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Sentinel: Integrative Robotic Surveillance with Remote Monitoring and Action

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Abstract— *This project aims at constructing a robot that can enter the surveillance area, to take manual action wherever required and to use an interruption counter-based odometer for calculating the distance covered in any direction. The robot also aims to use additional features such as obstacle sensors, poisonous gases sensors, metal detector, that can provide more detailed information to the security personnel about the place using which they can decide whether it is safe to enter the surveillance place or not. The whole robotic process aims to monitor and control from a remote display cum control system, where live video from the robot can be seen as well as information about all the other conditions can also be received in real time. The robot also aims to serve multiple applications.*

Keywords— *The Arduino Uno R3 microcontroller (ATMega 328), gas detector, a gun simulator, Wi-Fi module (ESP8266), a camera (ESP32), IR sensors.*

I. INTRODUCTION

Technology has led to a notable and fast development in the robotics and automation space, which includes many diverse fields. A subject under continuous, systematic observation or Oversight, such as one who is being held in custody or is being investigated, is referred to as being under surveillance. Thus, areas such as public areas, workplaces, industrial sites, and border crossings are the ones that require monitoring the most. It is mostly used for tracking activities. Monitoring can be done in both indoor and outdoor settings with the help of humans and embedded technologies, such as robots and other automation equipment.

Limitations of Existing Systems:

Restricted Communication Range: Existing robots often rely on technologies like RF, Zigbee, or Bluetooth, limiting their operational area due to short signal range and potential for dropouts.
Manual Camera Control: Many systems require manual manipulation of the camera, which is cumbersome and time-consuming, especially for a moving robot.
Limited Functionality: Existing systems are frequently designed for specific tasks like surveillance, hindering their adaptability to diverse situations.
Proposed Improvements for Enhanced Functionality
Single-purpose design: Existing systems lack versatility, being limited to specific tasks.

Benefits of Proposed System:

Extended Range and Secure Communication: Utilizing Wi-Fi modules with Arduino can potentially overcome range constraints and offer a more secure communication channel for robot operation.
Flexible Control Modes: The system can be designed to allow for both manual and automated control modes, providing operators with greater flexibility based on the situation.
Cost-Effective Design: By leveraging Arduino microcontrollers, the overall system complexity and cost can be significantly reduced.
Multiple-Application System: This system can be used in multiple areas such as combat zone, surveillance areas, military zones. Etc which describes it is a multi-purpose application robot.

II. LITERATURE SURVEY

In the robotics and automation sphere, which encompasses many different fields, technology has brought about a significant and dynamic development [1]. A person, organization, etc. under constant, methodical monitoring or supervision especially while they are being held in prison or are the subject of suspicion is said to be under surveillance. Therefore, regions like border crossings; public spaces, workplaces, and industries are where monitoring is most needed. It is mostly employed for activity monitoring. Both humans and embedded technologies, such as robots and other automation equipment, can assist in the act of monitoring in both indoor and outdoor environments [2-4][8].

A robot is just an automated electronic device that can carry out preprogrammed tasks, taking the place of human labor, producing incredibly exact results, and effortlessly getting over human constraints. Consequently, one of the greatest advances in robots is the replacement of people in surveillance domains. The Arduino Uno R3 microcontroller (ATMega 328) is the brains behind the robot [6-7][15-17][19]. The robot also has DC motors, a poisonous gas detector, a gun simulator, a battery, Wi-Fi module (ESP8266), a camera (ESP32), and a variety of sensors, including IR sensors for obstacle detection and IR sensors for automatic distance measurement, are also included in this robot [3-7]. The robot may be controlled manually or automatically. With the aid of the user app interface and wi-fi module, the user end and the robot may communicate [10][14][18][20].

III. METHODOLOGY

The user area and the robot section make up the two main components of the system. In this way, the user section can communicate with the robot end using a laptop or mobile

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device. Therefore, as opposed to individuals who utilize a traditional fixed computer system, the user section can be more portable by utilizing a laptop or mobile device [10][14][18][20]. There are three methods to execute the communication: radio frequency (RF), Bluetooth, or Zigbee devices. However, Bluetooth has a shorter range than RF technology. Therefore, we may move ahead and connect the user section with the internet, which is the basic notion of the Internet of Things, in order to realize the idea of widening the range [1-5][10]. An Arduino microcontroller, which is a crucial component of the robotic vehicle, is used at the robot end. It is mounted on the robot's body. DC motors with a rpm of 30 are attached to the wheels beneath the chassis. Every motor needs a 12 volt supply, which may be obtained from an external battery source

Relay drivers are used to interface the motors with the Arduino. The robot is controlled in the proper directions by programming the microcontroller using IDE software. This is how it operates in the manual mode. Infrared sensors and other sensors are also employed for automatic distance measuring and obstacle identification.

Hardware/Software Required:

There are several necessary hardware components needed for this surveillance robot to operate properly. The following are the primary parts utilized in our project, along with information on their features and purposes:

Arduino Microcontroller:

The robot's central processing unit is an Arduino Uno microcontroller, a popular selection due to its ease of use. This programmable device, built around the AtMega328 chip, acts as the robot's brain. It receives commands sent by the user over the internet, processes them based on pre-written code, and controls the motors responsible for the robot's movement. To enable wireless communication, an ESP8266 Wi-Fi module is integrated with the Arduino.

DC Motors:

The driving force behind the robot's movement comes from DC motors. These are essentially rotary electrical engines that convert the supplied direct current (DC) power, typically at 12V, into mechanical rotation. The specific motors chosen for this project operate at a speed of 30 rotations per minute (RPM), allowing for controlled movement of the robot.

Infrared Sensor:

The robot utilizes an infrared sensor to perceive and understand its surroundings. This sensor functions by emitting infrared radiation and detecting the reflections bouncing back from objects or the environment. With a typical operating range of 2 cm to 30 cm and a voltage requirement of 3V to 5V, this sensor is strategically placed on the robot to identify obstacles or edges along its path.

By incorporating a clever design element, the infrared sensor can also be used to measure the distance travelled by the robot. A small hole can be strategically placed in one of the robot's wheels. As the wheel rotates, the infrared light will periodically pass through this hole and be detected by the sensor on the opposite side. By counting the number of times the light is detected per revolution and multiplying by the known wheel circumference, the system can estimate the distance travelled since the last detection.

Power Supply:

The robot's movements are fuelled by two 6V lead-acid batteries connected in series to provide a combined 12V power supply for the motors. This same power source also extends to the Arduino and other components that require electricity to function effectively.

Wi-Fi Module:

To establish wireless communication capabilities, the robot incorporates an ESP8266 Wi-Fi module. This cost-effective and self-contained chip integrates a TCP/IP protocol stack, essentially enabling any microcontroller to access a network. Its compact size and portability make it ideal for integration with the Arduino, granting the robot Wi-Fi functionality.

Poisonous Gas Sensor:

The robot uses a MQ2 gas sensor integrated to detect the presence of various gases, including explosive or flammable ones. Its ability to sense changes in gas concentration can make the robot invaluable for sniffing out leaks or ensuring safety in hazardous environments.

Metal Detector: The robot has a metal detection circuit built around the CD4011 integrated circuit (IC), the robot can be equipped to locate metallic objects hidden underground or within obstacles. This functionality could prove beneficial in search and rescue operations or for landmine detection tasks.

Arduino Software Development Environment (IDE):

The robot's code is created on Arduino IDE, a free and user-friendly software for Windows, Mac, and Linux. This open-source platform provides a text editor (for writing code) and tools to upload the code (called sketches) to the Arduino board, allowing us to program the robot's movements and sensor interactions.

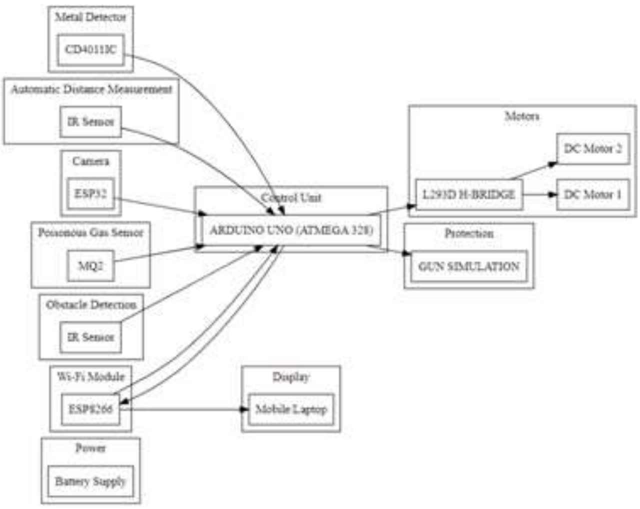

Fig. 1: Block Diagram

Block Diagram

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The method surveillance robot is implemented which is a multi-application robot. The robot can do several activities such as Poisonous Gas Detection, Metal Detection, Automation Distance Calculation, and live streaming.

Step1: Download Serial Wi-Fi Terminal App:

- Begin by accessing the appropriate app store on your Wi-Fi-enabled device (such as a Smartphone or tablet).
- Search for and download a serial Wi-Fi terminal application.
- Once downloaded, install the application on your device.

Step2: Connecting to Wi-Fi module

- Open Setting on the external controlling device.
- From setting → Wi-Fi →select the Wi-Fi of Wi-Fi module and connect with the appropriate credentials.

Step3: Adding device on Serial Wi-Fi Terminal

- Open the Serial Wi-Fi terminal Application and move to add devices section.
-
- Click on the plus symbol and fill all the requires details to connect to the device such as Name, IP address, and port number.

Step4: Give the commands to move the Device

We can give several commands to the device so we can perform several activities with the device.

All the commands are defined in the code to have specific function.

- F (Forward): Initiates forward movement of the device.
- B (Back): Triggers backward movement of the device.
- L (Left): Commands the device to turn left.
- R (Right): Instructs the device to turn right.
- S (Stop): Halts the device's movement instantly.
- G (Gun Sound): Simulates a gunshot sound effect.
- (Off Gun Sound): Stops the gun sound simulation.
- D (Dynamic Movement): Activates dynamic movement mode. In this mode, the device moves forward with strain. If any interruption occurs, such as obstacle detection, metal detection, or detection of poisonous gas, the device stops immediately and provides the distance travelled from the starting point.

These commands provide intuitive control over various functionalities of the device, enabling seamless operation and interaction with the environment.

Fig. 2: Add devices

Fig. 3: Entering credentials

Step 5: Connecting to camera for live Streaming

- Connect the pin from the camera (ESP32) to the vacant port on the WiFi module.
- Once connected, the WiFi module will assign an IP address to the camera.
- Enter this IP address into the address bar of a web browser on any device.
- Access the live streaming feed from the camera directly in the web browser window.
- Control and monitor the live streaming feed from the camera through the browser interface, including additional functionalities such as pan, tilt, zoom, and recording.

Fig. 4: Live streaming

IV. RESULTS

In our project, we've integrated a metal detection circuit, Poisonous gas sensor, Obstacle detection, a camera for live streaming. To simulate this scenario, we issued the "D" command, prompting the robot to move forward. Metal detection system designed to identify metal objects obstructing the path of the robot. Obstacle detection system designed to identify obstacles, such as walls, in the path of the rover. The MQ-2 gas sensor relies on its ability to detect changes in

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conductivity when exposed to target flammable gases.

Fig. 5: Metal Detection

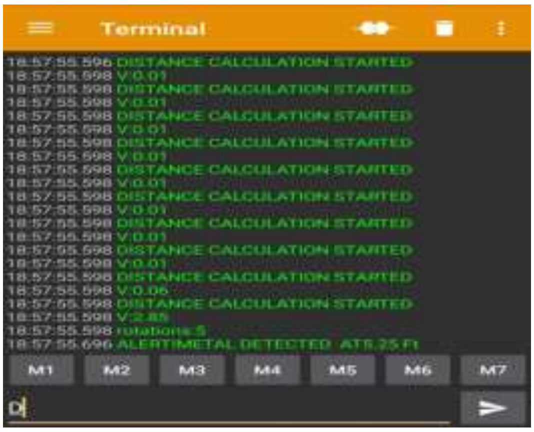

Fig. 6: Distance calculated for Metal Detection

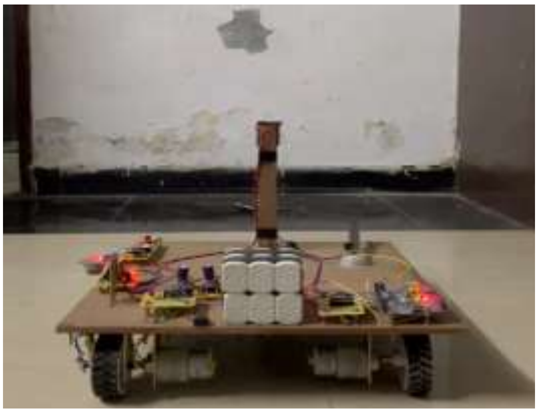

Fig. 7: Obstacle Detection

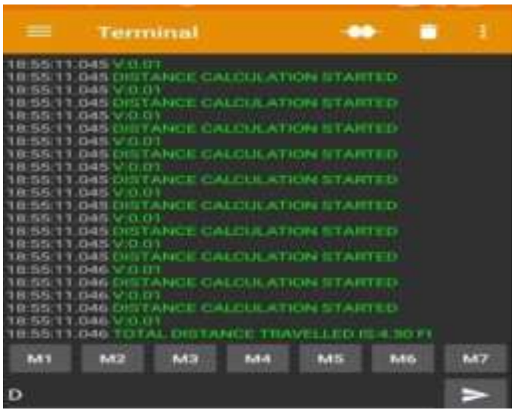

Fig. 8: Distance calculated for Obstacle Detection

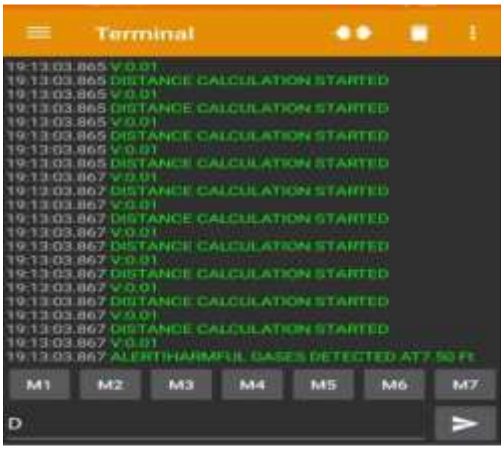

Fig. 9: Distance Calculated for Poisonous Gas Detection

V. CONCLUSION

In summary, our multi-application project embodies a comprehensive solution in robotics and sensor technology, catering to various real-world challenges. By integrating obstacle detection, poisonous gas detection, metal detection, live streaming, and automatic distance measurement capabilities, our system offers a versatile tool for navigating diverse environments effectively. The incorporation of obstacle detection mechanisms ensures smooth traversal through challenging landscapes, while the poisonous gas detection system promptly identifies and alerts users to potential hazards. Additionally, the metal detection functionality enhances situational awareness, while live streaming enables remote monitoring and surveillance. A notable aspect of our project is the automatic distance measurement feature, triggered by any interruption such as obstacles, metal objects, or poisonous gases. This functionality adds flexibility to our system, making it adaptable to diverse scenarios, from industrial operations to search and rescue missions. Moreover, our project's applicability extends to military operations, where the robust capabilities of our system can provide invaluable support in reconnaissance, surveillance, and threat detection missions. Overall, our project serves as a practical solution for addressing multifaceted challenges in real-world environments, offering enhanced safety and efficiency across various industries and applications.

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