IoT-Based Smart Home Door Lock Security System Using ESP32

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Abstract

Security has always been a paramount aspect in society. Traditional physical keys have always been used to secure doors but it still comes with some inconveniency and vulnerabilities despite it being the most ordinary technology until now. Each key is dedicated to a particular lock, necessitating the need for individuals to carry multiple keys for different doors. In the traditional key-based system, the burglars may exploit the weakness using the specialized tools and techniques to break into the house. Nowadays, there has been a shift towards incorporating modern innovations for enhanced security with the advancement in Internet of Things (IoT) technology. Automatic door locks have gained popularity in the industry as they offer improved protection for valuables and personal safety. This work is built upon the ESP32 as the backbone of the security system, in which it coordinates with the user to control the door locking mechanism. Result from the prototype suggests that the user could control the locking system seamlessly through the Telegram application. On top of that, the log data could be seen by the user in a readable manner in the Blynk application in real time. The achievement of this work concludes that the employment of IOT enables safety and convenience of home user in a single system is possible nowadays.

1. Introduction

With the rapid integration of technology into our daily life, the condition where human relies on machines and systems has become a natural consequence to fulfil human desire for the conveniency and efficiency. With the increase of recognition on the importance of smart home, there is a rising demand for innovative solutions which cater to the trend in the market nowadays (Kishore et al., 2023; Masykuroh et al., 2021; Simatupang & Tambunan, 2022; Ahmed et al., 2023).

The key aspect of a smart home is security which plays a vital role in protecting lives and property (Akhtar et al., 2019; S. et al., 2023). Home security systems have always been relying on traditional physical keys and locks but it consists of limitations which makes it vulnerable and unreliable (Raj et al., 2019; Gota et al., 2020).

Apart from that, the issue of unauthorized access poses a significant concern as well. It is these challenges that prompt the need for a smart home door lock security system, aimed at addressing these issues comprehensively (Tatarnikova & Ivanova, 2020; Shanthini et al., 2020).

As the IoT has emerged as a promising paradigm in this era, it offers new possibilities and opportunities to create an intelligent door security system that can inevitably enhance home security (Do et al., 2021). As physical

keys and locks are insufficient anymore, it becomes imperative to upgrade home security to a higher level (Sinha et al., 2021; Nath et al., 2016).

Moreover, the keyless entry which allow users to access doors remotely proves beneficial to some careless users who prone to lost their keys (Zamri et al., 2021; Eleyan & Fallon, 2020). The purpose of this work is to develop an IoT-based door lock security system which leverages the technologies that includes the keypad control (Khan et al., 2022), ultrasonic sensor control (Sahu et al., 2022), mobile applications control such as Blynk (Sobale et al., 2022) and Telegram (Nivethika et al., 2023) for reliable protection.

The system allows the authorized user to remotely control access to their doors and monitor their status through smartphones or computers (Ganesh et al., 2022). With the integration of IoT in the door lock security system, the user can enjoy the benefits of a smart and secure home environment with the complete control over their door security (Tippannavar et al., 2022).

This work aims to showcase the potential of IoT in revolutionizing the concept of home security and demonstrate its practical application in real-world scenarios. With the accomplishment, it can contribute to the advancement of smart home technology while ensuring the safety and well-being of individuals and their valuable assets.

2. Materials and Methods

The construction of the prototype for this work involves the utilization of various electronic components to build the hardware of the system. With the necessary code developed and implemented by the software, the desired functionalities of the system can be done.

The cooperation between the hardware and software plays a crucial role in ensuring the proper operation of the system. The overview of the system with the connections and wiring are shown in Fig. 1 while the complete list of the hardware and software used for this system is shown in Table 1.
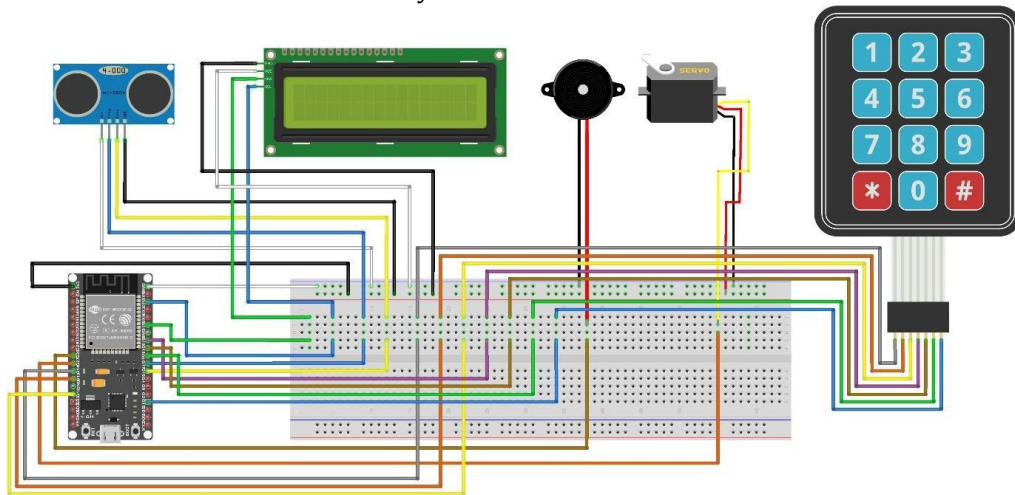


Fig. 1 *Schematic circuit of the door security system*

Table 1 *List of hardware and software*

| Hardware	Software
ESP32 microcontroller	Arduino IDE
Ultrasonic Sensor	Telegram
Liquid Crystal Display (LCD)	Fritzing
Servo Motor	Blynk
Piezo Buzzer	

3. Methodology

The block diagram as shown in Fig. 2 illustrates the comprehensive visual representation of the interconnections of the electronic components in the circuit system at a basic understanding. It shows the system's interconnection and flow of data signal from the inputs as they traverse through different components to generate the desired outputs. In general, there are four inputs fed into the microcontroller and three output that could be seen by the user. These interconnections are being coordinated by the ESP32 as the main controller in this prototype. On top of that, all data will be saved automatically on the cloud in real time during the operation, which reflects an IOT-based system., The Blynk application installed on a smartphone would enable to access to these data in a

comprehensive manner for the user. In addition, the Telegram also acts as interface input from the user to control the locking mechanism of this prototype.
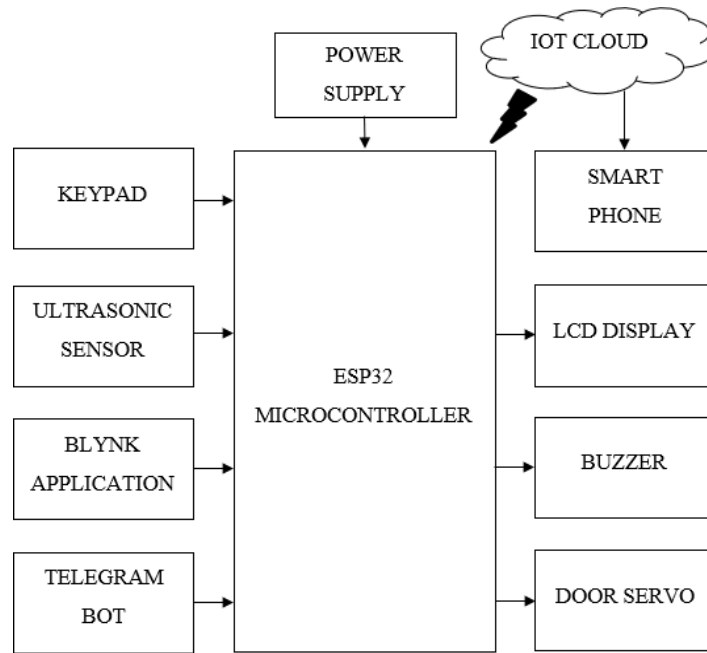
Fig. 2 *Block diagram of the door security system*
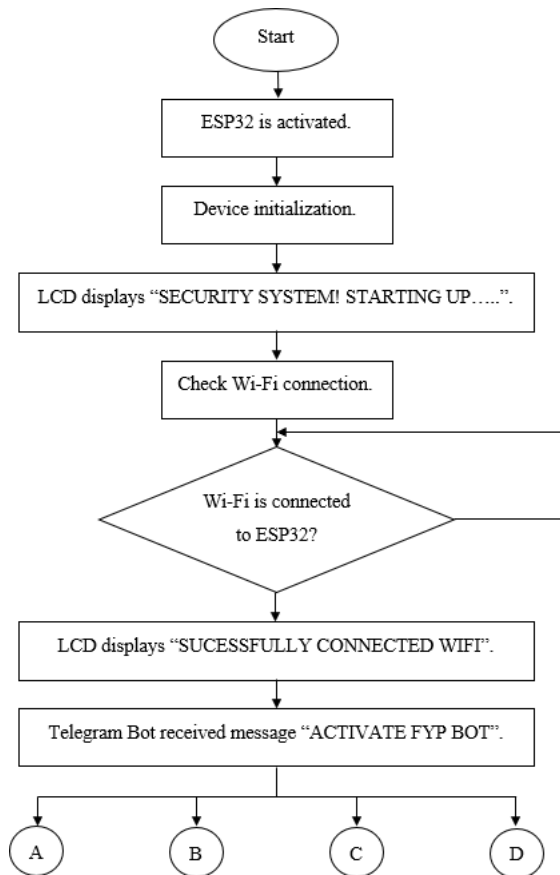
Fig. 3 *Flowchart for the activation of security system*

Table 2 shows the hardware interface of the system. It depicts the mode and the function of the components inside the security system. Fig. 3 illustrates the activation process of the security system where the setup

initialization including the microcontroller, electronic components and Arduino code is done. The Wi-Fi is also made sure to be connected by the microcontroller to ensure the functionality of IoT within the security system. After that, it will only proceed to the performance of the security system.

Table 2 *Hardware interface to the system*

Component	Mode	Function
Keypad	Input	To input password by pressing numbers.
Ultrasonic Sensor	Input	To detect waving action by the user.
Blynk Application	Input	To control the door status with the virtual switch.
Telegram Bot	Input	To control the door status and obtain the door status using related prompt.
LCD	Output	To display the notification message.
Piezo Buzzer	Output	To sound the alert.
Door Servo	Output	To lock or unlock the door.
Smartphone	Output	To obtain related data and information in Telegram.

Fig. 4(a) illustrates one of the primary access controls of the security system which is the keypad control. The keypad is utilized for the user to input the correct password which can either be the default password or the one-time password (OTP) to obtain the authorization and unlock the door for the user to access the area.

According to the password entered by the user, the LCD will provide relevant feedback or messages to indicate whether the password is correct or incorrect. Besides, the user will also receive message from their smartphones. Fig. 4(b) illustrates the usage of an ultrasonic sensor to facilitate the locking or unlocking action of the door by sensing the waving action of the user within the specific range of detection.

(a) **(b)**
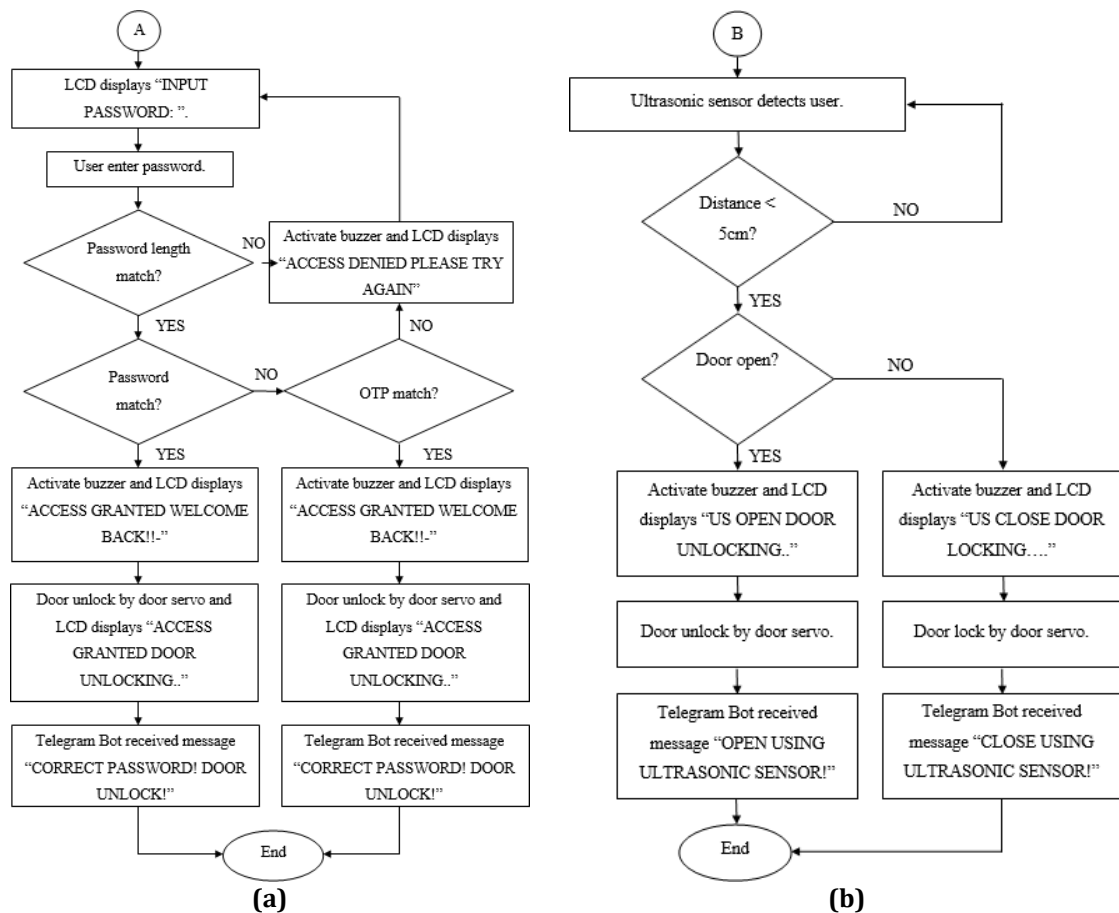
Fig. 4 (*a) Flowchart for keypad control; (b) Flowchart for ultrasonic sensor control*

Depending on the status of the door, it will trigger appropriate action of either locking or unlocking for the access control. As mentioned previously in the keypad control, the security system will send notification message to the user's smartphone to ensure they are informed with the door status in real time.

Fig. 5(a), Fig. 5(b) and Fig. 6 depicts the integration of Blynk and Telegram applications in the security system which utilizes the user's smartphone for efficient access control to the door. In Blynk application, it provides a virtual switch on the smartphone interface for the user to unlock or lock the door easily with a tap.
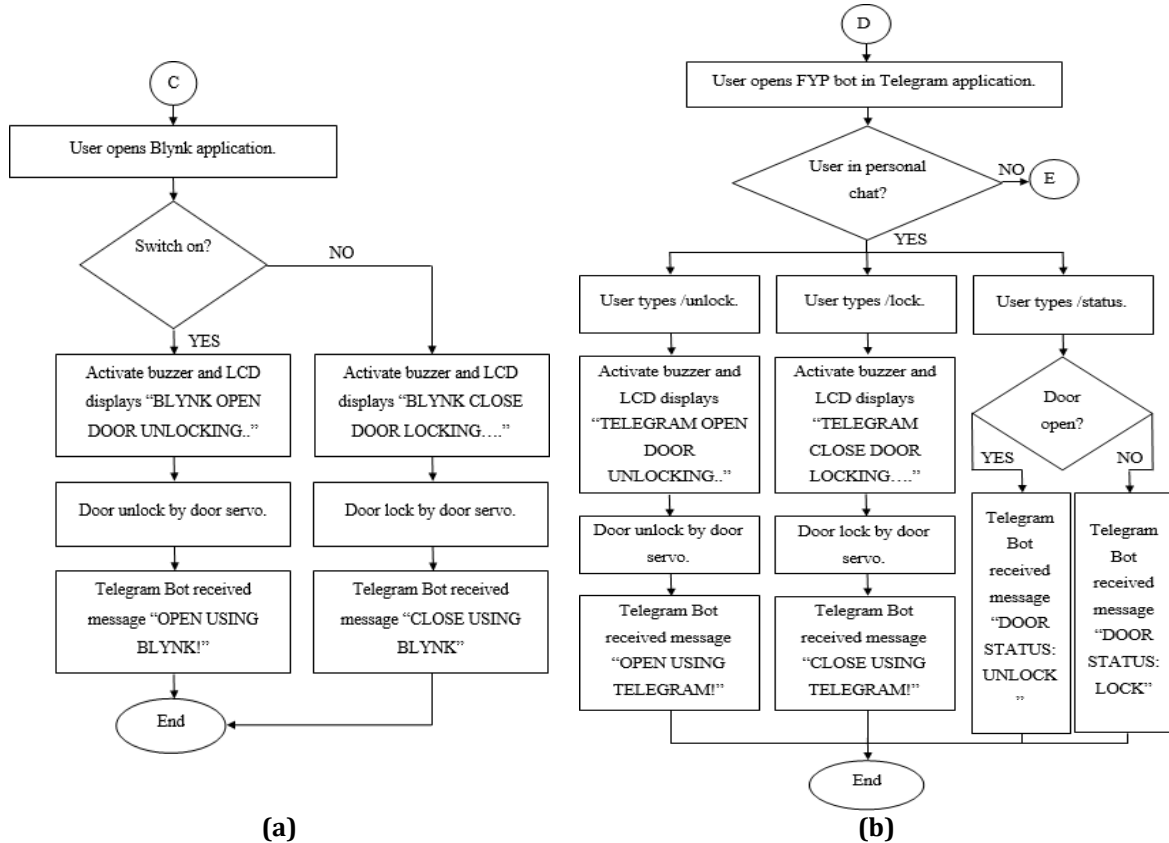

(a)   **(b)**

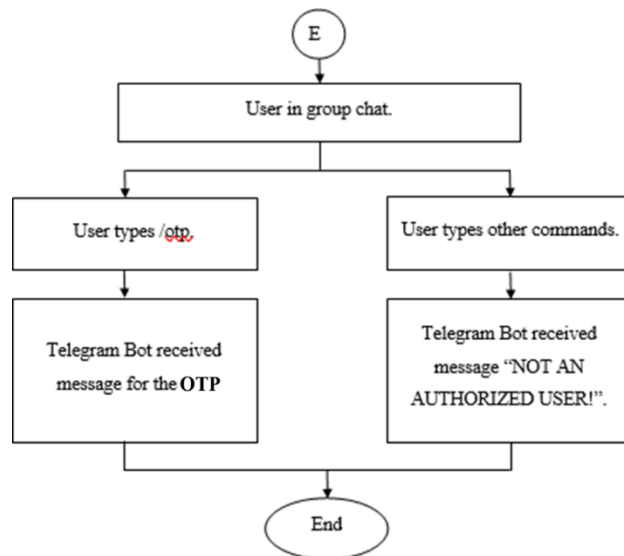**Fig. 5** (*a) Flowchart for keypad control; (b) Flowchart for ultrasonic sensor control*

Fig. 6 *Flowchart for Telegram control (group chat)*

In general, those flow shown in Fig. 4 to 6 are correlated to the preceding flow show in Fig. 3, in which it depending the choice taken by the user at that particular moment. The system will act according to the input given by the user and shown in the related flowchart.

The virtual switch also able to reflect the current state of the door. For Telegram, it offers the additional means for the user to execute control over the security system. The users can send specific commands to lock or unlock the door which trigger the actions on the security system.

Besides, the user can inquire about the current door status using dedicated commands. Apart from that, the user can grant temporary access to trusted individuals such as family members or close friends where they can obtain the OTP in the group chat to gain authorization into the area by themselves.

To keep user up to date, both Blynk and Telegram could provide notifications regarding on the status of the door as well as the user's action to lock or unlock the door. This is to ensure that the user is updated the current status of door lock in real time.

The overall process indicate that the user has full control of the locking mechanism at all time and the current status always updated from time to time through the application connected to the locking system.

4. Results

The hardware for IoT-based smart door lock security system as shown in Fig. 7(a) and Fig. 7(b) is developed according to the illustrated schematic circuit in Figure 1 where all the electronic components are interconnected with each other. The activation which includes the device initialization and the Wi-Fi connection will be done before it enters the functionality of the security system as shown in Fig. 8(a).
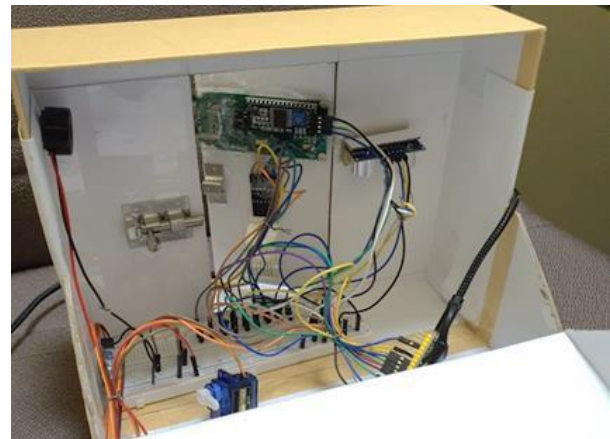
(a) **(b)**

Fig. 7 (*a) Outer view of the hardware; (b) Inner view of the hardware*

The door is locked as initial position as depicted in Fig. 8(b). After that, the security system can be used to manage the access control to the door by offering four distinct methods which includes the keypad control, ultrasonic sensor control, Blynk control and Telegram control. The keypad control specifically allows users to do the unlock action only (Fig. 9(a)) whereas other methods provide the flexibility to do both the locking and unlocking action.

(a) **(b)**

Fig. 8 (*a) Security system activated; (b) Door locks*

Besides, the security system also incorporates advanced features where the countdown timer will initiate when the door is remained open for extended period and locks by itself as shown in Fig. 9(b). In addition, the integration of Telegram introduces additional capabilities to the security system. The user can check the status of the door using specific command to know whether the door is locked or unlocked.

It also able to generate OTP to grant temporary access to authorized individuals as shown in Fig. 10. However, the password has a time limit where the individual must either use it within the period to make sure the input password is valid to enter the protected area.

To keep the user well informed, all the controls in the security system will be able to send updated notification through the Telegram platform (refer Fig.11). The user will be able to receive the messages regarding on the status of the door and actions taken to ensure they have the information wherever and whenever they want.
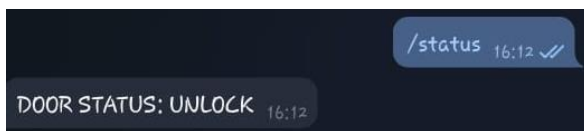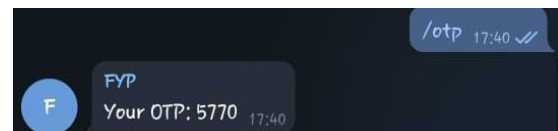

(a)   **(b)**

Fig. 9 (*a) Door unlocks; (b) Countdown timer*

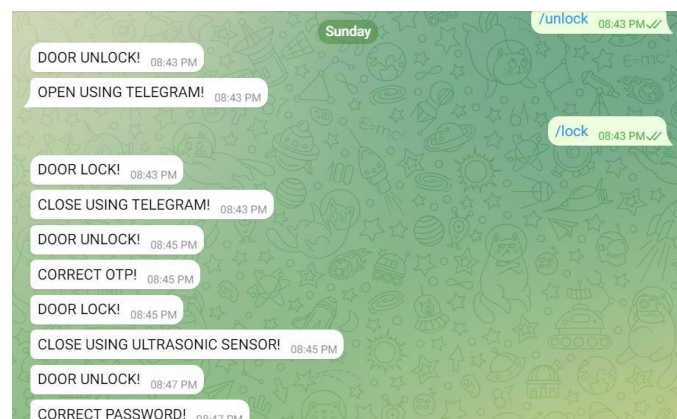**(a)**   **(b)**

Fig. 10 (*a) Notification for door unlocks; (b) OTP generated*

Fig. 11 *Flowchart for Telegram control (group chat)*

5. Discussion

The security system architecture incorporates ESP32 microcontroller to serve as the brain of the overall system which could handle necessary computational tasks as well as facilitates seamless communication among electronic components including ultrasonic sensor, I2C 16x2 LCD, keypad, piezo buzzer and servo motor. Activation process is done to allocate enough time for the security system to load and establish the Wi-Fi connection for it to be able to leverage the functionalities of the IoT, enabling remote access and control. To indicate the security system initialization, the initial status or the door and the Blynk virtual switch are set to a closed state.

There is a total of four methods of access control to the door. The keypad control is utilized to enable to the user to be able to enter the authorized area from the outside when they are physically present in front of the door. For the ultrasonic sensor control, it is to provide convenience to the user by acting as a touchless operation to unlock or lock the door from within the authorized area.

For the remaining two methods of access control, the user will be able to do lock or unlock action remotely regardless of their location or the time. With this, the user grant access to visitors or customers without having to be physically present at the door. Apart from that, the Telegram control also integrates advanced features such as OTP generation and status checking. The user can always stay informed with the current state of the door via Telegram platform using specific command. Trusted individuals by the user can also obtain OTP from the group chat to enter the authorized area via keypad without their access being granted by the authorized user.

6. Conclusion

In conclusion, this work managed to attain the objectives is successfully accomplished. This work showcased a modern and convenient solution to enhance the home security. IoT is a huge revolution in technological field where it aids in digitalizing the world by connecting every household product or other items to the Internet. With the integration of IoT technology into the door security system, it serves as an alternative to traditional key-based access to control access to the door. Apart from that, it also supports more secure authentication which adds on extra layer to protect against unauthorized access and intrusions. Although there are always room for improvements that can be done to further enhance the system with additional functionalities and features, the system itself can basically meet the purpose of the security and serves as an efficient means of protecting home and ensure the safety of individuals.

Acknowledgement

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

*The authors confirm contribution to the paper as follows: **data collection, prototype development and draft manuscript preparation:** Wong Sy Hui; **data and draft manuscript verification:** Rahmat Sanudin. All authors agree on the final version of the manuscript.*

References

Ahmed, A., Abdulkadir, S., Mohamed, J., Ali, S. A., Abdi, M., & Kahie, S. A. (2023). Design and Implementation of an IoT based Smart Door Lock System. *2023 2nd International Conference on Multidisciplinary Engineering and Applied Science (ICMEAS)*, *1*, 1–6. https://doi.org/10.1109/ICMEAS58693.2023.10379324

Akhtar, A., Ahmad, T., Sabahat, N., & Minhas, S. (2019). IoT Based Home Automation System Using ThingSpeak. *2019 International Conference on Computing, Electronics & Communications Engineering (ICCECE)*, 163–168. https://doi.org/10.1109/iCCECE46942.2019.8941737

Do, T.-N., Le, C.-L., & Nguyen, M.-S. (2021). IoT-Based Security with Facial Recognition Smart Lock System. *2021 15th International Conference on Advanced Computing and Applications (ACOMP)*, 181–185. https://doi.org/10.1109/ACOMP53746.2021.00032

Eleyan, A., & Fallon, J. (2020). IoT-based Home Automation Using Android Application. *2020 International Symposium on Networks, Computers and Communications (ISNCC)*, 1–4. https://doi.org/10.1109/ISNCC49221.2020.9297320

Ganesh, G. V, Reddy, A. N., Reddy, A. S. S. V, & Chowdary, N. V. P. (2022). Wireless Biometric Lock Using Arduino with the IoT. *2022 2nd International Conference on Artificial Intelligence and Signal Processing (AISP)*, 1–6. https://doi.org/10.1109/AISP53593.2022.9760583

Gota, D.-I., Puscasiu, A., Fanca, A., Miclea, L., & Valean, H. (2020). Smart home automation system using Arduino microcontrollers. *2020 IEEE International Conference on Automation, Quality and Testing, Robotics (AQTR)*, 1–7. https://doi.org/10.1109/AQTR49680.2020.9129989

Khan, M. A., Nisar, K., Lodhi, E., Khan, J., Khan, M. I., Soomro, T. R., & Nisar, S. (2022). Prototype Model of an IoT-based Digital and Smart Door Locking System with Enhanced Security. *2022 14th International Conference on Mathematics, Actuarial Science, Computer Science and Statistics (MACS)*, 1–7. https://doi.org/10.1109/MACS56771.2022.10023385

Kishore, D. V. S., Babu, Y. M. M., B., Y. M., Anitha, K., & Prabhakar, P. B. E. (2023). Cloud Controlled Home Safety and Management Solution for Equipment Automation via Internet. *2023 7th International Conference on Computing Methodologies and Communication (ICCMC)*, 39–44. https://doi.org/10.1109/ICCMC56507.2023.10083657

Masykuroh, K., Syifa, F. T., Setiyanto, G. R., Ramadhani, A. D., Kurnianto, D., & Iryani, N. (2021). Prototype Smart Door Lock By Using Wireless Network Based on Arduino Uno. *2021 IEEE International Conference on Communication, Networks and Satellite (COMNETSAT)*, 342–347. https://doi.org/10.1109/COMNETSAT53002.2021.9530806

Nath, S., Banerjee, P., Biswas, R. N., Mitra, S. K., & Naskar, M. K. (2016). Arduino based door unlocking system with real time control. *2016 2nd International Conference on Contemporary Computing and Informatics (IC3I)*, 358–362. https://doi.org/10.1109/IC3I.2016.7917989

Nivethika, S. D., Pandian, M. S., Parameswaran, N. G. S., Elakiya, E., Naresh, M., & Dhamodharan, S. (2023). Arduino UNO Based OTP Lock for Integrated Home Security System. *2023 2nd International Conference on Edge Computing and Applications (ICECAA)*, 1342–1347. https://doi.org/10.1109/ICECAA58104.2023.10212109

Raj, L. D. W., Santhosh, K., Subash, S., Sujin, C., & Tharun, P. (2019). Voice Controlled Door Lock System Using Matlab and Arduino. *2019 IEEE International Conference on System, Computation, Automation and Networking (ICSCAN)*, 1–6. https://doi.org/10.1109/ICSCAN.2019.8878708

S., R., Kumar, A. K., Titus, A., Hemajothi, S., Venkatesh, J., & L., A. (2023). Design and Development of an AI based Intelligent Door for Home Security System. *2023 International Conference on Advances in Computing, Communication and Applied Informatics (ACCAI)*, 1–8. https://doi.org/10.1109/ACCAI58221.2023.10200307

Sahu, S., Singh, R., Arya, P., & Nirala, R. (2022). Smart Home Automation Lighting System and Smart Door Lock using Internet of Things. *2022 4th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N)*, 1320–1325. https://doi.org/10.1109/ICAC3N56670.2022.10074243

Shanthini, M., Vidya, G., & Arun, R. (2020). IoT Enhanced Smart Door Locking System. *2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT)*, 92–96. https://doi.org/10.1109/ICSSIT48917.2020.9214288

Simatupang, J. W., & Tambunan, R. W. (2022). Security Door Lock Using Multi-Sensor System Based on RFID, Fingerprint, and Keypad. *2022 International Conference on Green Energy, Computing and Sustainable Technology (GECOST)*, 453–457. https://doi.org/10.1109/GECOST55694.2022.10010367

Sinha, S., Teli, E. H., & Tasnin, W. (2021). Remote Monitoring and Home Security System. *2021 Innovations in Power and Advanced Computing Technologies (i-PACT)*, 1–8. https://doi.org/10.1109/i-PACT52855.2021.9696996

Sobale, S., Patel, K., Patel, A., Nikam, S., Pathrabe, S., & Patil, S. (2022). OTP Based Door Lock System with Mobile Application using Arduino UNO and ESP8266 Wi-Fi module. *2022 Sardar Patel International Conference on Industry 4.0 - Nascent Technologies and Sustainability for "Make in India" Initiative*, 1–4. https://doi.org/10.1109/SPICON56577.2022.10180607

Tatarnikova, T. M., & Ivanova, A. (2020). Access Control System for the Premises Using the "Smart Home" Technology. *2020 Wave Electronics and Its Application in Information and Telecommunication Systems (WECONF)*, 1–5. https://doi.org/10.1109/WECONF48837.2020.9131442

Tippannavar, S. S., S., N., & S, P. K. M. (2022). Smart Home Automation Implemented using LabVIEW and Arduino. *2022 International Conference on Electronics and Renewable Systems (ICEARS)*, 644–649. https://doi.org/10.1109/ICEARS53579.2022.9752265

Zamri, M. A., Kamaluddin, M. U., & Zaini, N. (2021). Implementation of a Microcontroller-based Home Security Locking System. *2021 11th IEEE International Conference on Control System, Computing and Engineering (ICCSCE)*, 216–221. https://doi.org/10.1109/ICCSCE52189.2021.9530966