Intelligent Door Lock

Leveraging Bluetooth, Wi-Fi, Image Recognition, and 4X4 matrix keypad for Robust Access Control

***Abstract*—This research paper presents an innovative automatic door lock system that integrates Bluetooth, Wi-Fi, Face recognition, and a 4X4 matrix keypad to enhance security and convenience. The system aims to provide robust access control by leveraging modern technologies and multiple authentication methods. Bluetooth and Wi-Fi enable remote access and control, while Face recognition facilitates real-time user identification. The 4X4 matrix keypad is another alternative option. The system's architecture, implementation, experimental setup, and results are discussed, demonstrating its effectiveness in ensuring reliable and efficient door access control. The proposed solution has promising applications in various settings, including residential, commercial, and public environments.**

Keywords — Raspberry Pi, Wi-Fi, Bluetooth, Face recognition, 4X4 matrix keypad

I. INTRODUCTION

Automatic door lock systems have become increasingly popular in various settings, ranging from residential homes to commercial buildings, due to their ability to provide enhanced security and convenience. These systems utilize advanced technologies to improve access control and ensure a seamless user experience [1]. This research paper introduces a sophisticated automatic door lock system that combines Bluetooth, Wi-Fi, image recognition, and a 4X4 matrix keypad to achieve robust security measures and efficient door access control. [2]

The traditional lock and key mechanisms pose several limitations in terms of security, as keys can be easily lost, stolen, or duplicated without authorization. Automatic door lock systems address these concerns by integrating modern technologies, offering a more reliable and secure solution. By combining Bluetooth, Wi-Fi, Face recognition, and a 4X4 matrix keypad, the proposed system aims to provide comprehensive and multi-layered authentication methods for access control. [3]

Bluetooth technology enables wireless communication between devices over short distances, allowing for remote access control. By connecting a smartphone or other authorized devices to the automatic door lock system via Bluetooth, users can conveniently lock or unlock the door without physical keys. This feature enhances convenience and allows for remote access management. [5]

Wi-Fi connectivity expands the capabilities of the system by enabling broader connectivity options. Users can control the door lock system remotely through an internet connection, granting access to authorized individuals even when they are not physically present on-site. [7] The integration of Wi-Fi technology also allows for seamless integration with other smart devices and home automation systems, further enhancing the overall functionality and user experience. [6]

Face recognition technology plays a vital role in the proposed automatic door lock system. By employing sophisticated algorithms, the system can identify authorized individuals through captured images or real-time video streams. [8] This method ensures that only authorized personnel are granted access, significantly improving security measures. If an unauthorized person is captured then it will notify the owner. Image recognition also allows for customization, such as creating a database of authorized users and assigning different access levels based on their identities. [10]

To further enhance the security of the automatic door lock system, a 4X4 matrix keypad is incorporated. Users must provide a unique code or password on the 4X4 matrix keypad to gain access. And users can use any one door lock system to get an efficient door access control. [4] [9]

In this research paper, we will delve into the design, implementation, and evaluation of the automatic door lock system utilizing Bluetooth, Wi-Fi, Face recognition, and a 4X4 matrix keypad. The subsequent sections will discuss the system architecture, methodologies employed, experimental setup, data collection, and analysis of results. The objective is to demonstrate the effectiveness and practicality of the proposed system in ensuring reliable and efficient door access control.

II. LITERATURE REVIEW

1) Z. Mu, W. Li, C. Lou and M. Liu

This paper investigates and explores the application of smart door locks based on Bluetooth control technology. It examines the advantages and limitations of Bluetooth-based systems, conducts experimental tests to evaluate their practicality, and discusses potential applications beyond residential settings. The research contributes to practical guidelines for users and manufacturers, highlighting the promising potential of Bluetooth-controlLED smart door locks in enhancing security and convenience.

2) M. Shanthini, G. Vidya and R. Arun

This paper introduces an IoT enhanced smart door locking system, which leverages the Internet of Things (IoT) technology to revolutionize access control. The study explores the system's architecture, functionality, and benefits, showcasing its ability to offer enhanced security, remote access, and seamless integration with smart home ecosystems. The research emphasizes the potential of this cutting-edge technology in transforming traditional door locking mechanisms into intelligent, efficient, and user-friendly solutions for modern living.

3) B. Swathi, A. S. Kanoi, H. Kumar, J. H. Sinha and G. Sasank Redy Gajjala

The "No Key" Smart Door Unlock System presents an innovative approach to secure and convenient access control. This system employs biometric technology, specifically fingerprint recognition, in conjunction with Bluetooth communication. By integrating these technologies, the traditional physical key is replaced, offering enhanced security and user-friendly interaction. The user's fingerprint is stored and authenticated via a Bluetooth-connected device, eliminating the need for a physical key and providing a seamless and efficient method for unlocking doors. This abstract highlights the fusion of biometrics and wireless communication to revolutionize door access, emphasizing improved security and ease of use in the modern world.

4) S. K. Yashwant, P. V. Krishna, B. N. V. S. B. Kumar, G. Chandan and J. V. D. Prasad

iLock is a state-of-the-art, sophisticated door lock designed for wireless devices. This paper presents an in-depth analysis of iLock's advanced features, including biometric authentication, remote control capabilities, and seamless integration with wireless devices. The study showcases how iLock enhances security, convenience, and accessibility, making it a cutting-edge solution for modern access control needs. The research highlights iLock's potential in shaping the future of smart home security, offering users a seamless and secure way to control and monitor their door locks using wireless devices.

5) C. -T. Lee, Y. -C. Chung, T. -C. Shen and K. -W. Weng

This paper introduces a novel approach to electronic lock systems. By leveraging smartphone gesture passwords and the robust RSA algorithm, traditional lock mechanisms are transformed. This innovation enhances security through personalized gesture-based authentication, eliminating the need for physical keys or traditional codes. The abstract highlights the integration of secure RSA encryption with user-friendly smartphone gestures to create an advanced electronic lock system.

6) B. C. R, S. Joy, A. S. Bale, A. S. Naidu, V. N and V. S N

This paper outlines a technological breakthrough in the realm of IoT door lock automation. By harnessing advanced computing techniques, this innovation revolutionizes traditional locking systems. Through seamless integration with the Internet of Things (IoT), doors can be automated, enabling remote control and monitoring. The abstract emphasizes the fusion of cutting-edge computing with IoT capabilities, resulting in efficient and secure door lock automation for modern smart environments.

7) N. R. S, R. Venkatasamy, J. A. Dhanraj, S. Aravinth, K. Balachandar and D. N

This paper presents the design and development of an IoT-based smart door lock system. The study explores the architecture and implementation of the system, leveraging Internet of Things (IoT) technology for intelligent access control. The research highlights the integration of various sensors and communication protocols to enhance security, convenience, and remote access capabilities. The study showcases the potential of this innovative smart lock system in transforming traditional door locks into a sophisticated and efficient solution for modern living, offering users seamless control and monitoring of their doors through IoT-enabLED devices.

8) S. Bhatlawande, S. Shilaskar, T. Gadad, S. Ghulaxe and R. Gaikwad

This paper presents a smart home security monitoring system based on face recognition technology and an Android application. The study explores the design and development of the system, which combines facial recognition algorithms with a user-friendly Android app for seamless access control and real-time monitoring. The research highlights the system's ability to enhance security by accurately identifying authorized individuals and alerting homeowners to potential intrusions. The study showcases the potential of this integrated solution in providing a reliable and convenient approach to smart home security, enabling users to monitor and control access from their Android devices with ease.

9) V. Pandit, P. Majgaonkar, P. Meher, S. Sapaliga and S. Bojewar

This paper represents a paradigm shift in security solutions. Leveraging artificial intelligence and advanced technology, this innovation offers a proactive and adaptable approach to safeguarding assets. By continuously analyzing patterns and user behavior, the intelligent lock enhances security through real-time threat assessment and instant response mechanisms. This abstract underscores the integration of AI-driven intelligence into security systems, ensuring a dynamic and effective safeguarding solution for various applications.

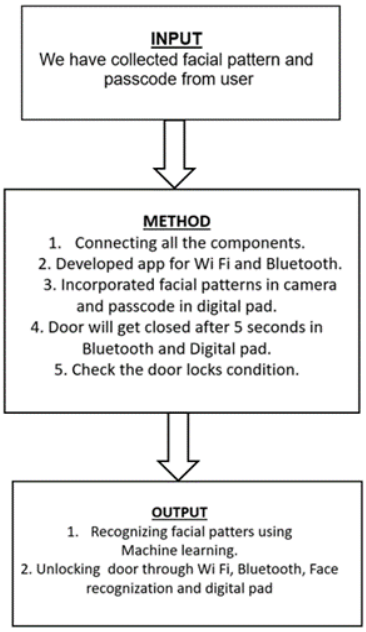
10) Singh, A. D. (2022, May 31).

This paper presents a cutting-edge application of technology in access control. Through the utilization of facial recognition and the versatile Raspberry Pi platform, traditional door locks are transformed into highly secure and user-friendly systems. This innovation enables seamless entry based on facial features, eliminating the need for physical keys or cards. The abstract underscores the convergence of face recognition and Raspberry Pi's capabilities, highlighting an advanced door lock solution that offers both convenience and enhanced security.

III. METHODOLOGY

A. Conceptual Framework

This provides an advanced security solution that utilizes Bluetooth, Wi-Fi, Image Recognition, and a 4X4 matrix keypad to establish robust access control. In face recognition we will incorporate the owner's facial data, if it captures an unauthorized person then it will alert the owner and a passcode to unlock the door using a 4X4 matrix keypad. Owner can also unlock the door using Wi-Fi and Bluetooth through an app. The door will be open for 5 seconds with Bluetooth and 4X4 matrix keypad.



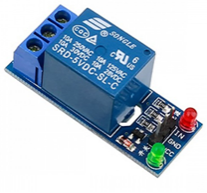
B. Components

Raspberry pi 3B+

The Raspberry Pi 3 Model B+ is a powerful single-board computer released in 2018. It features a 1.4 GHz quad-core processor, 1GB RAM, Wi-Fi, Bluetooth, Gigabit Ethernet, and GPIO pins. Popular for diverse projects like home automation and gaming due to its affordability and community support.

Relay Module 5V

A Relay Module (5V) is an electronic component that acts as a switch, controlLED by an external signal, to open or close a circuit. It's commonly used to control higher voltage or current devices with a low-voltage signal, such as from a microcontroller like an Arduino or Raspberry Pi. The "5V" designation refers to the operating voltage of the relay module.



Solenoid Lock 12V

A 12V solenoid lock is an electromechanical device that uses an electric current to control the movement of a locking mechanism. When energized with 12 volts, the solenoid generates a magnetic field, causing a plunger to move and engage or disengage the lock. These locks are commonly used in security systems, access control, and automation applications where remote locking and unlocking is needed.

12V Adapter along with DC Jack

A 12V adapter with a DC jack is a power supply unit that converts AC (alternating current) voltage from a wall outlet into 12V DC (direct current) output. The DC jack serves as the connection point for the adapter's output, allowing it to power various devices and electronics that require a 12V power source. This setup is commonly used for a wide range of applications, including powering LED strips, cameras, routers, and other electronics requiring a stable 12V power input.

4X4 Keypad

A 4x4 keypad is an input device featuring a grid of 16 buttons arranged in a 4x4 matrix format. Each button represents a specific character, number, or function. When a button is pressed, it completes a circuit in the corresponding row and column, allowing a microcontroller or similar device to detect and interpret the pressed key. 4x4 keypads are commonly used in various electronics projects, security systems, and control interfaces.

720p USB Camera

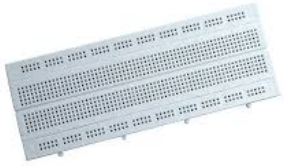
A 720p USB camera is a compact imaging device capable of capturing video and images at a resolution of 1280x720 pixels. Connected via USB, it's easily integrated into various devices like computers, laptops, and single-board computers. With its HD resolution, it's suitable for video conferencing, live streaming, surveillance, and other applications where clear visuals are essential.

64GB MicroSD Card

A 64GB MicroSD card is a small, portable storage device that offers 64 gigabytes of memory capacity. It's commonly used to expand storage in smartphones, cameras, and other devices with MicroSD card slots. With its ample space, it can store a significant amount of data, including photos, videos, documents, and applications, making it a versatile and convenient storage solution for various digital needs.

Breadboard

A breadboard, also known as a prototyping board or solderless breadboard, is a fundamental tool in electronics and prototyping. It provides a convenient platform for quickly assembling and testing electronic circuits without the need for soldering.



LED Light

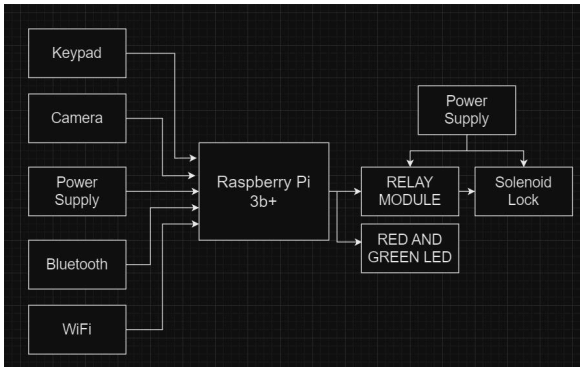
An LED (Light-Emitting Diode) is a semiconductor device that emits light when an electric current passes through it. LEDs have become a widely used and energy-efficient lighting solution in various applications due to their longevity, low power consumption, and compact size.

Jumper wires

Jumper wires are essential components in electronics and prototyping that are used to establish temporary electrical connections between various components on a breadboard, printed circuit board (PCB), or other similar platforms. These wires are crucial for creating

and testing circuits without the need for soldering, allowing for quick experimentation and design iteration.

C. Block Diagram



The Intelligent Door Lock System utilizes a Raspberry Pi 3B+ as its core component, integrating a keypad, camera, Bluetooth, and Wi-Fi functionalities. The system's block diagram consists of:

User Input Modules:

Keypad: Allows users to input PIN for authentication.

Camera: Captures images or video for identity verification.

Wi-Fi: allows user to remotely control GPIO pins

Bluetooth: Communicates with authorized devices for proximity-based authentication.

Raspberry Pi 3B+:

Processing Unit Receives data from input modules, performs authentication, and makes access decisions.

Authentication Logic:

Trained Data: Stores authorized user data for comparison.

Decision Logic: Analyzes input data and database to determine access authorization.

Lock Control:

Electronic Lock: ControlLED by Raspberry Pi to grant or deny access.

Wireless Communication:

Bluetooth Module: Facilitates communication with authorized devices.

Wi-Fi Module: Enables remote access and control.

User Interface:

Wi-Fi Connection: Provides remote access through devices connected to the same network.

Mobile App: Allows users to control and monitor thelock remotely.

Power Supply:

Raspberry Pi Power: Supplies power to the Raspberry Pi and its modules.

Lock Power: Supplies power to the electronic lock.

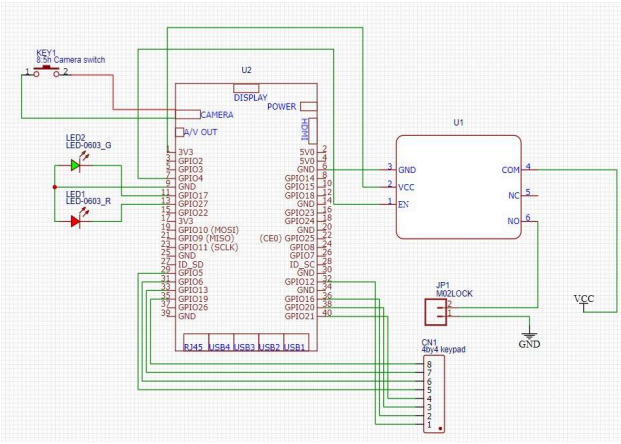
Camera Control:

Raspberry Pi Camera Interface: Captures images or video for verification.

Authentication Feedback: green and red LED

LEDs: Provides visual or audible feedback on access attempts.

D. Schematic Diagram



1. Raspberry Pi: Microprocessor that controls the GPIO pins and stores code for execution.

2. Solenoid Lock: Electric Solenoid lock being controlLED by a system.

3. Relay Module: Electrically operated switch for controlling the Lock.

4. 4x4 Matrix Keypad Module: Keypad is used as an input device to read the key pressed by the user and to process it. The 4x4 keypad consists of 4 rows and 4 columns.

5. USB Camera: USB camera is used to detect and verify the face of a person and authorize it to lock or unlock the door.

6. LED: Red and Green LED are used to determine the Tries to unlock the door.

Connections:

- 3.3 Volts input is connected to the VCC of the relay module.
- Ground of the Raspberry Pi is connected to the Ground of the relay module.
- GPIO4 is connected to the Input pin of the relay module.
- One terminal of the lock is connected to the Normally Open(NO) pin of the relay module.
- Another pin of the lock is connected to the ground .
- Common pin(COM) of the relay module is connected to the 12V power supply.
- GPIO pins 12,16,20,21 are connected to the column pins of the 4x4 matrix keypad.
- GPIO pins 5,6,13,19 are connected to the row pins of the 4x4 matrix.
- GPIO17 and GPIO27 are connected to the Green and Red LED respectively and both LED's are connected to the ground.
- USB camera is connected to the one of the USB port of the Raspberry Pi.

E. Conceptual Application

In this we have features like Wi-Fi, Bluetooth, face recognition and 4X4 matrix keypad. Where the user has the flexibility to choose any feature. For incorporating facial patterns we used Machine Learning for face recognition and passcode was incorporated through a python code in Raspberry Pi. Through BlynkIOT, BlueDotowner can unlock doors with Wi-Fi and Bluetooth. For 5 seconds and gets closed automatically after 5 seconds in Bluetooth and 4X4 matrix keypad.

F. Implementation of Hardware

Input and power supply is taken from laptop or 5V adapter using USB to B-type cable.

Wi-Fi:

The raspberry pi is connected to the home Wi-Fi. Through Wi-Fi raspberry pi receives integer values which leads to locking and unlocking of the door.

Bluetooth:

When the user with Bluetooth access to raspberry pi is nearby the smart locking system. They can connect to raspberry pi through Bluetooth and send serial messages through Bluetooth to command the door to lock or unlock.

4x4 matrix keypad:

The matrix keypad's column is connected to GPIO pins 12, 16, 20, 21 and rows with GPIO pins 5, 6, 13, 19. The user can use the correct passcode to

unlock the door. If the entered passcode is correct then green LED should light up and if it's wrong then red LED will blink.

Facial Authorization

The USB Camera connected to the raspberry pi detects the face of the person present in front of the camera. If the face matches the trained data of the authorized person present in raspberry pi then the door gets unlocked and green LED will blink otherwise if the face doesn't match then the red LED will light up.

Usage of Relay Module

The Ground and VCC of the relay module is connected to ground and 3.3V pin of raspberry pi. GPIO 4 pin is connected to the input pin of the relay module. From a 12V power supply ground is connected to the solenoid lock directly and 12V wire is connected to common (COM) of the relay module. The normally open pin(NO) of the relay module is connected to another terminal of the solenoid lock. Whenever GPIO 4 becomes low the circuit is completed and the door will unlock.

G. Implementation of Software

Wi-Fi:

To control lock through GPIO 4 using Wi-Fi, a Blynk application is being used. When code is launched the raspberry pi is connected to the Blynk device based on the authorization token given in the Blynk application and then through the application we can make a switch and control GPIO 4 which basically controls the lock. This is secured because the Blynk application is protected with email and password.

Bluetooth:

For controlling GPIO through Bluetooth, a BlueDot application is used. In code we define the pins which are used to control the lock according to which blue buttons appear inside this application whenever it's connected to raspberry pi(in our case 1 blue button). Everyone cannot access our lock through Bluetooth using this same application because we need to add the Bluetooth device from inside raspberry pi which is username and password protected.

4x4 matrix Keypad

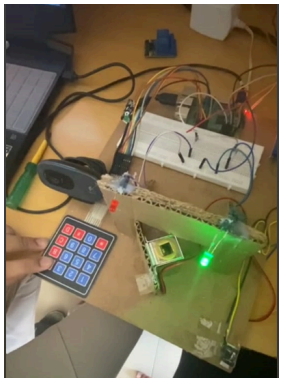
The pins which are connected to the 4x4 matrix keypad are defined in the code. The button values are also defined in the code. Two of the buttons on the keypad are made as a special button and they act as enter button and clear button. Whenever a key is pressed it gets stored inside a variable. When the enter key is pressed then if the value stored in variable and the passcode matches then door will unlock and GPIO 17 also gets output which lights up green LED and if password is wrong GPIO 27 will get output to blink red LED.

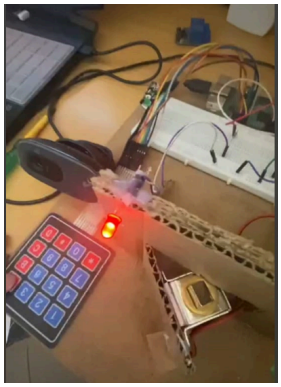
Face Recognition

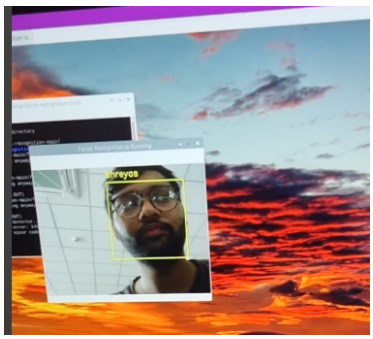
The authorized user's face data is trained and stored inside raspberry pi. Whenever a person's face is detected by the camera then it will check that if the face matches the authorized person and will send output to unlock the door accordingly. Also when an intruder is detected through the camera in Raspberry Pi , then it will send an email notification to authorized.

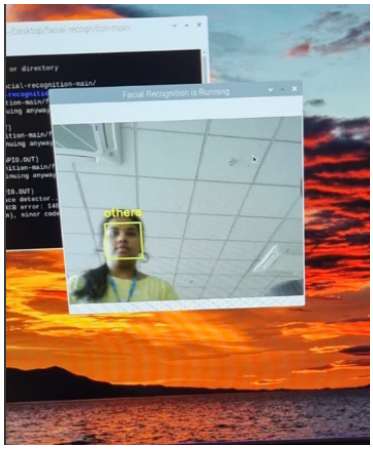
H. Results

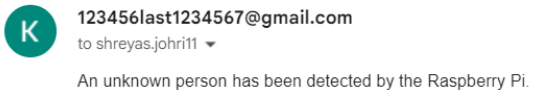
By using BlynkIOT and BlueDot the door gets unlocked through Wi-Fi or Bluetooth. When an authorized person whose face is recognized by raspberry pi is able to unlock the door and it will be open till raspberry pi recognizes an unauthorized person. And if some unauthorized person tries to open the door then it won't get unlocked as it is an unrecognized data of face for raspberry pi. And by entering the correct passcode the door gets unlocked if the passcode is wrong then a red light will blink. The door is closed after 5 seconds when we unlock it through Bluetooth and a 4X4 matrix keypad.











IV. CONCLUSION

In summary, the Intelligent Door Lock System, incorporating Bluetooth, Wi-Fi, Face recognition, and a 4X4 matrix keypad, offers a robust and versatile approach to access control. By combining these technologies, the system achieves heightened security and user convenience. Its adaptability and potential for future innovation make it a significant contribution to the field of access control systems. Further research could refine its integration and usability, while real-world testing would validate its effectiveness across various scenarios. In conclusion, this system sets a promising direction for enhancing security in an increasingly interconnected world.

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