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Access Control Smart home using face recognition and RFID Card

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Abstract – In addressing the pressing need for heightened home security, this project presents a unified IoT-based system amalgamating multiple modules to offer comprehensive monitoring and control. The system seamlessly integrates the ESP32 CAM module with a PIR sensor for motion detection and image capture, enabling instantaneous notifications via the Telegram application. Central to the system is an advanced door-locking mechanism utilizing an RFID module and a solenoid lock, controlled directly by the ESP32 microcontroller. Access is restricted solely to authorized individuals with registered RFID cards, with visual and audible feedback provided through LEDs and a buzzer. Leveraging network connectivity, users can remotely monitor and manage the system via the Blynk app, receiving alerts for any activity detected by the PIR sensor and unauthorized access attempts. This integrated solution offers an economical and robust approach to fortifying home security, harnessing the power of IoT technologies to provide homeowners with unparalleled peace of mind.

Keywords: Smart home, Access control, Face recognition, RFID card, Security, Authentication.

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1. INTRODUCTION

In an era characterized by rapid technological evolution and the pervasive integration of digital systems into daily life, the demand for robust home security solutions has escalated significantly. With the proliferation of interconnected devices and the emergence of the Internet of Things (IoT), traditional approaches to home security have undergone a profound transformation, offering unprecedented opportunities for comprehensive surveillance and control. This embarks on a comprehensive exploration to design and implement an IoT-enabled home security system that transcends conventional paradigms, harnessing cutting-edge.

At the heart of this innovative system lies the ESP32 CAM module, a versatile microcontroller boasting an array of functionalities, including motion detection and image capture. Augmented by a highly sensitive infrared (IR) sensor, this module serves as the cornerstone of the surveillance infrastructure, diligently monitoring designated areas and capturing high-resolution images in response to detected motion. Seamlessly integrated with the Telegram application, these images are expeditiously transmitted to homeowners' smartphones, facilitating real-time notifications and enabling remote monitoring of security events with remarkable immediacy and precision.

In addition to its formidable surveillance and access control capabilities, the proposed system prioritizes user engagement and interaction, leveraging the LCD to provide rich visual feedback and employing a configurable buzzer to deliver instant alerts in response to potential security breaches or unauthorized access attempts. Every facet of the system is meticulously engineered to ensure an immersive and intuitive user experience, fostering a sense of empowerment and confidence in homeowners' ability to safeguard their premises effectively.

Furthermore, the integration of ubiquitous communication platforms such as Telegram and Blynk fosters seamless connectivity and remote management, enabling homeowners to stay informed and in control regardless of their physical location or time constraints. Through the convergence of state-of-the-art technologies and a steadfast commitment to user-centric design principles, this thesis aims to redefine the very paradigm of home security, offering a comprehensive solution.

By delving deep into the intricacies of system architecture, meticulously dissecting implementation methodologies, and

subjecting the system to rigorous performance evaluations, this research not only addresses the immediate challenges of home security but also lays the groundwork for future innovations in the realm of IoT-enabled surveillance and control systems. Through a multidisciplinary approach that seamlessly melds engineering ingenuity with an unwavering commitment to user-centric design principles, this aspires to equip homeowners with the tools they need to safeguard their most cherished assets in an ever-evolving digital landscape, ushering in an era of unparalleled security and tranquility.

2. LITERATURE REVIEW

The literature review embarks on a comprehensive exploration of studies aimed at fortifying home security through the integration of Internet of Things (IoT) technologies, with a particular focus on ESP32 microcontrollers and the Telegram application. These technologies, when combined, offer a potent toolkit for enhancing surveillance, access control, and real-time notifications in residential settings. As the demand for smart home solutions continues to surge, researchers and enthusiasts alike are increasingly drawn to the transformative potential of these technologies in safeguarding homes and properties.

A. Shukla and R. Diwan laid the groundwork with their pioneering work on RFID-based access control systems. By integrating RFID technology with biometric authentication, they introduced a robust mechanism for regulating access to residential premises [2]. This approach not only enhances security but also simplifies the user experience by providing a seamless and reliable means of authentication.

Expanding upon the foundation laid by A. Shukla and R. Diwan Verma, G.K., and Tripathi, P.delved into the realm of passive RFID technology. Their exploration of innovative door-locking mechanisms demonstrates the versatility of RFID in addressing diverse security challenges within the IoT ecosystem [14]. Passive RFID systems offer distinct advantages, including low power consumption and simplified deployment, making them well-suited for integration into smart home environments.

In parallel, Norarzemi, Ummi Annisa, et al. showcased the versatility of RFID technology in a smart parking application. By leveraging RFID tags for vehicle identification and tracking, they demonstrated how IoT technologies can streamline parking management and enhance security in residential and commercial settings [3]. This application exemplifies the broad spectrum of use cases for RFID technology beyond traditional access control systems.

As the field of IoT continues to evolve, the emergence of ESP32 microcontrollers has sparked considerable interest among researchers and hobbyists alike. Arya K.V., Abhinav Adarsh leveraged the capabilities of the ESP32-CAM microcontroller in conjunction with the Telegram Bot interface to create a sophisticated home security system [11]. This system enables homeowners to monitor their properties in real time and receive instant notifications of security events, enhancing situational awareness and response capabilities.

Building upon this foundation, Babiuch, Marek, and Jiri Postulka. proposed a cost-effective home security solution using the ESP32CAM microcontroller and a combination of motion and door sensors [5]. By integrating these sensors with the ESP32 microcontroller, they created a robust intrusion detection system capable of alerting homeowners to potential security breaches in real time.

In a similar Nurjaman, demonstrated the effectiveness of ESP32-CAM-based home security systems with Telegram notifications. By incorporating advanced sensors such as PIR and smoke sensors, they expanded the capabilities of these systems to include threat detection and environmental monitoring [15]. This holistic approach to home security reflects a growing trend toward integrated solutions that address multiple aspects of safety and security.

Eethamakula, Kosalendra, et al. further extended the concept of home security by integrating temperature sensors into their ESP32-CAM-based system. This addition enables homeowners to monitor environmental conditions within their properties, providing valuable insights for energy efficiency and comfort optimization [6]. By combining security with environmental monitoring, this approach exemplifies the potential for IoT technologies to enhance not only safety but also quality of life.

In addition to academic studies, Anwar Shaik and Kishore D on Medium offer practical insights into the implementation of ESP32-CAM-based security systems with Telegram integration[10][15]. These tutorials provide valuable resources for enthusiasts and DIYers looking to deploy advanced home security solutions using off-the-shelf components and open-source software.

Overall, the literature review highlights the diverse array of approaches to home security enabled by IoT technologies, ESP32 microcontrollers, and the Telegram application. From RFID-based access control systems to sophisticated home surveillance systems, these technologies offer unprecedented opportunities for enhancing safety, security, and peace of mind in residential settings. As the field continues to evolve, researchers and practitioners are poised to explore new

avenues for innovation and collaboration, driving the continued advancement of smart home technologies.

3. METHODOLOGY

The ESP32-CAM Surveillance System, augmented with a Passive Infrared (PIR) sensor, operates seamlessly to provide comprehensive surveillance functionality. Upon initialization, the ESP32-CAM establishes communication with the Telegram platform, facilitated by a Telegram bot. This bot is tailored to receive commands and interact with the ESP32-CAM system.

When motion is detected by the PIR sensor, which is integrated into the ESP32-CAM board, it triggers an interrupt. The interrupt handler, programmed within the Arduino sketch running on the ESP32-CAM, responds promptly to this event. It initiates the camera module to capture a snapshot of the surveillance area.

Upon capturing the image, the ESP32-CAM system proceeds to encode and transmit it to the designated recipient via Telegram. This transmission is facilitated by the Telegram bot, which acts as an intermediary between the ESP32-CAM and the user. The bot ensures secure and efficient communication, handling both incoming commands from the user and outgoing messages containing images captured by the surveillance system.

Additionally, the Telegram bot provides users with the flexibility to control the surveillance system remotely. Users can issue commands such as /start, /enablepir, and /disablepir to initiate conversations, enable or disable motion detection functionality, and manage system settings. These commands offer users a straightforward means of interacting with the ESP32-CAM Surveillance System, enhancing its usability and versatility.

Through this integrated approach, the ESP32-CAM Surveillance System effectively combines real-time motion detection with instant image capture and remote communication capabilities. This seamless integration empowers users to monitor and respond to security events promptly, making it an invaluable asset for industrial surveillance applications.

Module 2:

The system utilizes an ESP32 microcontroller as its core, integrating various sensors and components such as a PIR sensor for motion detection, an RFID reader for card scanning, a buzzer for alerts, a door lock for access control, and an LCD screen for local display. The ESP32 firmware orchestrates these components, managing sensor inputs, controlling the door lock, interfacing with the Blynk app, and handling the LCD display.

When motion is detected by the PIR sensor, the ESP32 initiates an alert sequence. It notifies the user via the Blynk app, signaling the motion event. Simultaneously, the buzzer is activated to audibly indicate the detection, while the LCD screen displays a corresponding message.

In the case of an RFID card scan, the ESP32 reads the card's unique identifier and cross-references it with a list of authorized IDs. If a match is found, indicating an authorized user, the ESP32 unlocks the door and notifies the user via the Blynk app. The LCD screen confirms the successful access. However, if the scanned ID does not match any authorized entries, signaling an unauthorized attempt, the ESP32 triggers an alert. The buzzer sounds an alarm, a notification is sent to the Blynk app, and the LCD screen displays a message indicating the unauthorized access attempt.

The Blynk app serves as the user interface, facilitating remote control and monitoring of the system. Users can remotely lock or unlock the door via the app's buttons and receive real-time updates on sensor status and access logs. Furthermore, the app receives notifications from the ESP32, alerting users to motion detection or unauthorized access attempts. Additionally, users can opt to receive email alerts for critical events, enhancing the system's notification capabilities.

Throughout development and deployment, stringent security measures are implemented to protect against unauthorized access and data breaches. Communication channels are encrypted, and secure authentication methods are employed for the Blynk app. Regular monitoring and testing ensure the system's reliability and effectiveness in providing access control and security for the designated environment.

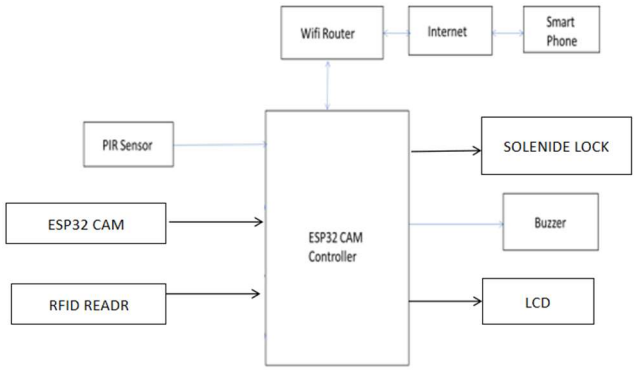


Fig 1: Block diagram

Fig 2: Pin diagram

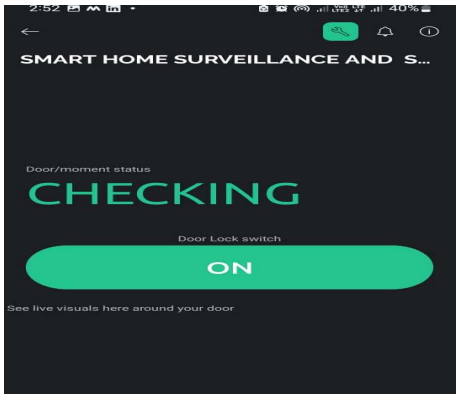


Fig 3: Blynk App

4. DISCUSSION AND RESULT

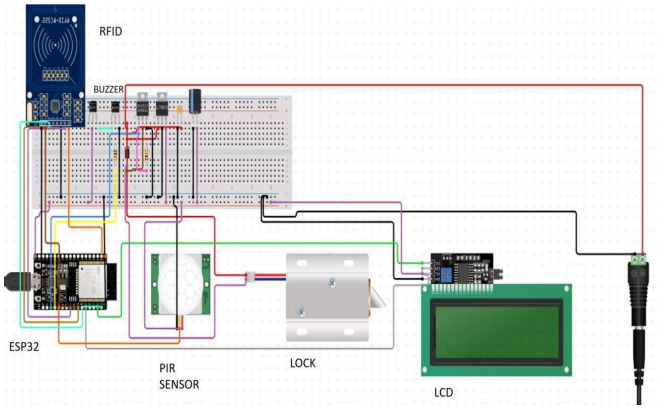
The implementation of the IoT-enabled home security system demonstrated effective surveillance and access control capabilities. Key outcomes include:

- Continuous monitoring using advanced sensors like the ESP32 CAM module with IR sensors.
- Successful regulation of entry with RFID technology and solenoid locks.
- Real-time notifications via communication platforms like Telegram and Blynk.
- User-friendly interfaces providing visual feedback.
- Remote management for monitoring and adjusting security settings.

5. CONCLUSION

The IoT-based home security system is a major advancement in residential protection, providing a comprehensive solution against potential threats. Our project successfully integrates advanced technologies for continuous surveillance, efficient access control, real-time alerts, and remote management.
Utilizing cutting-edge sensors like the ESP32 CAM module with IR sensors, our system ensures timely detection of suspicious activities and captures high-quality images for evidence. RFID technology and solenoid locks regulate entry effectively, boosting overall security.

Real-time notifications via platforms like Telegram and Blynk enable prompt responses to security events, empowering homeowners to take immediate action. User-friendly interfaces, including an LCD display, enhance usability and monitoring.



However, challenges like initial setup complexity and internet dependency need refinement. Cybersecurity and privacy issues also require ongoing attention.

Future enhancements may involve leveraging AI, improving connectivity, implementing biometric authentication, optimizing energy usage, promoting interoperability, and reinforcing security measures.

In conclusion, our IoT-based home security system offers an effective solution to residential security needs, continuously evolving to provide top-tier protection and peace of mind.

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