

INNOVATIVE SECURITY SOLUTIONS: THE IMPACT OF SMARTGATE AND ANNOUNCEMENT SYSTEMS IN ACADEMIC INSTITUTIONS

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Abstract

This project aims to design a Smartgate with an announcement system to enhance operational efficiency and security. By addressing the limitations of manual gate operations and associated safety hazards, our goal is to deliver a secure and user-friendly gate control solution. The system integrates components such as the ESP32 CAM, Servo Motor, Arduino Nano, MP3 Module and all remotely operated via the Blynk server. To evaluate the system's performance, comprehensive data collection, model analysis, testing, and simulation were conducted. Results indicate that the system significantly improves gate operations by offering real-time monitoring and audio notifications, surpassing traditional manual systems. This project allows the flexible control by user requirements.

Keywords: Announcement system, Operational efficiency, Real-time monitoring, Remote control, Security, Smartgate.

INTRODUCTION

A woman's modesty is a significant aspect in Islam, where covering one's body is mandatory to preserve dignity and self-respect. This is particularly relevant in the context of female student dormitories, where safety and privacy are paramount. This situation highlights the urgent need for a better system to control access to these areas.

An automated gate system, combined with a robust audio announcement mechanism, enhances both security and convenience. This system integrates electrical and mechanical components to allow gates to be opened or closed without physical force, typically controlled by a switch, along with public address (PA) systems comprising loudspeakers, amplifiers, and microphones for clear and effective communication. Maintaining safe and secure residential surroundings, especially in student dormitories, is crucial. Traditional methods like padlocks and chains are ineffective and time-consuming, while security guards often leave their posts to unlock gates for late-arriving students, increasing the risk of unauthorized access.

The significance of this research lies in simplifying and enhancing the efficiency of security guards' work while ensuring the safety and honour of students, particularly female students. This integrated automated gate control system with an announcement feature aims to fill the research gaps identified in existing studies, offering a more efficient, reliable, and secure solution for residential environments in academic institutions. The study objectives include developing an automated gate control system with real-time video monitoring, remote control via the Blynk app, and automated notifications. Additionally, the audio announcement feature ensures that relevant information is communicated effectively to all residents, enhancing the system's overall effectiveness.

LITERATURE REVIEW

The development and implementation of automated gate systems have become increasingly common due to the growing need to optimize convenience and security in both residential and institutional settings. These systems combine various technologies, including wireless communication, mechanical components, electrical systems, sensors, and microcontrollers, to create transparent and safe solutions. Several projects demonstrate different strategies and technological advances in automated gate systems to enhance security, minimize labor costs, and increase efficiency during operation. Kurdi *et al.* (2023) developed an automated gate system combining mechanical and electrical components powered by AC motors, enhancing security and ease of operation for various users. Similarly, bin Mohd Zafie (2021) created a smart gate prototype controlled via an Android app, using a sliding gate mechanism and ESP8266 module for communication, showcasing remote control capabilities. Navindra (2015) focused on using Active RFID readers and MICAz motes to control boom gates, increasing security operation efficiency. Aryza & Tarigan (2021) developed an automated door system using a PIR sensor and microcontroller, integrating IoT technology for remote control and real-time feedback. Jain *et al.* (2023) explored automated access control using QR codes for monitoring entry and exit points, employing an Arduino board, servo motor, and QR code reader to enhance security. Lastly, Eltoun & Xue (2014) developed a vehicle license plate recognition system using MATLAB, achieving high accuracy rates and demonstrating effectiveness in managing vehicle access. These projects collectively illustrate significant advancements in automated gate systems, highlighting their importance in improving operational efficiency and security by integrating various technologies and innovative approaches to meet the growing demands for enhanced security and convenience.

RESEARCH METHOD

The development of the automated gate control system involved key stages to ensure effective operation and integration of components. Initially, the main components included an Arduino Nano as the primary controller, an ESP32 Cam for real-time video monitoring, an ESP8266-01 Wi-Fi module for wireless communication, a Servo Motor for gate movement, and a Serial to MP3 Module with Speaker for audio notifications. Additionally, a reed switch and magnet were used as a door sensor, and an emergency button was included for added functionality.

The design phase began with creating a schematic circuit that connects all these components to the Arduino Nano, ensuring each component could communicate effectively with the main controller. The next step was programming the Arduino Nano using the Arduino IDE to handle input signals from the switch, process these signals, and send appropriate commands to the output components. This included activating the Servo Motor for gate movement, playing audio notifications via the Serial to MP3 Module, capturing images with the ESP32 Cam, and monitoring the door status using the reed switch. During the development phase, the hardware was assembled, ensuring all components were securely connected and positioned. The ESP8266-01 module was configured for reliable Wi-Fi communication, enabling remote control and monitoring via the Blynk app, allowing users to operate the gate remotely and receive real-time updates on their smartphones.

The testing and evaluation phase focused on ensuring that each component of the automated gate control system functioned correctly and reliably. The Arduino Nano, which acts as the main controller, was tested for its ability to process signals from the switch and send appropriate

commands to other components. This involved verifying the accuracy of signal processing and command execution to ensure precise control of the system. The ESP32 Cam, responsible for real-time video monitoring, was tested to ensure it could capture clear images and transmit them effectively under various lighting conditions. The ESP8266-01 Wi-Fi module was evaluated for its wireless communication capabilities, including connectivity and data transmission rates, to guarantee stable and efficient communication between the system and the Blynk app. The Servo Motor, which controls the gate movement, was tested for its responsiveness to control signals from the Arduino Nano and its performance under different load conditions. The Serial to MP3 Module with Speaker, used for audio notifications, was tested by playing various audio files to ensure clear and loud sound output and evaluating its response time when activated by the Arduino Nano. The Door Sensor, comprising a reed switch and magnet, was tested for its sensitivity and accuracy in detecting the door's open or closed state, ensuring reliable status updates to the Arduino Nano. Finally, the emergency button was tested to ensure immediate response when pressed and its integration with the Arduino Nano to trigger necessary safety protocols promptly.

RESULTS AND DISCUSSION

The Smartgate system heavily relied on the MG996R Servo Motor for its gate movement mechanism. Through rigorous testing, the servo motor was meticulously calibrated to ensure smooth operation. The GATEOPEN function successfully opened the gate by moving the servo from 90 to 100 degrees, while the GATECLOSE function closed the gate by moving the servo from 100 to 80 degrees, incorporating a 15-millisecond delay for precision. Initial challenges such as inconsistent movement were effectively addressed by recalibrating the servo and ensuring a stable power supply. This resulted in reliable gate operation, which is critical for the system's overall performance. The design's single wheel mechanism not only simplified the system but also maintained high efficiency. Furthermore, its adaptability to various surfaces, including concrete and asphalt, enhanced the reliability of the gate operation.

For real-time visual feedback, the ESP32 Cam proved to be indispensable. Connecting to a dedicated Wi-Fi network with the SSID "GATE" and password "12345678" provided a secure and reliable connection, thereby reducing the risk of unauthorized access and network congestion. This dedicated network setup significantly enhanced the stability and quality of the video stream, allowing for effective real-time monitoring via the Blynk app. By strategically optimizing router placement and fine-tuning camera settings, the ESP32 Cam consistently delivered high-quality video streams, ensuring robust surveillance and enhancing the overall safety for students.

The integration of the Blynk App allowed for comprehensive remote control and monitoring of the Smartgate system. Users could access the main workspace to control the gate, view live video feeds, and monitor the status of the door. The Open and Close buttons in the app triggered specific audio announcements indicating changes in gate status. Additionally, users could set the system to operate automatically by configuring the automation settings in the Blynk app. This feature allowed the SmartGate to respond to certain conditions without manual intervention, enhancing the system's efficiency and user convenience. Users could also set up notifications within the Blynk app or via email, helping them stay informed about the system's status and any significant events, such as the gate being opened or closed, thus further assisting in efficient system management.

The strategically positioned speaker provided essential audio feedback for the system, ensuring that announcements such as "Pagar Dibuka" (Gate Opening) and "Pagar Ditutup" (Gate

Closing) were clear and audible across the relevant areas. The serialEvent function managed event-driven audio playback based on received byte values. During testing, issues with audio playback were identified due to loose connections. These were resolved by verifying the connections and updating the code, resulting in reliable and clear audio feedback. The optimal placement of the speaker significantly enhanced user awareness and interaction with the system, ensuring that notifications were heard promptly and clearly, thereby improving overall system efficiency and security.

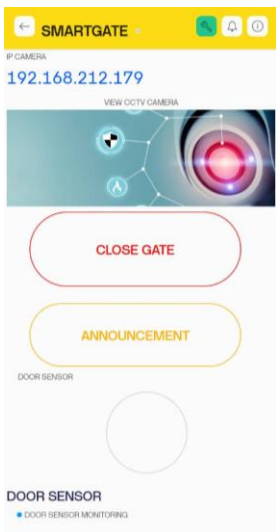


Figure 1. Overview of Smartgate System in Blynk App



Figure 2. Automation Settings Configuration in Blynk App



Figure 3. Notifications Setup in Blynk App



Figure 4. Audio QR Code



Figure 5. Result from video streamig



Figure 6. Servo motor and wheel connection

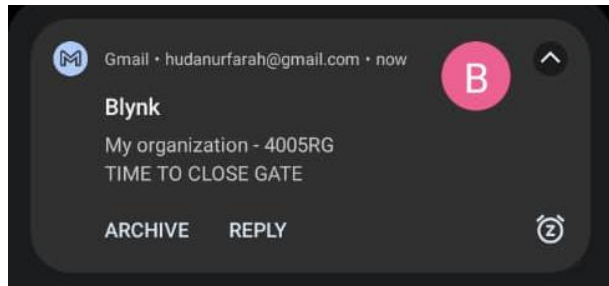
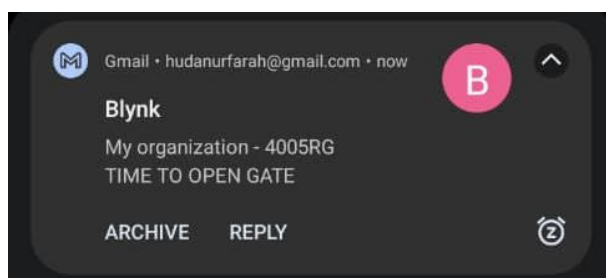


Figure 7. Examples of email notification

CONCLUSION

This project successfully developed a remote and automated gate control system utilizing Arduino Nano, ESP32 Cam, and the Blynk application, achieving the primary objectives of remote control and monitoring to enhance convenience and security. The system effectively addressed challenges like connectivity issues and signal delays, demonstrating reliable performance and real-time gate management. Key advantages include secure and dedicated Wi-Fi connectivity for high-quality video streaming, robust and precise gate movement with the MG996R Servo Motor adaptable to various surfaces, and comprehensive remote monitoring through the Blynk app with clear audio feedback from strategically positioned speakers. These features collectively offer an efficient, affordable, and user-friendly solution that significantly enhances community security and convenience. Future improvements could involve enhancing Wi-Fi stability, integrating advanced sensors and AI for smarter automation, and employing alternative power sources like solar energy to ensure continuous operation.

ACKNOWLEDGEMENT

The authors extend their gratitude to the Head of the Electrical Engineering Department, Politeknik Sultan Azlan Shah, Mr. Saiful Adli bin Yusoff, for providing this opportunity. Special thanks are also given to MyTech Electronics for providing essential facilities and resources. Additionally,

heartfelt appreciation goes out to friends, family, lecturers, and fellow students for their unwavering support and encouragement.

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