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Motion Following Motorized Camera Base

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Abstract: *In the present era, security and surveillance are essential for homes and working spaces. The shortcomings of fixed-camera systems have become apparent in such a scenario. Fixed-camera systems usually create blind spots and need to be installed multiple times, thus raising costs and decreasing efficiency. Our project seeks to overcome these shortcomings by creating a smart, motion-tracing motorized camera system. The concept is to have a single-camera system that can automatically track movement in real time in a 180° field of view. This is done by combining five PIR motion sensors with an ESP32 microcontroller to analyze the data and drive an MG995 servo motor to turn the camera in the direction of the detected motion. The device comes with a USB webcam for real-time video streaming to a PC and relies on the Blynk app to deliver real-time email alerts to users. Through integration of several technologies—motion detection, servo control, and IoT connectivity—our project provides an efficient, cost-effective, and dynamic alternative to traditional surveillance systems*

Keywords: Motion Detection, ESP32, PIR Sensors, MG995 Servo Motor, USB Webcam, Blynk App, Smart Surveillance, Real-Time Tracking, IoT Security, Camera Automation

I. INTRODUCTION

Security is now a fundamental requirement in contemporary society, particularly with the increase in property crime and the demand for more intelligent surveillance systems. Conventional fixed-camera systems employed for observing houses, offices, and public areas are often found wanting because they cannot respond to dynamic movement. These systems normally have narrow fields of view, which lead to blind spots and less comprehensive coverage.

The ″Motion Following Motorized Camera Base″ provides an intelligent and adaptive solution by allowing a single camera to follow motion in real time across a 180° field of view. The system relies on motion detection using multiple PIR sensors, real-time camera movement via a servo motor, and IoT-based notification systems for user alerts. When it senses movement, the camera automatically turns to point toward the direction of motion, eliminating blind spots and ensuring continuous monitoring of the area.

The primary objective of this project is to create and implement a dynamic surveillance system capable of detecting motion via sensor input and automatically repositioning the camera. This improves situational awareness and minimizes the necessity for multiple static cameras.

The objectives of this project are as follows:

- To install a motion detection system using five PIR sensors for optimal 180° coverage.
- To utilize an ESP32 microcontroller to process sensor outputs and control servo motor movements with precision.
- To use a USB webcam mounted on an MG995 servo motor for automatic tracking of detected motion in real time.
- To offer real-time user notifications through LED indicators and send motion alerts via the Blynk IoT platform.
- To create an affordable, mass-producible product that can be used in residential, small office, and smart surveillance applications.

II. LITERATURE OVERVIEW

Smart Surveillance and Motion Detection Systems

Ahmed et al. (2015) emphasized the importance of dynamic surveillance systems in enhancing security, particularly in residential and institutional environments. Their work outlined the shortcomings of traditional CCTV systems, which often leave blind spots due to fixed positions. They proposed integrating motion sensors for smarter tracking.

PIR Sensor-Based Automation:

Singh and Kumar (2018) demonstrated the use of PIR sensors in motion-triggered lighting and alarms. They highlighted the accuracy and low-power benefits of PIR technology, making it suitable for real-time motion sensing applications. Their study served as a foundation for incorporating PIR sensors in automated surveillance.

Servo-Based Camera Control Systems:

Sharma and Joshi (2019) explored servo motors for camera positioning in robotic applications. Their system used sensor feedback to adjust the camera angle, improving tracking capabilities. The research underlined the effectiveness of servo motors like MG995 for precise angular movement.

ESP32 for IoT-Enabled Systems:

Deshmukh et al. (2020) presented the ESP32 microcontroller as a reliable solution for IoT-based automation. Its dual-core processing and integrated Wi-Fi make it ideal for real-time applications such as remote surveillance and device control. Their findings validate the use of ESP32 in IoT-enabled monitoring systems.

Blynk for Real-Time User Alerts:

Kamble and Raut (2021) utilized the Blynk IoT platform to notify users about environmental changes and intrusions via mobile alerts. Their integration of Blynk with microcontrollers showed how remote monitoring could be achieved efficiently through cloud-based communication.

Cost-Effective Surveillance Models:

Reddy and Thomas (2022) proposed low-cost surveillance alternatives using readily available components like webcams, servo motors, and microcontrollers. Their research supported the viability of building scalable systems for small-scale security without compromising performance.

III. PROPOSED SYSTEM

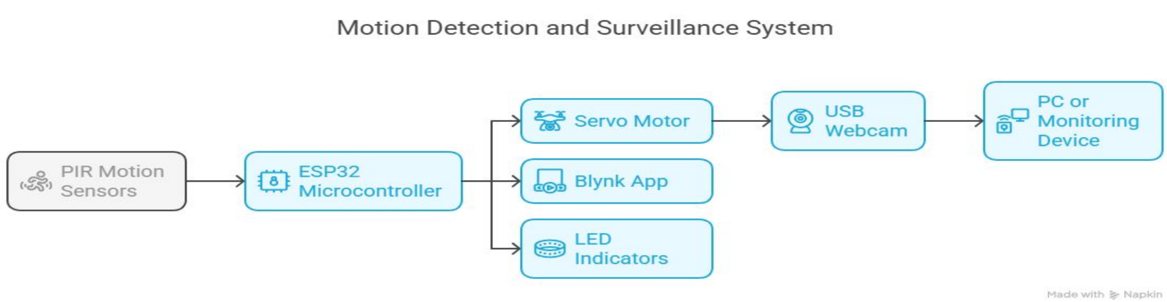

Fig 1: Block Diagram of Project

The system avoids the disadvantages of fixed-camera surveillance—**such as** blind spots and expensive installation costs—by employing a **Motion-Following Motorized Camera Base** that tracks movement within a 180° field of view. Five PIR sensors are strategically placed to cover various zones, reporting to an **ESP32** microcontroller. The **ESP32** interprets the sensor inputs, calculates the direction of movement, and, if required, uses a wireless link (e.g., NRF24L01 or ESP-NOW) to exchange information with distant sensors.

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When movement is detected, the **ESP32** actuates an **MG995** servo motor to adjust the camera's position. Live video is streamed by a USB webcam, and five LEDs light up depending on which sensor was activated. The **ESP32** also provides real-time notifications through the **Blynk** app, alerting users to motion.
Using modular components, the system can easily be set up in different environments without extensive rewiring. This economical solution substitutes several static cameras with one responsive panning camera, simplifying both hardware and monitoring complexity. Combining motion detection, accurate servo control, and IoT alerts, it offers an affordable and efficient alternative to conventional surveillance systems.

1. Sensor Unit Components

PIR Motion Sensors (×5): Detect infrared changes in their assigned zones to pick up movement.
ESP32 Microcontroller**:** Acts as the brain of the system—reads sensor outputs, debounces signals, and determines direction of motion..

Fig 2 : PIR Motion Sensors and ESP32

2. Camera Control Unit Components

MG995 Servo Motor**:** Rotates the camera platform smoothly to face the detected zone.
USB Webcam: Streams live video of the monitored area to a connected PC or host.
Blynk App (IoT Interface): Uses ESP32's Wi-Fi to send instant email/push alerts to users.

Fig 3 : MG995, Webcam, Blynk Iot

Component Functionality

- Motion Detection and Processing: PIR sensors detect movement and send digital signals to the ESP32. The microcontroller reads these signals, determines the direction of motion, and, if necessary, transmits the data wirelessly using NRF24L01 or ESP-NOW modules.
- Camera Control and Video Streaming: Based on the detected motion, the ESP32 sends PWM signals to the MG995 servo motor to rotate the camera. A USB webcam mounted on the servo captures live video and streams it to a connected device for real-time monitoring.
- User Feedback and Alerts: LED indicators show which sensor has been triggered, providing immediate visual feedback. At the same time, the Blynk app sends real-time notifications to alert users whenever motion is detected.

IV. RESULT & CONCLUSION

The Motion Following Motorized Camera Base was successfully implemented and tested under several real-world conditions. The system achieved all its primary objectives, and its performance was both reliable and consistent. The key results and observations are as follows:

Motion Detection & Tracking**:** The PIR sensors effectively detected motion in their respective areas and transmitted signals to the ESP32. The system was able to continuously determine the direction of movement and respond with appropriate servo motor actuation.

Servo Response & Camera Rotation**:** The MG995 servo motor responded accurately and quickly to commands from the ESP32 with minimal lag. The camera rotated smoothly toward the direction of detected motion, providing real-time visual tracking within the 180° field of view.

Video Streaming**:** The USB camera delivered a clear and consistent live video stream to a connected PC. The feed updated in real time as the camera adjusted its position according to movement.

Visual Alerts & Feedback**:** LED lights illuminated correctly based on the active PIR sensor, offering immediate visual feedback. Simultaneously, the Blynk app provided real-time alerts to the user, enabling uninterrupted remote monitoring.

System Stability**:** The system performed consistently across multiple tests without disconnections or response errors. The ESP32 reliably handled motion detection, servo control, and IoT communication, ensuring overall stability and efficiency.

Power Consumption**:** Power usage remained within acceptable limits for all components. Independent power supply management for the servo and ESP32 ensured smooth operation without resets or voltage fluctuations.

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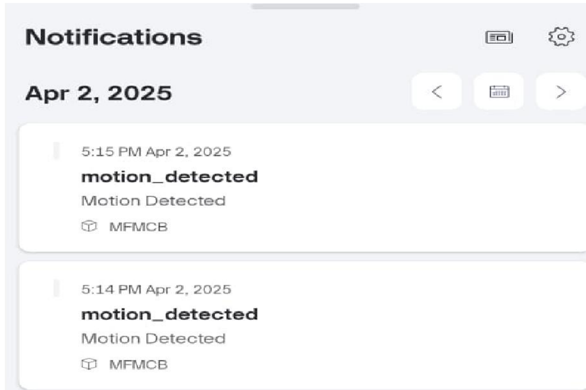

Fig 4: Results

V. FUTURE SCOPE

Although the existing prototype successfully demonstrates the feasibility of a smart, motion-tracking surveillance system using cost-effective components, there are various opportunities for future growth and improvement:

360° Camera Coverage

– Use a continuous rotation servo or a multi-axis gimbal system instead of the MG995 servo to enable complete 360° coverage and vertical tilt for improved tracking of rapid or complex movement patterns.

AI-Based Object Recognition

– Implement camera-based object detection using AI frameworks (e.g., TensorFlow Lite) to identify motion sources (human, animal, vehicle) and flag suspicious activity for intelligent decision-making.

Night Vision & Low-Light Monitoring

– Incorporate infrared (IR) or thermal cameras to enhance system performance in nighttime or low-light conditions, enabling 24/7 monitoring without compromising detection accuracy.

Cloud Storage & Remote Access

– Enable automatic video uploads to cloud platforms (e.g., Firebase, Google Drive) and develop a mobile/web dashboard for live camera viewing, history playback, and sensor status monitoring.

Multi-Zone Integration

– Extend the system to support multiple camera bases synchronized via mesh or Wi-Fi networks, allowing seamless tracking across wider surveillance zones such as large campuses or parking lots.

Power Efficiency & Backup

– Include power-saving features, battery backup systems, and solar energy integration to ensure reliable operation in off-grid or power-sensitive environments.

Voice & Audio Alerts

– Add speakers and microphones for audio alarms, real-time communication, or two-way interaction in security-critical areas such as entrances or gates.

Smart Home & IoT Ecosystem Integration

– Integrate with platforms such as Google Home, Alexa, or Home Assistant to enable voice commands, automated triggers (e.g., turning on lights), and expanded smart home functionality.

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