engineering proceedings

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Proceeding Paper

IoT-Based Smart Remote Door Lock and Monitoring System Using an Android Application †

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† Presented at the 1st International Conference on Industrial, Manufacturing, and Process Engineering (ICIMP-2024), Regina, Canada, 27–29 June 2024.

Abstract: Nowadays, it is very important to secure our home perfectly. To make our life easier and more secure, we are presenting our smart door lock system project. We implement an IoT-based smart door lock system using an ESP32-CAM and an Android application in this project. Most of the time in our daily life, we forget to lock our doors and later we suffer from confusion about whether we locked all doors perfectly or not. In this project, we implement a smart door lock system, by which the owner can see the visitor's picture and then lock or unlock their doors from anywhere and at any time using the Android application. Whenever visitors come to visit the home and press the doorbell, the owner will receive a notification on his/her smartphone and then the owner can see the visitor's picture by using the Android app. After checking the visitor, the owner can let them enter the house by unlocking the door remotely. If the door is locked perfectly, then the door lock signal in the application will show a green signal. If the door is not locked perfectly, the signal will show red and then the owner can remotely lock their door easily from anywhere. In this project, we have also utilized a theft alert. If anyone comes in front of the door and tries to enter the house forcefully then a theft alert notification will be sent to the owner's smartphone and a Buzzer Alert will ring in the house loudly so that the neighbors can be aware of the theft and can take action. The automatic door lock feature is also available in this system.

Keywords: IoT; smart door lock; home security; theft alert; ESP32-CAM IP camera

Citation: Sonamoni, J.S.; Sikdar, R.; Akib, A.S.M.A.S.; Islam, M.S.; Sourov, S.; Al Ahasan, M.A.; Islam, M.; Habib, M.A.; Mridha, M.F. IoT-Based Smart Remote Door Lock and Monitoring System Using an Android Application. *Eng. Proc.* **2024**, *76*, 85. https://doi.org/10.3390/engproc2024076085

Academic Editors: Golam Kabir, Sharfuddin Khan, Mohammad Khondoker and Hussameldin Ibrahim

Published: 19 November 2024

1. Introduction

The first line of defense in a home is the doors. In a traditional door lock system, doors can only be locked using physical keys. People can lock or open their doors with physical keys only, which is a risky procedure. Using physical keys increases the risk that the key will be misplaced, stolen, or copied. The traditional door lock also has problems with keys breaking in locks and inappropriate door locking. Due to the lack of security in the traditional door lock system, it is quite simple for a thief to break in and enter the house. By enabling remotely monitored and accessible facilities with real-time security,

the IoT contributes to safer homes and towns. Making sure that our home is secure is very important. Keeping things secure is one of the most crucial justifications for using high-security locks. Smart doors, which do not require manual opening, are highly helpful for increasing security. To open the door, people only need to press a push button or remote control. The smart door helps you save a lot of time and effort. As the Internet of Things (IoT) permeates every industry, we here propose an IoT-based smart door lock system to improve home security. IoT-enabled sensors are used in smart locks to provide keyless entry systems that let users open doors remotely using a smartphone or any other internet-connected device. Smart locks give consumers the freedom to unlock their doors from anywhere at any time without a key. Today, we can observe that there are numerous varieties of smart door locks available. However, we are introducing a smart door lock system with a few extra features that will improve and increase the security of our lives. To improve our house security, we created an IoT-based smart door lock system using an Android application. Our suggested solution offers door status monitoring (open or closed), door locking or unlocking after verifying the visitor's photo via an Android app, a warning alert, and communication with the application installed on smartphones and other apps. The home's owner can monitor the door's state, operate the door from a distance, and monitor visitors by looking at the images the ESP32-CAM has taken of them. The ESP32-CAM module is manufactured by Espressif Systems, a company based in Shanghai, China. Our proposed solution tackles several key security challenges, including reducing door-lock confusion, enabling door unlocking only after verifying the visitor's photo, preventing theft, and providing remote door access at any time, from anywhere. Our proposed system's main goals are to increase home security and avert probable security issues. Our project differs from others' projects since we designed our system with new features. The "IoT-based Smart Door Lock System using Android Application", as our proposed system is called, combines all of its functions to keep the house secure. The major contributions of this study are as follows:

- We propose a novel door security system with unique features such as the Theft Alarm mode for enhanced safety and security.
- We developed an Android application that helps users to verify and control the status of their doors remotely through their smartphones.
- We used an IP camera that enables users to view visitors' pictures and grant access from anywhere after anyone presses the doorbell.

Overall, the system represents a significant contribution to the field of door security systems, offering enhanced safety and convenience to users.

2. Literature Survey

When we first started looking into the smart door lock system, we found that a few of the researchers had made some great suggestions. The researchers proposed using an Android-based door security system, an application that uses Internet of Things (IoT) technology to monitor and regulate the door's status. The communication mechanism between smartphones and door lock systems in this instance was the MQTT cloud [1]. Another door lock system was suggested to help consumers increase door security by utilizing facial detection and recognition. Through the Telegram app for Android, the distant user can grant or deny access to the visitor [2]. The principal component analysis (PCA) approach is used for face recognition and detection. Intruder detection is accomplished by performing image processing on video frames of data that have been captured and calculating the difference in pixels between the running frames and the previously captured frames [3]. The ESP32 CAM and IoT technologies used to monitor and control the door, as well as the Blynk app for linking the door with a smartphone, are presented as part of a smart Wi-Fi door lock system [4]. The user can control door accessibility and voice alerting remotely using a smartphone and they can also receive emails notifying them when guests are photographed at the door [5]. Motion sensors are utilized to monitor activity in front of the door; if somebody enters the area, a motion sensor is triggered, and an image is

taken [6]. When a device release request is made, the door lock security authentication server recognizes the appropriate door lock, transmits a signal, and releases the device. According to the door lock release procedure, the smartphone must establish a wired or wireless network connection with the door to unlock it and the application must also be connected and active to communicate with the door lock [7]. The use of face detection and recognition algorithms integrated with Raspberry Pi (Raspberry Pi Foundation, Cambridge, UK), which is used to manage access to the door, as well as MATLAB (version 9.14) for the face recognition process, is presented as a smart anti-theft door lock system [8]. The other system under consideration is made up of an STM32L100 microcontroller (STMicroelectronics, Plan-les-Ouates, Switzerland), which serves as the system's brain, a TIP102 transistor (ON Semiconductor, Scottsdale, AZ, USA) that manages 12 V DC solenoids, and an Xbee module (Digi International Inc, Boston, MA, USA) that allows for user interaction and GPS position tracking [9]. The researchers proposed a smart door lock system that would require a PIN for entry. After entering the PIN code, a motor opens the door automatically [10]. In this system, the person attempting to leave the house's range is identified using an Ibeaco feature and if the person leaves the range, an alarm is sent to the owner. Even when the house is unoccupied, the front door can be seen in real time thanks to video technology and smartphone devices that can communicate with the door system via communication technology [11]. Another approach that has been proposed is a smart lock system that uses the IoT. The user will only be allowed access to the lock if they enter the correct PIN and validate their fingerprint within the lock application on their smartphone [12]. The integration of IoT has shown promise in real-time data acquisition and IoT-based approach addresses the challenges of traditional methods and offers more efficient, data-driven solutions [13]. We found significant drawbacks. Additionally, some of their suggested solutions do not address every security issue that arises in daily life. In this paper, we proposed a system that can overcome all of the obstacles and developed a tool that can completely secure our home.

3. System Architecture

In this project, the "IoT-based Smart Door Lock System using Android Application", we proposed a door lock system that can be operated via an Android app on a smartphone. The user must initially launch the Blynk app version 1.2, which is linked to the door lock system. The Android Studio program runs the application. To monitor the status of the door and control it after launching the Blynk app, the user must enable the internet connection on his or her smartphone. It is a system for IoT access doors. Figure 1 represents the functioning flowchart of the Android application.

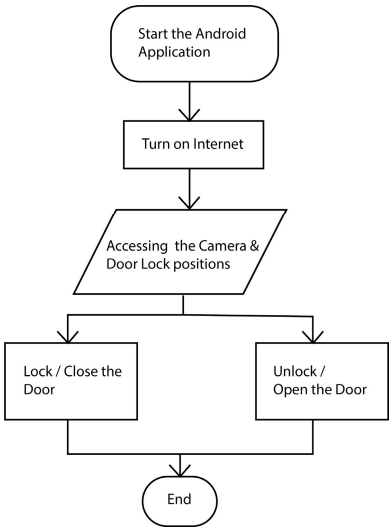

Figure 1. Flowchart of the door lock system.

3.1. Hardware Design Specifications

The following hardware equipment is used in our IoT-based smart door lock system. ESP32 CAM(IP): The affordable ESP32-CAM IP camera module is excellent for expanding the number of video-capturing devices as shown in Figure 2. It is a whole module with a built-in microprocessor that allows it to function independently. This module features Wi-Fi, Bluetooth, an inbuilt video camera, and a MicroSD card slot for data storage. When the ESP32-CAM initially connects to the Wi-Fi network, an IP address is immediately issued to it. Most routers or internet devices retain this address to simplify usage and improve efficiency.

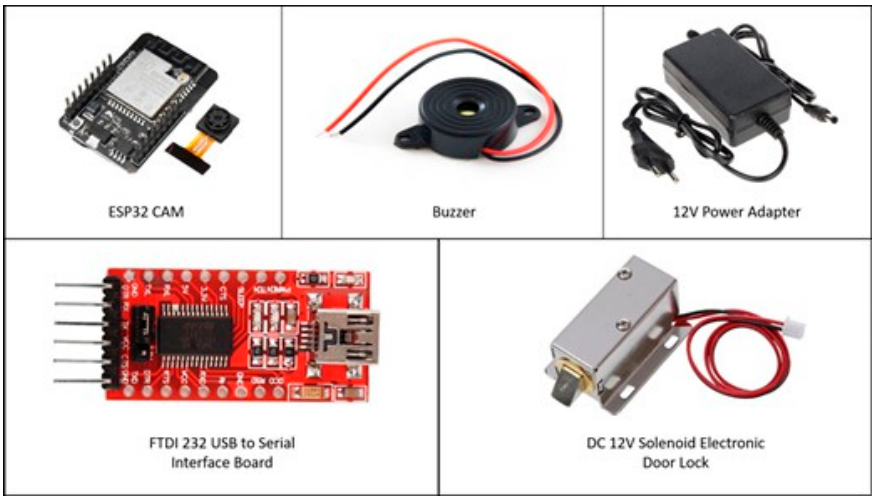

Figure 2. Specification of hardware.

FTDI 232 USB to Serial Interface Board: TTL serial communication is carried out using the FTDI 232 USB to Serial Interface Board. The board is unbranded and manufactured in China. It is frequently used to provide communication between ESP-01 and Arduino mini development boards for microcontrollers. The ESP32 CAM was programmed in our proposed system using the FTDI 232 USB to Serial Interface Board as shown in Figure 2. To program the ESP32 CAM, we first linked the FTDI 232 USB to our laptop and then the ESP32 CAM to the Serial Interface Board.

DC 12 V Solenoid Electronic Door Lock: The solenoid electric door lock enables the unlocking of a door using a key card, secret push button, or another similar device. The product is unbranded and manufactured in China. To lock or unlock the door, electromagnetic radiation is used. For projects like home automation and smart and automatic doors, cabinets, windows, etc., this lock is frequently employed. When powered with up to 12 V DC, the solenoid activates, causing movement in the electronic door lock mechanism. It also returns to its original position when the voltage is turned off. Figure 2 shows the DC 12 V Solenoid Electronic Door Lock.

12 V Power Adapter: In our system, we used a 12 V power adapter as shown in Figure 2. The 12 V power adapter was sourced from Local compnay, located in Dhaka, Bangladesh. It is an outside power source. It is the most often used power source. There are two different kinds. It is frequently used in instrumentation and electronics and voice, data, and analog communications, as well as networking applications, telecommunication networks, and fiber optic networks.

5 V Power Adapter: When a USB connector is required to power the end application, a 5 V power adapter is most frequently employed.

Internal Battery (18,650 Lithium-Ion Battery): We used an 18,650 lithium-ion battery as our internal power source, named for its specific dimensions of 18 mm by 65 mm. These batteries are commonly found in flashlights, laptops, and high-drain devices due to their higher capacity and discharge rates.

Buzzer: In our system, a buzzer was used as shown in Figure 2. It is a signaling tool that uses audio. A buzzer's primary job is to transform audio signals into sound. It is DC voltage-powered. It is frequently utilized in timers, alarm clocks, printers, computers, and other devices. Buzzers come in many different designs, and depending on the design, they can produce a variety of sounds including an alarm, melody, bell, and siren.

3.2. Circuit Diagram

In Figure 3 here, we can see the circuit diagram of the IoT-based automated door lock system. Here, we can see an ESP32 CAM which is connected to the 12 V electro-magnetic door lock. Here, there is also a push button and there is a voltage regulator to convert the voltage.

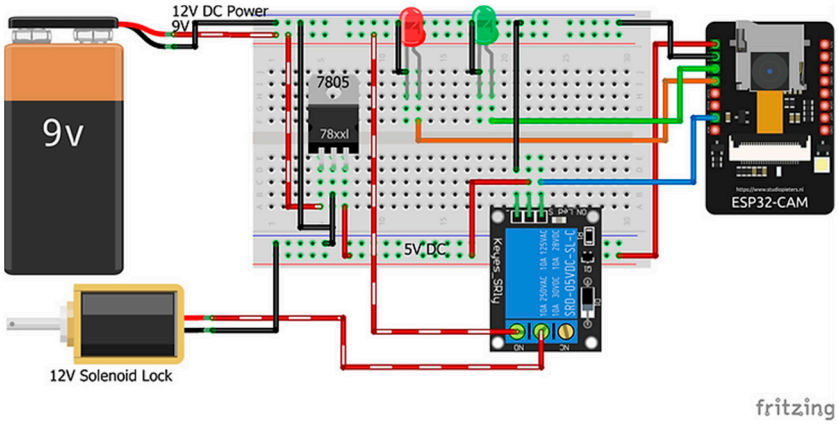

Figure 3. Circuit diagram of smart door lock system.

3.3. Software Design Specification

We used an Android app to monitor and control the door lock. Blynk is a complete collection of tools that enables anyone to remotely create and manage connected electronic devices of any size. Millions of commercial connected goods as well as personal IoT projects can be prototyped and deployed using this platform. Blynk offers a no-code way to construct iOS, Android, and web applications, link hardware to the cloud, and analyze both recent and old device data. Users can access other helpful services, receive critical notifications, and remotely operate devices from anywhere in the world. With the Blynk app, we can control our smart door lock system as shown in Figure 4.

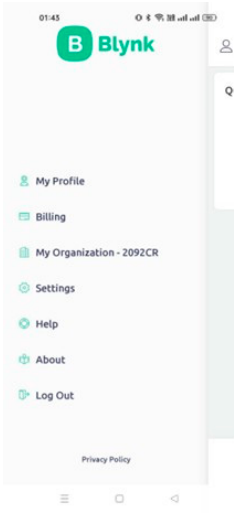

Figure 4. Android app.

3.4. Setup Process Using Blynk App

Below is a step-by-step guide for setting up the system using the Blynk app:

- Step 1: We started by downloading and installing the Blynk software on our Android handset.
- Step 2: We started a new project by selecting the ESP32 board and signing up for an account in the Blynk app.
- Step 3: Blynk delivered an authentication token to our email address once we created the project. This token was required by the code.
- Step 4: We programmed the ESP32 CAM using FTDI 232 USB. To program our ESP32 CAM, we used an FTDI 232 USB to Serial Interface Board. When we connected the ESP32 CAM to FTDI, we connected GPIO 0 to GND. We then connected our laptop to the FTDI 232 USB port and completed the ESP32 CAM programming.
- Step 5: We created the circuit, which is shown in Figure 3. We used an ESP32-CAM, a TIP122 transistor, 7805 5 V regulators, a 220 µF capacitor, a 12 V DC barrel jack, a 1N4007 diode, 1K and 10K registers, and a push button switch to build the circuit illustrated in Figure 3. The Blynk app alerts us when we press the push button.
- Step 6: Following the completion of the circuit, we added a few widgets to the Blynk app to control the smart lock. We began by scaling it and adding an Image Gallery. After resizing and adjusting the Image Gallery, we selected the virtual pin V1 before exiting the Image Gallery.
- We added a Styled Button to the Add Image option. We selected GP14 and clicked OK. Because this button is used to capture photographs, we selected push type, typed "TAKE PICTURE", changed the button's color, and resized it. We then went back to the Styled Button to create the next button to unlock the door. We tapped on the Styled Button, chose pin GP12, clicked OK, entered "UNLOCK DOOR" on the left and "LOCK DOOR" on the right, and then tapped the Styled Button once more.Because this is a switch type, we changed the color and size of the button in addition to selecting the switch type. The final widget, notification, was then added. We chose the notification and hit the button to add it.
- Step 7: After finishing all of these steps, we turned on the circuit's 12 V power supply and pushed the play button on the Blynk app. We received a notification on the Blynk app whenever someone pressed the push button. The visitor could then be photographed by pressing the "TAKE PICTURE" button. Every time we clicked "TAKE PICTURE", we received a new snapshot of a visitor. After studying the image, we could easily unlock or lock the door by selecting "UNLOCK DOOR" and "LOCK DOOR" on the Blynk app.

4. Experimental Analysis

After examining several existing smart door lock systems, we have found that there is a system where anyone can enter the house without a key by utilizing a PIN number. There, a security system is installed to verify the PIN, and the user can enter the PIN using a keypad. But this is now a typical door lock system. In another approach, the state of the door lock, including whether the door is open or closed, is sent using mobile application communication technology. The technology automatically notifies the home's owner through SMS when the door is open. With this technology, the owner can only be informed of the door's status, but the door control is not possible remotely. There are other methods that use a Wi-Fi-connected door lock, the ESP32 CAM, and the Blynk app. If a visitor rings the doorbell, the owner receives a notification on his or her phone along with a picture of the visitor. The owner can use a mobile phone to unlock the door after reviewing the notification and photo as shown in Figure 5. Although this approach is effective, it lacks any further security features. For security reasons, the Pi camera is used to take the picture and communicate it to the appropriate person, as shown in Figure 6. Then, using the Telegram app for Android, the authorized individual can remotely control the door. However, aside from this, this system does not have any further security features. Our proposed system,

the "IoT-based Smart Door Lock System using Android Application", combines several helpful and unique features that can raise the standard for home security. Users of our system can use the Android application to lock or unlock their doors after checking the status of their doors. Additionally, the user will receive an immediate notification whenever a visitor rings the doorbell. The user can then use the Android app on their smartphone to view and take a photo of the visitor after receiving the notification and open the door for them. Moreover, our system has a Security Mode called Theft Alarm. Furthermore, if no one appears for five minutes, the door will automatically lock as a special function. Therefore, after comparing our system with other existing systems, we can say that it offers several distinct and useful characteristics that will boost home security and make our lives better and more secure.

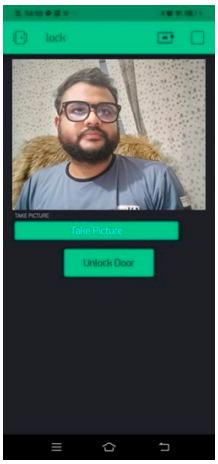

Figure 5. Accessing camera with Blynk.

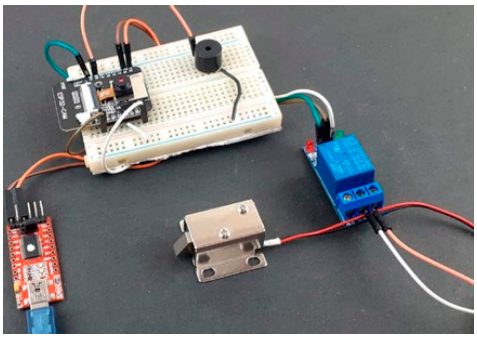

Figure 6. ESP32 CAM connecting to door lock.

5. Conclusions

The IoT-based Smart Remote Door Lock and Monitoring System with an Android app improves home security, although it has limitations and room for development. Internet access is crucial to the system's remote operation, which can be unstable or unavailable. In poor illumination or with concealed face features, facial recognition technology for visitor identification may be inaccurate. Integration with other smart home devices may provide compatibility concerns and vulnerabilities, necessitating strong cybersecurity. Future work could increase system stability by incorporating offline functions for critical aspects, optimizing facial recognition algorithms for accuracy, and rigorously testing for a seamless connection with other smart home devices. For user privacy and system integrity against cyber attacks, cybersecurity protocol and data encryption research must continue. Addressing these constraints and improving them can help the IoT-based Smart Remote Door Lock and Monitoring System become a full solution for digital home security and convenience.

Author Contributions: Conceptualization, A.S.M.A.S.A.; methodology, A.S.M.A.S.A.; software, A.S.M.A.S.A.; validation, M.A.A.A. and M.I.; formal analysis, A.S.M.A.S.A. and R.S.; investigation, M.A.H.; resources, M.S.I.; data curation, A.S.M.A.S.A.; writing—original draft preparation, M.S.I.; writing—review and editing, J.S.S.; visualization, M.F.M.; supervision, A.S.M.A.S.A.; project administration, A.S.M.A.S.A.; funding acquisition, A.S.M.A.S.A. and S.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Robo Tech Valley, grant number [707].

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data were created.

Conflicts of Interest: Author A. S. M. Ahsanul Sarkar Akib was employed by the company Robo Tech Valley. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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