

Door lock system based on internet of things and Bluetooth by using Raspberry Pi

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ABSTRACT

Recently, there are a large number of smart lock systems that can be used in the workplace or home, but many of them depend on finding an external key, password, fingerprint, and facial recognition, where these systems suffer from weakness as the physical key may be forgotten in a place, the password can be memorized which is hard for some peoples, and the fingerprint system sometimes does not work on people who suffer from chronic diseases, such as people with diabetes and for each of these systems the person needs a free hand so that he/her can open the lock which means that is if the person carries something he/her needs to be placed somewhere. The facial recognition system cannot recognize the person's face when the place has poor lighting. This paper proposes a home door lock system that relies on the internet of things (IoT) technology and portable electronic devices Bluetooth such as a smart mobile using the device Bluetooth media access control (MAC) address as a key and the IoT for monitoring, which leads to a door lock that does not require a free hand. The proposed lock system outcome can be a good candidate for home security applications.

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1. INTRODUCTION

In our daily life, we see many kinds of locks, which may be door locks in a certain place, car door locks. These locks are divided into traditional and smart door lock (SDL) see [1]-[3], Figure 1. Generally, the origin of the mechanisms of locks and keys are still unknown. Although archaeological evidence of early locks remains scant, numerous articles and books have been written over past two centuries. Historically, from the beginning, all locking devices and keys were made entirely of solid wood, especially those seen in Egypt and Mesopotamia. The key made from wood appears to have emerged very early in most different cultures that rely on wood as basic material and even now as a key tool. Wooden locks make a lot of sense; they are very similar in how they operate and function [3]. In fact, various types of wooden key specimens are preserved in many houses and structures with traditional doors in most parts of the world, especially in the Mediterranean region. Alternatively, it is difficult to determine who inspired whom, in terms of the cultural impact of door locks, or whether the similarities can be seen as similar solutions to problems or needs common to all of humanity. It seems that the earliest simple tool locks and wooden keys may have been invented by several early civilizations at the same time [4]-[6]. In general, we can say that ropes and cords were used to tie doors, and legend has it that knotted ropes became a common symbol of safety in

various early cultures. According to Curtis and Pontin, locks and keys made of bronze and iron were used after the bronze age [4], [7].

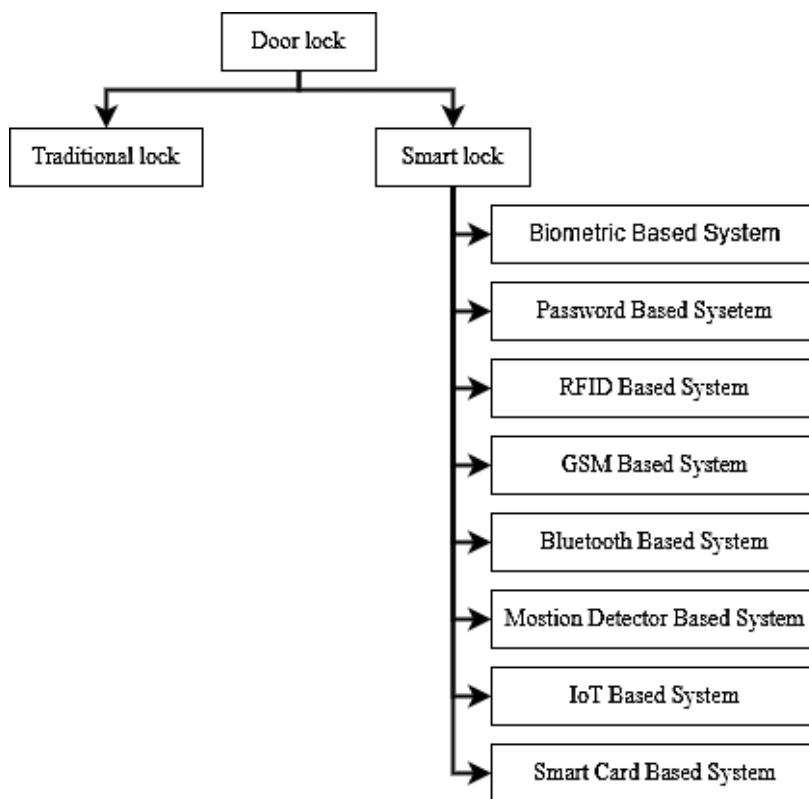


Figure 1. Types of locks

The world doesn't seem like a safe place these days, but a home security system is needed to deter hackers and thieves [8], [9]. Installing home security is very important and can be a way to give us the peace of mind we deserve. Home security systems are the perfect way for us to increase our overall sense of security. There are many types of security on the market today, such as biometric fingerprint security, face detection security, dynamic signatures, and more [10]-[12]. Hands-free key-opening technology is another way to open the door when we lose the key because we don't have it and the system relies on the mobile phone to be the key, because the mobile phone has become an essential thing in people's life and has been carried and carried everywhere. Never forget. The security aspect is the top concern of IoT connected entities. Data can be personal, corporate or consumer [13], [14]. To come up with an acceptable SDL application, security must be viewed as a major challenge. Advances in digital technology have changed how locking mechanisms and keys work and are made to the point that the small plastic pieces, numbers and codes within the computer chips inside them are more effective than locks made of metal, opening with a key. In theory, any mechanical locks that operate with a key are an option. Meanwhile, all locks are an option, Linus Yale explained that any lock that relies on a key and a keyhole has the ultimate risk, although the solution is to not use a key at all [15], [16].

2. METHOD

The scheme or architecture and the physical structure of the developed system is given in Figure 2. The system basically consists of three components. First component is an interface tool or a hardware that can access to the authorization page, which can connect to the wireless network, such as smartphone, tablet or laptop computer belonging to the user. The second component is a low-cost and card-size computer (Raspberry Pi 3), which is connected to the door lock so that it can send a direct electrical opening command and runs a web server software, magnetic lock, and camera. The mini-computer must be directly connected to

the wireless network and has a static IP address on this network. Each user has a different username and secret key.

The admin can register user using an App that work on android and iOS Figure 3 also the admin can answer the door without the need for him/her to come near the door by using the App he/her can open it remotely by seeing an image of the visitor at the door and open the door see Figure 4. Only the admin installs the App the users do not need any App to open the door. For a registered user wants to pass through a door, he/she should open their Bluetooth of their smart device and automatically connect and submits his/her user secret key information (Bluetooth media access control (MAC) address) to the mini computer of the door. At this stage, the control software running on the mini computer connects to the authentication service (AS) and investigate whether the user has a permission to enter or not at that time see Figure 5.

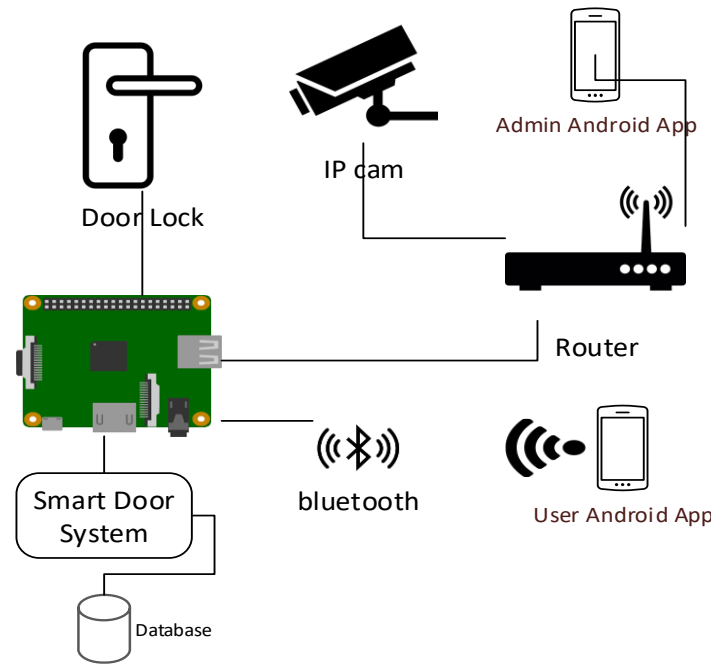


Figure 2. System architecture for SDL system

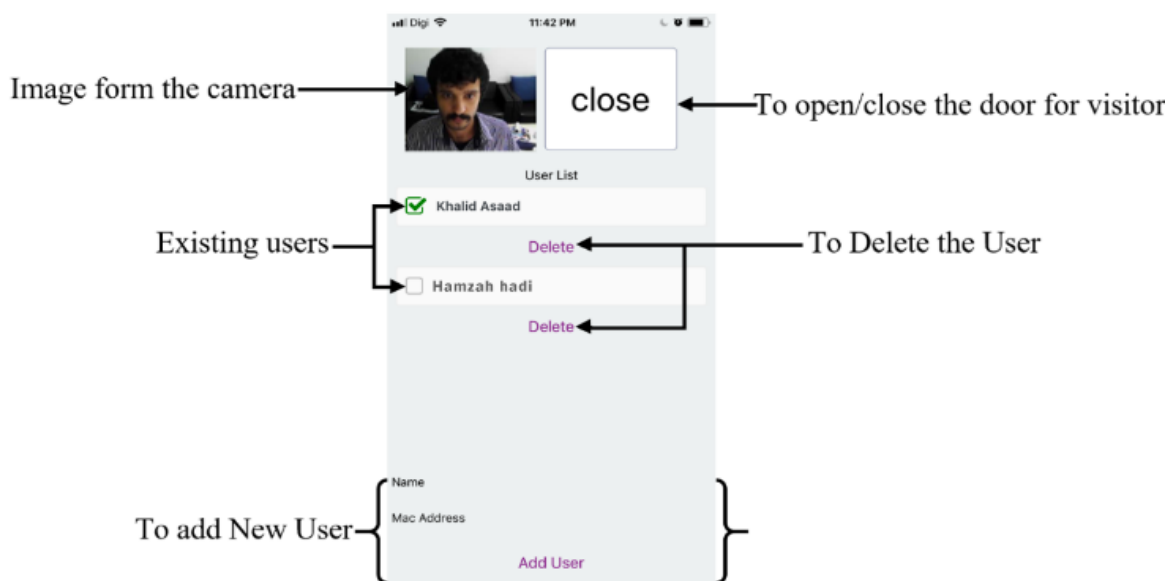


Figure 3. SDL App

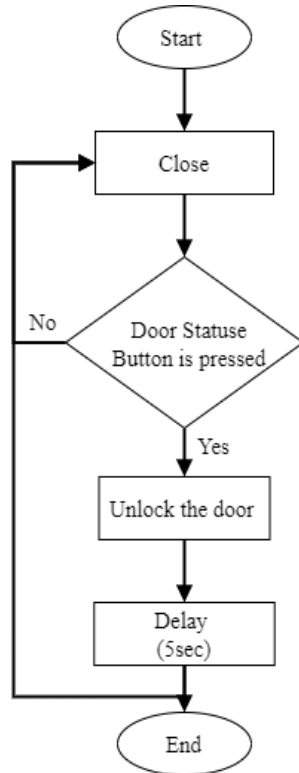


Figure 4. Unlocking door using App

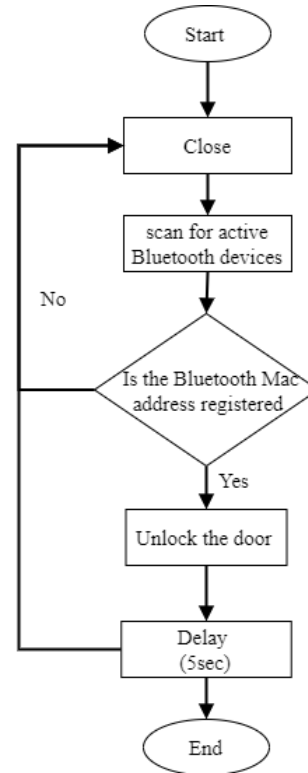


Figure 5. Unlocking door using Bluetooth

3. SYSTEM HARDWARE

3.1. Main controller (Raspberry Pi 3)

Raspberry Pi 3 shown in Figure 6 is small computer it uses a standard keyboard and mouse on a computer screen, or a low-cost credit card sized computer connected to a TV. This is a small device that allows people of all ages to explore computing and learn how to program in languages like Scratch and Python. From web surfing to high-definition (HD) Video Playback, Spreadsheet, Word Processor, and Game. All the things the desktop expects can do [17], [18].



Figure 6. SDL App [19]

3.2. Magnetic lock

Magnetic lock shown in Figure 7 is a locking device assembled with electromagnet and iron plate Figure 6. The electromagnet is used to control the entire locking mechanism. By connecting the electromagnet of the door frame and the engine plate to the door. In today's world, magnetic locks with other locks are compared very cheaply and are cheaper than conventional light bulbs. The concept of magnetic lock depends on electromagnetism. It consists mainly of an electromagnet that attracts the connector with a sufficiently large force so that the door does not open [20], [21].

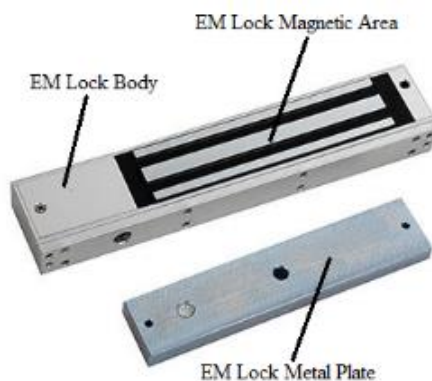


Figure 7. Magnetic lock

3.3. DL-link WiFi camera (DCS-930/930L)

DCS-930/930L shown in Figure 8 is a unique and versatile monitoring solution for your home or small office. Unlike traditional webcams, DCS-930/930L is a complete system with built-in CPUs and web servers that send high-quality video images for security and surveillance. A simple installation and intuitive web-based interface provides an easy integration with ethernet or 802.11 n wireless networks. DCS-930/930L also comes with remote monitoring and motion detection capabilities for a complete and cost-effective home security solution [22], [23].



Figure 8. DL-link WiFi camera (DCS-930/930L)

4. SOFTWARE

In order to make the system work with multiple users the system should have database here google firebase is used because it has analytics, authentication, messaging, and real-time features that make it somewhat better than other databases and also the admin (house owner) should have an app to add/delete the users and open the door to visitor also the app should work on android and iOS and that can be done by using Expo [24], [25]. Expo is an open source framework for applications running natively on android, iOS, and the web [26]. Expo brings together the best of mobile and web, and enables features important to building and Scaling Apps, such as Live Updates, Real-Time App Sharing, and Web Support. The expo npm package brings these features to any React Native project where Develop and shared performant websites and complex in browser using JavaScript without the need for Xcode and Android Studio and Major upgrades don't need for native changes.

5. RESULTS AND DISCUSSION

5.1. Registered users in database

There are two types of register users as show in Figure 9 are that permitted to enter the house and don't permitted to enter the house. Users that are permitted to enter the house are registered in the database who have permission to enter the house. For example, Khalid Asaad as shown in Figure 9(a) has been permitted to enter the house with the checked status is "true". Therefore, once the Raspberry Pi detects the

active Bluetooth (Figure 9(b)) and the MAC address matched with the database, the EM lock will be disconnected, and the door will be opened.

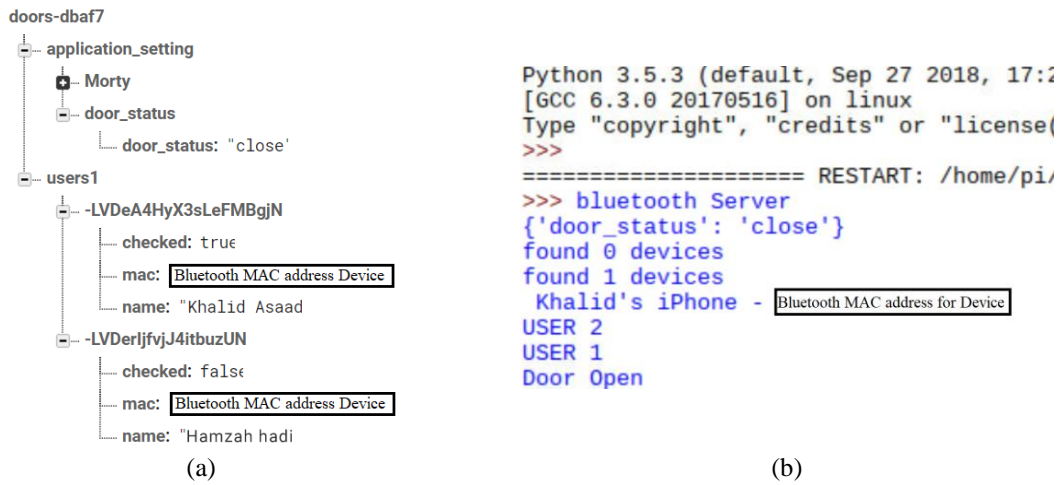


Figure 9. Raspberry Pi feed for users that been allowed to open the door (a) Raspberry Pi output and (b) firebase database

Users that are registered in the database but not permitted to enter the house like user (Hamzah Hadi). When the user is near the door the Raspberry Pi will match the MAC address in the database. Even the MAC address is matched, but the door will stay close because the checked status is “false”. This is showing that; the owner/admin has the authority either to permitted or unpermitted the registered user to access the house.

5.2. Unregistered device

The same process will occur, where the Raspberry Pi will detect the active Bluetooth, and try to match the MAC address with the database. Once it is mismatch, the door remains close. For unregistered Device, the controller still can capture and display the information of the unregistered Device such as “found 1 device”, “THINKPAD-PC” (device type and name) and MAC address of the device as shown in Figure 10. Therefore, the admin could aware any intruder that intend to get into their house.

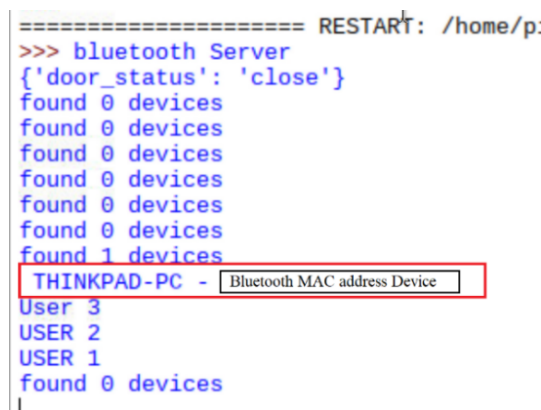


Figure 10. Raspberry Pi feed for unregistered device

5.3. Homeowner

The home/office owner can remotely open the door for any visitor using the Door Lock App. For instance, when the doorbell is ringing the owner can see who is at the door by clicking on the camera feed

box in the App. The image will be refreshed and the image of the visitor will appear. He/she has to presses on the status button in the App to open the door as shown Figure 11.

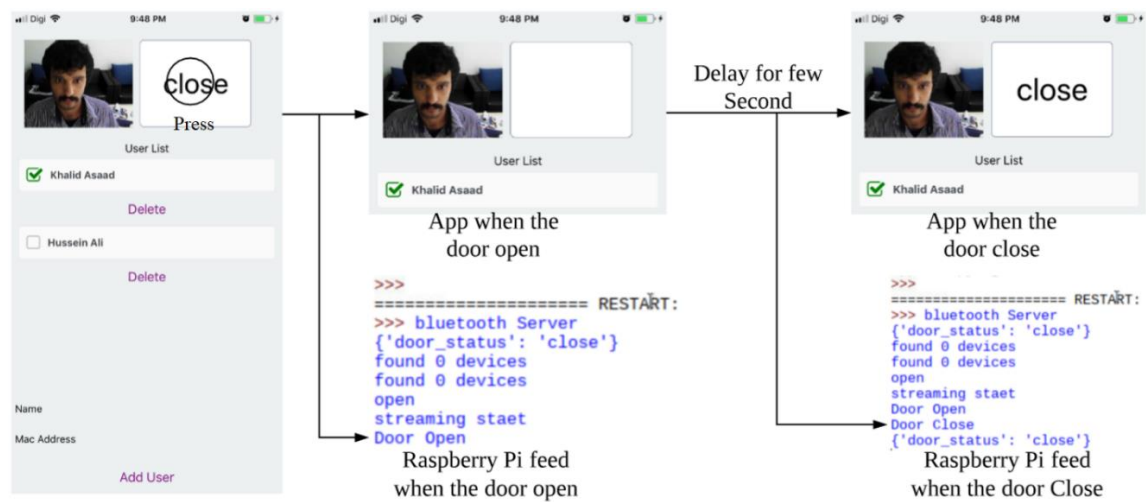


Figure 11. How open the door to visitor

5.4. Multiple doors

There are two ways to make the system operating at multiple door locks shown in Figure 12. First, by adding sub-database for each door lock (door 1 and door 2) as shown in Figure 12(a) and simultaneously the second page in the App will be added as shown in Figure 12(b). This door 2 page will have the same appearance and layout as door 1 page.

The second way is by adding two checkboxes in front of each user shown in Figure 13 where the first checkbox for door one and the other one is for door two as shown in Figure 13(a). Even, the admin can check the boxes for both doors for any user based on his/her preference. Meanwhile, the database will only have one sub-database for the door as illustrated in Figure 13(b). The only issue in the multi door lock system is that there will be some delay in the system when two or more users approach different doors at the same time and that because the Raspberry Pi can detect one device at a time. The delay will come in form of one of the users that the Raspberry Pi detect its Bluetooth first can open his/her door before the others.



Figure 12. Two-door locks system using two sub-databases (a) firebase database and (b) Door Lock App

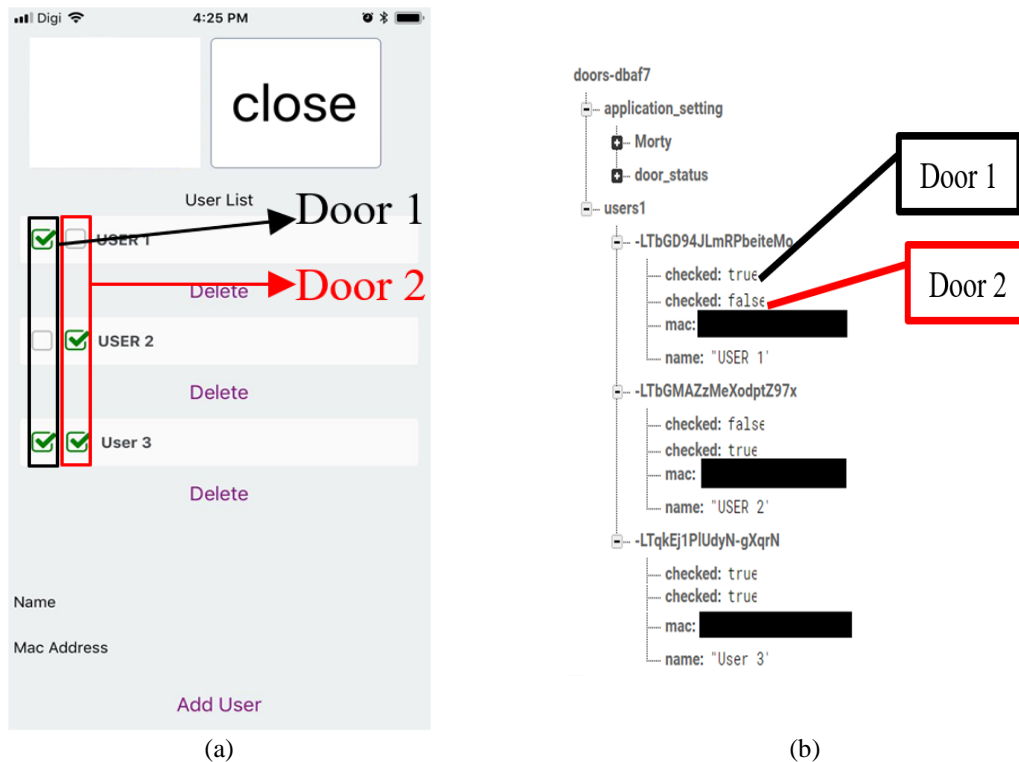


Figure 13. Two door locks system using the same sub-database (a) Door Lock App and (b) firebase database

6. CONCLUSION

The SDL system can run properly and stably. It can be implemented as the designed, needed functions and features. This could be accomplished and achieved just by proper hardware software and development, as well as multiple debug and test procedures. All the planned features and functions were implemented successfully in the system: all the needed user information was displayed in the mobile app in both OS android and IOS. All the data could successfully pass from the mobile apps to the Raspberry Pi server through the firebase service.




REFERENCES

- [1] C. Vongchumyen *et al.*, "Door lock system via web application," in *2017 International Electrical Engineering Congress (iEECON)*, Mar. 2017, doi: 10.1109/ieecon.2017.8075909.
- [2] H. H. Qasim, A. E. Hamza, H. H. Ibrahim, H. A. Saeed, and M. I. Hamzah, "Design and implementation home security system and monitoring by using wireless sensor networks WSN/internet of things IoT," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 10, no. 3, pp. 2617-2624, Jun. 2020, doi: 10.11591/ijece.v10i3.pp2617-2624.
- [3] N. N. Nagamma, M. V. Lakshmaiah, and T. Narmada, "Raspberry Pi based biometric authentication vehicle door locking system," in *2017 IEEE International Conference on Power, Control, Signals and Instrumentation Engineering (ICPCSI)*, Sep. 2017, doi: 10.1109/icpcsi.2017.8392138.
- [4] D. Aswini, R. Rohindh, K. S. M. Ragavendhara, and C. S. Mridula, "Smart Door Locking System," in *2021 International Conference on Advancements in Electrical, Electronics, Communication, Computing and Automation (ICAECA)*, Oct. 2021, doi: 10.1109/icaeca52838.2021.9675590.
- [5] J. Vegas, C. Llamas, M. A. González, and C. Hernández, "Identifying users from the interaction with a door handle," *Pervasive and Mobile Computing*, vol. 70, p. 101293, Jan. 2021, doi: 10.1016/j.pmcj.2020.101293.
- [6] O. A. Hasan, A. T. Rashid, R. S. Ali, H. H. Qasim, M. A. A. Sibahee, and L. Audah, "Design and implementation of a centralized approach for multi-node localization," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 12, no. 3, pp. 2477-2487, Jun. 2022, doi: 10.11591/ijece.v12i3.pp2477-2487.
- [7] V. Sariitha, S. L. Chandana, U. S. B. K. Mahalaxmi, D. Shamia, P. Chawla, and A. Chaturvedi, "An intelligent sensing and detection system for accident preventions in four wheeler vehicles," *Materials Today: Proceedings*, Jun. 2021, doi: 10.1016/j.matpr.2021.05.353.
- [8] H. H. Qasim, A. M. Jasim, and K. A. Hashim, "Real-time monitoring system based on integration of internet of things and global system of mobile using Raspberry Pi," *Bulletin of Electrical Engineering and Informatics*, vol. 12, no. 3, pp. 1418-1426, Jun. 2023, doi: 10.11591/eei.v12i3.4699.




- [9] H. H. Ibrahim *et al.*, "A comprehensive study of distributed Denial-of-Service attack with the detection techniques," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 10, no. 4, pp. 3685-3694, Aug. 2020, doi: 10.11591/ijece.v10i4.pp3685-3694.
- [10] Y. J. Xin, W. Zhong, and L. Hong, "Smart Gate System Design and Implementation Based on Cloud Platform," *Procedia Computer Science*, vol. 154, pp. 40-46, 2019, doi: 10.1016/j.procs.2019.06.008.
- [11] M. A. Omran, B. J. Hamza, and W. K. Saad, "The design and fulfillment of a Smart Home (SH) material powered by the IoT using the Blynk app," *Materials Today: Proceedings*, vol. 60, pp. 1199-1212, 2022, doi: 10.1016/j.matpr.2021.08.038.
- [12] A. A. Almayyahi, R. Sulaiman, F. Qamar, and A. Essa, "High-Security Image Steganography Technique using XOR Operation and Fibonacci Algorithm," *International Journal of Advanced Computer Science and Applications*, vol. 11, no. 10, 2020, doi: 10.14569/ijacsa.2020.0111064.
- [13] Andreas, C. R. Aldawira, H. W. Putra, N. Hanafiah, S. Surjarwo, and A. Wibisurya, "Door Security System for Home Monitoring Based on ESP32," *Procedia Computer Science*, vol. 157, pp. 673-682, 2019, doi: 10.1016/j.procs.2019.08.218.
- [14] J. Patel, S. Anand, and R. Luthra, "Image-Based Smart Surveillance and Remote Door Lock Switching System for Homes," *Procedia Computer Science*, vol. 165, pp. 624-630, 2019, doi: 10.1016/j.procs.2020.01.056.
- [15] Z. Zhu and Y. Cheng, "Application of attitude tracking algorithm for face recognition based on OpenCV in the intelligent door lock," *Computer Communications*, vol. 154, pp. 390-397, Mar. 2020, doi: 10.1016/j.comcom.2020.02.003.
- [16] Y. Motwani, S. Seth, D. Dixit, A. Bagubali, and R. Rajesh, "Multifactor door locking systems: A review," *Materials Today: Proceedings*, vol. 46, pp. 7973-7979, 2021, doi: 10.1016/j.matpr.2021.02.708.
- [17] M. S. Hadis, E. Palantei, A. A. Ilham, and A. Hendra, "Design of smart lock system for doors with special features using bluetooth technology," in *2018 International Conference on Information and Communications Technology (ICOIACT)*, Mar. 2018, doi: 10.1109/icoiact.2018.8350767.
- [18] A. E. Hamza *et al.*, "Design and implement WSN/IoT smart parking management system using microcontroller," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 10, no. 3, Jun. 2020, doi: 10.11591/ijece.v10i3.pp3108-3115.
- [19] Mehrunnisa, J. S. Priyanka, and B. S. Chandra, "Automatic Door Un-locking and Security System Using Raspberry Pi," in *2022 IEEE International Conference on Distributed Computing and Electrical Circuits and Electronics (ICDCECE)*, Apr. 2022, doi: 10.1109/icdcece53908.2022.9793143.
- [20] N. Harke, A. Patil, Y. Nimbalkar, S. Khore, and P. S. Rathod, "Smart Door Lock System Using Face Recognition," *International Journal for Research in Applied Science and Engineering Technology*, vol. 10, no. 5, pp. 3111-3113, May 2022, doi: 10.22214/ijraset.2022.43015.
- [21] N. Y. L. Venkata, C. Rupa, B. Dharmika, T. G. Nithin, and N. Vineela, "Intelligent Secure Smart Locking System using Face Biometrics," in *2021 International Conference on Recent Trends on Electronics, Information, Communication and Technology (RTEICT)*, Aug. 2021, doi: 10.1109/rteict52294.2021.9573869.
- [22] T.-N. Do, C.-L. Le, and M.-S. Nguyen, "IoT-Based Security with Facial Recognition Smart Lock System," in *2021 15th International Conference on Advanced Computing and Applications (ACOMP)*, Nov. 2021, doi: 10.1109/acomp53746.2021.00032.
- [23] M. A. Y. Ali, E. A. Hussein, and D. M. Abdulsahib, "Multi-Security System Based on Fingerprint Biometric Sensor and Wi-Fi Camera," in *2022 Muthanna International Conference on Engineering Science and Technology (MICEST)*, Mar. 2022, doi: 10.1109/micest54286.2022.9790226.
- [24] N. Thorve and M. Subhedar, "Vehicle antitheft mechanism using IoT," *Materials Today: Proceedings*, vol. 66, pp. 3609-3615, 2022, doi: 10.1016/j.matpr.2022.07.135.
- [25] Y. Saif *et al.*, "Roundness Holes' Measurement for milled workpiece using machine vision inspection system based on IoT structure: A case study," *Measurement*, vol. 195, p. 111072, May 2022, doi: 10.1016/j.measurement.2022.111072.
- [26] H. A. Saeed *et al.*, "IoT health monitoring system for preventing and controlling risk in confined space using microcontrollers," *International Journal of Engineering and Technology*, vol. 8, no. 4, p. 619, Dec. 2019, doi: 10.14419/ijet.v8i4.30134.

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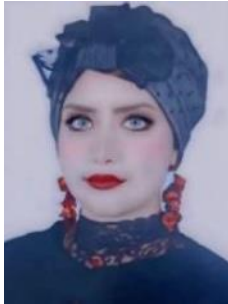
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