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IOT BASED ANDROID CONTROLLED SURVEILLANCE ROBOT

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Abstract - *The rising need for secure and remotely controlled monitoring systems has raised the significance of intelligent surveillance systems [7]. In this paper, an IoT-based Android-controlled surveillance robot for real-time monitoring systems is discussed and demonstrated. The proposed work uses the ESP32-CAM module to stream real-time video streaming over the internet [1],[3],[6]. The Node MCU ESP8266 enables wireless communication between the robot controller and the Android app interface [2],[5]. The ultrasonic sensor enables the robot to detect barriers and navigate safely to the target destination [7]. The metal detector sensor enables the robot to detect metal objects in the environment and respond accordingly. The GPS module helps to track the real-time location of the robot. The robot can be controlled from any corner of the world using the Android smartphone device. The proposed robot systems can be applied effectively to dangerous and restricted areas [7],[8].*

Key Words: **IoT, Surveillance Robot, ESP32-CAM, Android Application, Wireless Communication, Obstacle Detection, GPS Tracking.**

1.INTRODUCTION

Recently, the demand for efficient and effective surveillance solutions has risen with increasing security concerns in both public and private sectors [7]. Existing surveillance solutions involve continuous human observation, which may not always be safe and efficient [7],[8], especially at security-critical sites. To overcome these drawbacks, IoT-based surveillance solutions have attracted considerable interest [2],[7]. These solutions support real-time observation and remote control with the help of internets connectivity. Robotics with embedded technology helps perform surveillance tasks at sites that are either difficult to reach or not safe for human entry [1],[6]. Wireless communication and sensing technologies together make the system more flexible and efficient. Visual observation with the help of cameras is an important component for providing vision support for decision-making purposes [3], [5]. Mobile solutions further make user interaction easier, allowing control and command from any corner of the world. Obstacles-sensing sensors assist safe movements for robotics. Position tracking provides an added benefit of security and accuracy for observation purposes. The proposed system will work on designing an effective and affordable surveillance robotics solution.

1.1 MOTIVATION

The need for implementing this system arises out of the fact that in environments where the presence of a human being might be dangerous or difficult to accomplish, there is a need for a safe and efficient surveillance system. In fact, the normal system of surveillance done in fixed environments requires a lot of manual observation and is therefore not so reliable or useful in a dynamic or dangerous setting like a surveillance mission or a restricted area inspection process or in a crisis or disaster scenario where continuous observation might be necessary. With improvements in IOT and mobile technology and its ability to implement intelligent robot platforms with real-time observation and controlling abilities, it is possible to work out a low-cost portable and friendly robot for surveillance purposes as a motivation to this project.

Need for the System

- Surveillance at a Distance in Dangerous Surroundings
- A great need exists for the development of monitoring systems capable of functioning in danger or non-accessible zones with minimal threat to human operators.
- Real-Time Monitoring and Control Live video streaming with continuous monitoring and control through an android application are necessary for rapid decision-making. Cost-Effective and Scalable Solution The current state-of-the-art surveillance systems available may be costly; hence, there is a need for development in IoT-based robotic surveillance that is cost-effective.

1.2 Objectives

This project embodies the development of an IoT-based Android-controlled surveillance robot that shall be able to monitor everything in real time and work remotely with wireless communication. The system shall thus provide live video streaming, safe navigation, accurate location tracking for improving efficiency in surveillance. Reducing human involvement in risky environments by embedding

hardware, sensors, and mobile application control becomes the ultimate aim of this project to attain reliable and cost-effective performance.

The main goals of the system are:

- It should also be designed to remotely control a robot that is capable of transmitting live videos by using IoT technology.
- To implement obstacle detection and safe navigation for reliable operation in various types of environments.
- This includes, but is not limited to, the facilitation of real-time GPS-based location tracking to effectively monitor and control.

1.3 Literature Survey

Traditional surveillance systems consisted of fixed cameras [7], providing less coverage and the need for continuous human interaction, thus not appropriate for dynamic conditions. As a solution to the limitations, IoT surveillance systems were developed, allowing remote control using the internet. With the advent of robotics, mobile surveillance robots were developed to offer better coverage and less human involvement. In some research works, the concept of wireless cameras, ultrasonic sensors, and live video streaming [1],[3],[6], as well as obstacle detection, was explored, but the system was complex and quite expensive. Recently, research has been done on the usage of the Global Positioning System for location tracking [6],[7] and control interfaces on Android, but the systems were not fully integrated with various sensing capabilities. From the analysis of various studies, the need for a small, affordable, and multifunctional surveillance robot, capable of video streaming, remote control, obstacle sensing, and location solutions, is required. A solution to the problem has been proposed, incorporating all the sensing capabilities into a single platform.

1.4 Proposed Methodology

The proposed approach purely centers on the design and development of an internet of things surveillance robot. The internet of things surveillance robot is fully capable of real-time surveillance and control. The proposed design incorporates embedded controllers, sensors, and wireless communication modules in a mobile robot. Node MCU ESP8266 acts as the key controller with full functionality of motor controlling, processing of data from sensors, and communication with Android applications. The ESP32-CAM helps in real-time video streaming from the surveillance robot to the user via wireless connectivity. The command from the user accessed via Android applications is processed by the controller to manage and control the movement of the surveillance robot via DC motors. Additional features incorporated in the design include ultrasonic sensors that aid in real-time object detectability and ensure safe navigation of the surveillance robot during movement. A GPS and metal detector sensor helps in real-time location monitoring.

2. SYSTEM DESIGN AND HARDWARE IMPLEMENTAION

The system design of the proposed surveillance robot aims at incorporating hardware components efficiently for the purpose of conducting effective real-time surveillance. This is because the robot is equipped with a mobile platform that facilitates the robot's movement and facilitates the functioning of the different components while the robot is in motion. Additionally, the system is equipped with different components that have been installed in the robot for the purpose of achieving balance while the robot is in motion.

The Node MCU ESP8266 is used as the control unit and is responsible for communication with sensors/motors and Android applications. The communication is carried out via Wi-Fi. An ESP32-CAM module is used at the front of the robot to transmit live videos. The ultrasonic sensor is used for obstacle detection. DC motors are used for movements. They are controlled using a motor driver.

Other modules like a GPS receiver module and a metal detector sensor improve the monitoring capabilities of the system. The GPS receiver module allows for real-time tracking, while the metal detector sensor helps in detecting nearby metal objects. A battery pack provides power for the functionality of all modules. This battery can be recharged, thus facilitating continuous functionality.

2.1 Detailed Circuit of the System

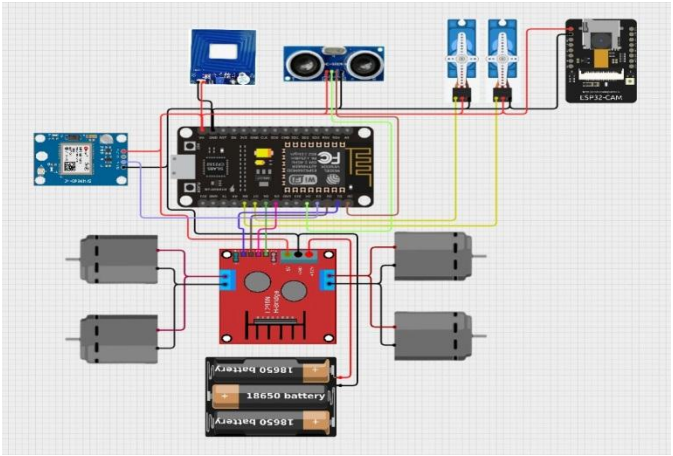

Figure 1: Hardware Connection Diagram

The performance verification of the designed surveillance robot was done under different test conditions to check its robustness. The system was tested in indoor, outdoor, and semi-controlled settings like rooms, corridors, and open areas. Different tested surface conditions like smooth, tiled, rough, and cemented floors were considered for analyzing motion performance. The robot was controlled through a Wi-Fi hotspot/router within stable to moderately stable conditions. Testing of the system was done for a longer period of time to check its performance under continuous conditions. Lighting conditions and different ranges separating the user from the robot were also considered under these tests. The system used a rechargeable battery for power, which was tested under continuous conditions. During the test period, the surveillance robot functioned correctly for commands like moving forward, backward, left, or right directions with less delay. The motion of the robot performed well, and it also behaved correctly while making turns. The braking function performed correctly, which helped the robot to brake properly on command. During continuous tests, it has been observed that there has been less delay in controlling speed and direction. No performance failure has been observed.

2.2 Assembled Surveillance Robot Prototype

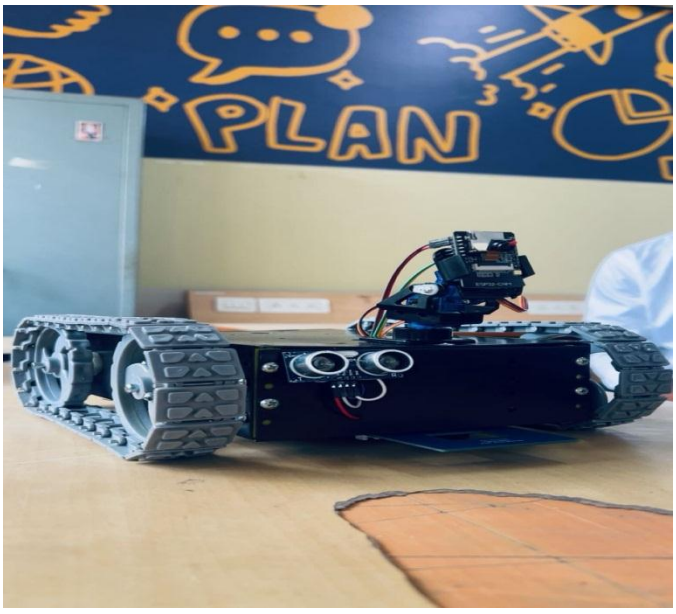

Figure 2: The complete assembled design of the surveillance robot

The above image clearly emphasizes the physical structure of the robot and the placement of key hardware components in the system. The ESP32-CAM module is installed at the front of the robot to perform live streaming, and the ultrasonic sensor is well-installed to detect any obstacles in its way as it travels with its DC motors and power system unit. It also shows the compactness of component placement on the robotic platform, a design that minimizes the size for an entire system and further enhances its mobility. The positioning of the camera at an elevated and forward-pointing view in order to create a wider field of view allows for better monitoring. This sensor placement ensures a position that will not obstruct the robot's operation while detection accuracy is maintained. The hardware balance helps to promote smooth motion by avoiding possible mechanical strains to the chassis. This practical assembly approach supports smooth operation and enhances the reliability of the surveillance robot during real-time use.

3. SYSTEM ARCHITECTURE & BLOCK DIAGRAM

The system architecture of the proposed surveillance robot helps in understanding the coordination of different hardware modules and the user interface that enables the robot to have the ability to be controlled in real time. The system architecture, with the help of the block diagram, indicates that the control signals from the Android application are received wirelessly by the Node MCU ESP8266, which processes the signals, thereby controlling the movement of the robot using the motor driver and the DC motors. At the same time, the ESP32-CAM helps in the live viewing of the surveillance robot, thereby ensuring that surveillance occurs in real time. Signals from the ultrasonic sensor, metal sensor, and GPS sensor help in realizing the capability for obstacle detection, object recognition, and location identification in real time.

3.1 System Block Diagram Of the Proposed Model

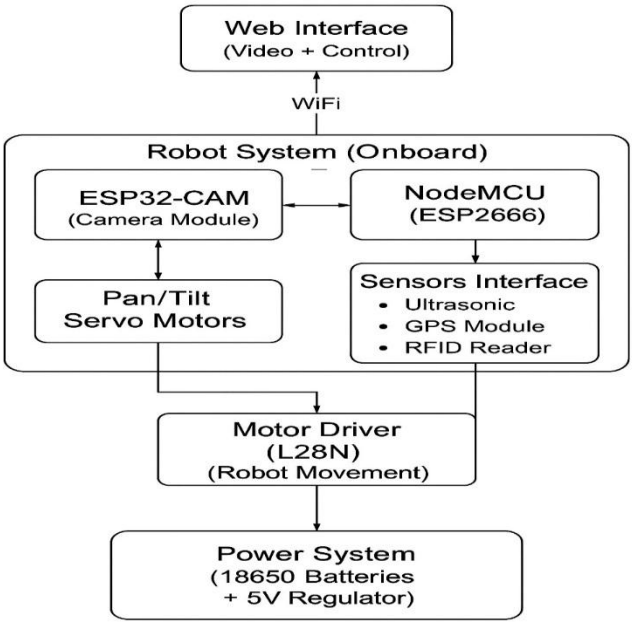

Figure 3: Block Diagram of System

The block diagram represents the functional design of the proposed surveillance robot using the IoT system. The system can be controlled from a distance using a user interface that transmits commands to the Node MCU ESP8266 using wireless communication. The ESP8266 processes the commands and then transmits corresponding signals to the motor driver of the system to control the speed and rotation of the DC motors. The ESP32-CAM helps perform visual surveillance of the system since it enables live streaming of visuals from the system. Other modules of the system include ultrasonic sensors and GPS modules that aid in surveillance since they assist in tracking and sensing obstacles. The system uses a controlled power supply system to provide constant voltage to all components of the system.

4. SOFTWARE IMPLEMENTATION AND CONTROL STRATEGY

The software design of the proposed robot for surveillance via programming ensures proper control, real-time observation, and proper interaction between the human controller and the hardware component of the robot. The controlling algorithm is programmed with embedded programming techniques that handle the tasks of robot motion, processing, and communication functions. The Node MCU ESP8266 develops the primary controlling algorithm that receives tasks from the android application via Wi-Fi communication.

Based on the inputs received from the users, the controller provides suitable control signals to the motor driver in order to control the speed and direction of the DC motors. The data received from the ultrasonic module is processed in real-time to enable and facilitate the detection of obstacles as well as safe navigation. Location information received from the GPS module is constantly updated and provided to the user for tracking purposes. The ESP32-CAM module has a different firmware to enable real-time video streaming.

The Android application developed is essentially the user interface through which the robot could be controlled from a distance and its video output could be displayed in real time. The control system design takes a modular approach by which various activities like controlling movements, video streaming, as well as sensor updates, could be carried out concurrently.

Additionally, the software has the capability of executing several processes at the same time without compromising the performance of the system. Instead, different processes are allocated for motion control, data reception from sensors, and video streaming to facilitate smooth operation. On the control logic part, the strategy placed emphasis on executing user commands at a given instance while continually sensing feedback from sensors to facilitate safe movement. Communication between the robot and control interface has been optimized to eliminate any form of delay, which enhances quick feedback to user commands. Error-handling functions have also been implemented to ensure the system remains stable even during temporary network disruptions. Additionally, the software has a modular design that facilitates ease of modification and addition of new features in the future.

4.1 Android Monitoring & Web Control Interface of the Proposed Surveillance system

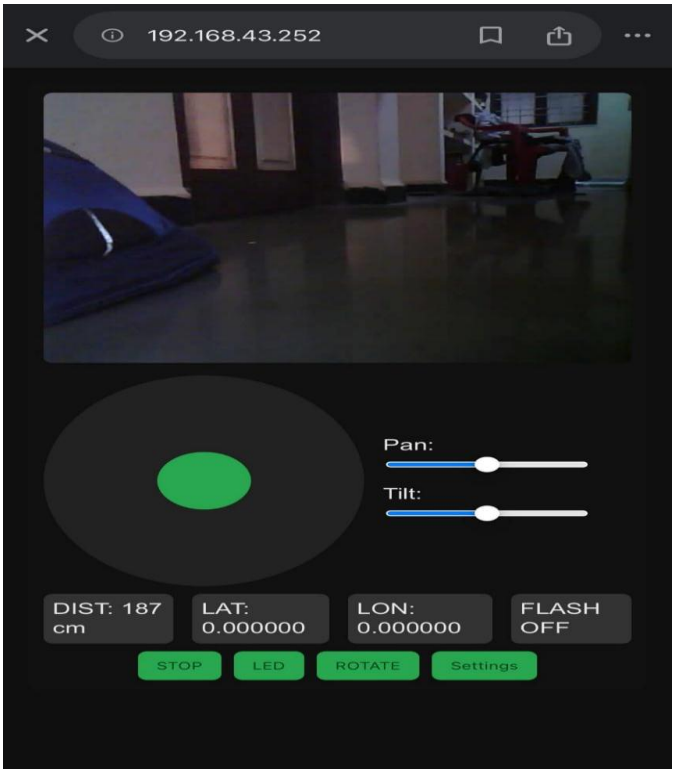

Figure 4: Web control and monitoring

Illustrates the interface used for controlling the surveillance robot as well as the monitoring of the live video output. The interface generates a real-time video feed from the ESP32-CAM module via a web-based control interface. A joystick interface has been incorporated into the system for moving the robot in various directions, whereas sliders are used for the control of the pan-tilt movement of the camera. The interface further provides data related to the sensor readings of the obstacle distance as well as the location data obtained from the GPS module interface. Control buttons are provided for pausing the robot, control of the lighting system, and system settings. Such a system provides a smooth control of the robot from a distance and indicates a proper integration of software with hardware.

5. RESULTS AND DISCUSSION

The software design of the proposed surveillance robot supports effective control and monitoring as well as smooth user and hardware communication. The Node MCU ESP8266 contains the major control program and accepts motion commands from the Android app using Wi-Fi communication. According to the commands accepted by the Node MCU ESP8266, it provides corresponding signals to control the speed and direction of the DC motors using a motor driver. It also processes the sensor values of the ultrasonic sensor in real time to enable safe passage and continuously updates the GPS values for location tracking. The ESP32-CAM works separately with its own firmware to perform the video streaming task. The Android app works as the user interface. The software design performs all the tasks simultaneously, namely motion control, sensor processing, and video streaming. This reduces the response time and ensures stability. The software design also simplifies future development.

6. CONCLUSION

This paper proposed the design and implementation of an IoT-based Android-controlled surveillance robot that could perform real-time monitoring and remote operation. The system was able to integrate embedded controllers, sensors, wireless communication, and a camera module to perform effective tasks related to surveillance. It also enhanced the functionality and reliability with live video streaming, obstacle detection, and GPS-based location tracking. The experimental observation confirmed smooth movements and stable communications along with responsive control in different operating conditions. The modular and cost-effective design makes the proposed system a suitable choice for security monitoring, inspection, and surveillance in environments where human presence can be limited or unsafe. In the end, the results prove that the approach proposed is efficient and practical for modern applications in surveillance.

The developed system shows that it is possible to combine IoT and embedded systems for an efficient and mobile surveillance system. The wireless control system reduces human intervention and increases safety and monitoring efficiency. Combining all modules for sensing increases adaptability of the robot to various situations and conditions. Scalability is easy with this system and it can be modified for various uses. The model can be applied to defense surveillance systems, disaster monitoring systems, and industry inspections with modifications and advancements.

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