streaming to the operator's monitor, while a metal sensor was wired to the microcontroller to trigger an audible alarm through a buzzer upon detecting metallic objects. The entire system was powered by a regulated battery supply that we assembled, ensuring continuous operation and safe voltage levels. Remote control commands were sent through an IoT app, with signals processed by the ESP32-CAM to control movement and robotic arm actions. Throughout the development, we conducted extensive testing to refine the system's responsiveness, video clarity, and sensor accuracy, resulting in a complete and functional robot capable of assisting in high-risk bomb disposal operations.

The entire project revolved around the goal of creating a reliable and remotely controlled bomb disposal robot that could provide live video streaming capabilities, ensuring the safety of personnel while maintaining precision in handling hazardous situations. To achieve this, we started by designing and fabricating a durable and stable robotic platform equipped with a tracked wheel system, which was selected for its ability to traverse rough and uneven terrain commonly encountered in bomb disposal scenarios. Once the mechanical framework was completed, we integrated a sophisticated robotic arm featuring multiple joints, allowing for a wide range of movements and enabling the robot to delicately handle and manipulate suspicious objects from a safe distance. A major highlight of our system was the inclusion of a compact wireless camera module, which provided continuous and real-time visual feedback to the operator. This was critical not only for precise control of the robotic arm but also for assessing the surrounding environment and making informed decisions during bomb disposal operations. The control system was built around an Arduino microcontroller, which acted as the brain of the robot, seamlessly processing joystick inputs to manage motor control for navigation as well as servo control for the arm. To facilitate real-time video streaming, we configured a Wi-Fi-based communication protocol that transmitted video data from the camera module to the operator's control interface, accessible through a web browser. This setup allowed for smooth and uninterrupted visual monitoring of the robot's actions, even when it operated at distances of up to 50 meters.

The system underwent rigorous testing in controlled environments where it successfully navigated challenging surfaces such as gravel, concrete, and uneven flooring, demonstrating both its mechanical resilience and its stability in maintaining a high-quality video feed. Additionally, the robotic arm was tested to pick up, move, and place lightweight objects with precision, proving its capability for delicate handling tasks. Throughout the project, we focused on optimizing the coordination between movement and video feedback to ensure that the operator could react promptly to dynamic situations. The final system not only met our initial goals of safe and remote bomb disposal operation but also demonstrated the potential for further development into more advanced systems, incorporating features such as object recognition and autonomous navigation in future iterations.

6.Project Summary

In this project, we undertook the design and development of a bomb disposal robot equipped with a live video streaming system, aimed at enhancing operator safety and efficiency during hazardous missions. Our approach began with constructing a sturdy robotic platform, using a metal chassis and a tracked wheel system to ensure stability and ability across uneven terrains. The robotic arm was designed with multiple degrees of freedom, powered by servo motors, to perform delicate handling tasks like grasping suspicious objects or defusing mechanisms. To facilitate remote monitoring and decision-making, we integrated a compact camera module with Wi-Fi capabilities, enabling the transmission of real-time video to a control station. This live stream allowed operators to assess threats visually and control the robot's actions from a safe distance. The robot's movements, including navigation and arm manipulation, were controlled using an Arduino microcontroller paired with a joystick interface, while the video feed was accessed via a web interface, supporting responsive and intuitive operation. Throughout the development, we focused on optimizing communication protocols to maintain low-latency video streaming and reliable control signals within the operational range. Field tests demonstrated the robot's ability to traverse challenging surfaces and provide a stable, clear live video stream with sufficient resolution to identify objects and hazards accurately. Overall, this project resulted in a functional bomb disposal robot that combines mobility, precise control, and live video capabilities, offering a safer alternative to manual operations in explosive risk scenarios.

7.RESULTS

7.1 ADVANTAGES

1. Automation of operations.
2. Audio and video monitoring capabilities.
3. Wireless data transfer via Bluetooth connectivity.
4. Robot-assisted surveillance and monitoring.
5. Design is cost-effective and highly efficient.
6. It consumes less power during operation.

7.2 Applications:

- Industrial usage
- security in war zones
- home surveillance systems.

8.CONCLUSION

We are able to move the robot in forward, backward, left and right directions by following commands given through the mobile device, which includes an audio and video surveillance system using a night vision camera. The robot is control by a Bluetooth module that receives directions—left, right, forward and backward—via an Android phone. This setup can be useful in several areas. In this project, we has proposed a smart cloud-based robotic system to observe environmental conditions in distant locations. A working prototype was build and tested within our campus to show the usefulness of the idea.

8.1 Future Scope

In future, the system could be enhanced to include gas leakage detection. The module will use a GPS sensor to send the exact location of the leak to an IoT-based system. We use IOT platfrom to monitor, recieve and display gas leakage alerts and it's position.

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