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DESIGN AND CONSTRUCTION OF A SMART DOOR LOCK WITH AN EMBEDDED SPY-CAMERA

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Abstract— Doors are designed for safety, protection of people, places and properties which should be kept locked when not in use to have a secured home, but there has been high level of concern with issues of security and safety with doors and its structure. At present, most doors are under mechanical lock and key which are not adequately secured from authorized individual. This smart door lock system with embedded spy camera as security solution used to view video of a persons who tries to accessor gain entrance to home and to ensure that guest is not under attack while granting access to the door. The method of implementation involves the use of ESP-32 AI enabled interfaced with Arduino microcontroller-ATMEGA328P to control the locking and unlocking process of the door. Designing and implementing a security system for door locking purpose based on GSM technology, monitoring camera, alarm system and web app. The system uses a camera for video surveillance and it remotely transmits video images to the phone/computer using Wi-Fi as medium and allow door control from any location. This system is enabled when a call is received from a registered mobile no; when a command is received from its mobile app or by entering the IP address and password, the door is opened and the authorized user is allowed access to the house. The entrance door is closed after few microseconds to prevent unauthorized users gaining entrance. Again, if another person arrives, the system requests either of the mode to give access. The designed system was tested in real-time and has shown competitive results compared to other work without the methods used.

Keywords—Security, Smart door, Android Smart Phone, Microcontroller, Door Security System, Arduino Uno

I. INTRODUCTION

Security and safety are one of the common issues that brings worries for human being. As Security of human life and property is one of the paramount challenges facing nations and corporate organization [17]. Home security and possessions can be one of the most essential challenges faced by individuals, corporate organizations or any other nation [2]. Human lifestyle, behaviour and thinking in modern society is changing radically with the advancement in technology, and the simple home is changing into a smart home. This is due to advancement in technology which has increased the safety and security of people along with their belongings.

Doors are entrances to homes, offices and many other kinds of enclosure; they may also provide access for visitors, lawbreakers and criminals. Doors are meant to be secured and to prevent intrusions from unwanted persons; and are controlled majorly by locks and keys. From time past until present, security locks usually include mechanical devices made of forged metal such as simple lock and bolt, the door chain, pin tumbler lock, the jam lock and padlock [6]. The common way everyone is familiar with is using physical keys to lock or unlock door, but this tested and known method comes with it challenges. There can only be one unique key for a lock. For different locks you have different keys. Furthermore, carrying a large number of keys is a burden and increases the chance of keys getting stolen, misplaced or lost [7]. People always remain busy in their day to day work and also want to ensure the safety of their belongings. Sometimes they forget to look after their necessary

things like keys, wallets etc. Without these, they are unable to access their home or any place they access using keys.

In this modern world with already more than 7billion human population, expected to exceed 11billion by 2100 to be living in the world [28], crime has become ultra-modern in nature, theft and home abduction is on the rise by day. Which has raised question about doors and the safety of homes and other kinds of enclosure. Individuals and cooperate bodies are becoming more aware of the dangers associated with relying on keys and parameter fencing to provide security to exclusive areas of their apartments and organization because criminals and fraudsters can forge keys or make master keys that can be used to break into such rooms or offices. So, security does matter in this daily life [1]. The disadvantage of traditional lock is that when homeowners lost key and have no alternative key, they have to wait for long hours for a technician to come, otherwise they will have to break the door or lock. Another challenge with keys is that key may be locked away or maybe misplaced inside the house, in this case even authorized persons won't have access to his/her property or belongings [2].

The function of pad lock and jam lock is to prevent an unauthorized person from gaining access to a place. [6] say that the simple jam lock and pad lock can be forced open or the keys duplicated by unauthorized persons which is however classified as a loop holes which give an unauthorized individual access to where they are excluded. Therefore, they cannot be completely relied on. It is hence vital to provide a smart security door, one which is also efficient and reliable; with high discriminative capability, non-reliance on the physical quality of the individual concerned, does not have key access or any physical locking interface and which is by far less expensive than their counterparts [13]. There are so many systems already existing in the society to provide security, among those the microcontroller-based door lock system is one of the best methods to provide security [15]. The smart door lock system requires adequate security for user data control, monitoring and securing every device itself. There are several advantages of smart lock system, being that, it is secure, unapproved individuals won't have any means of accessing the home and there is no requirement for a key. The main thing which will be required is a smartphone to call the door with the required app installed.

Considering current global security challenges around, the importance of a real time smart door and security system is important. This paper presents the development of a prototype smart lock with embedded spy camera system by presenting the concept of lock system. The development of the basic component to achieve the prototype will also be presented. The experimentation of the system and the result which was the prototype will be presented (in plates) and discussed.

II. RELATED WORKS

[18] proposed a low cost and low complexity microcontroller-based door access control system, a security door system which adopted a valid smart card to authenticate and/or deny entry to a room or building. A smart digital door lock for home automation was proposed in the work of [19] their work embedded Zigbee module in a digital lock equipped to use digital details like secret code, smart card, and finger prints as the method for authentication instead of the mechanical key system and the door lock acts as a central controller of the overall system. [11] designed a storage locker system using the biometric technique of fingerprint recognition as a means to activate the opening and closure of the lock. [29] prototype a security door that can be remotely controlled. A GSM phone set acting as the transmitter and another GSM phone set with dual tone multi-frequency (DTMF) connected to the door motor through a DTMF decoder interfaced with microcontroller unit and a stepper motor.

[16] designed security door that opened by pressing the keys of the assigned codes on the mobile phone, or by entering the corresponding code in a computer set interfaced with the system. The door opens automatically when the right code is entered and remains open for 10 seconds before closing back. [8] designed a GSM-based biometric access control system. The Fingerprint Scanner automatically scans a finger placed on it, and compares it against its template. The GSM module is used in the acknowledgement mode to send an Access Request SMS to the Admin Phone. If the admin acknowledges the request, the microcontroller opens the door and displays "access granted".

Other smart lock system has been built around Bluetooth and Radio frequency identification (RFID) technology. [22] was based on short ranged Bluetooth Technology on Android Mobile devices for door lock security and controlled using android application. [26] work was based on video technology stored in cloud along with Bluetooth technology on Raspberry Pi for communication between visitor and owner as a security feature. [12] presented a prototype system of door locks automation system using Bluetooth-based on android Smartphone. The design is the combination of android smart phone as the task master, Bluetooth module as command agent, Arduino microcontroller as controller center/data processing center, and solenoid as door lock output. [10] implemented lock system using Bluetooth Technology Android based smart door lock system with multi-user feature for a single lock. [24] uses an Arduino having an HC-05 wireless Bluetooth Transceiver for controlling door. The application uses Arduino as its controller and HC-05 as a communication link between mobile applications. A cellphone-controlled password-protected door lock system was proposed in [1] to open door with the help of an Android app that generates a password recognized by Bluetooth to control the opening and closing of the door located at some distance from the

user. [20] proposed android based smart door lock system with normal mode and multimode user operations, combining the use of GSM module, Electric Door Strike, and Bluetooth HC-05 interfaced on an Arduino Uno Board.

[30], [31], [32] and [23] made improvement not using only RFID but advanced the security level by adding fingerprint and GSM mobile system, [19] build up with the addition of DTMF and GSM system, and [14] system uses RFID and GSM mobile system, [5] uses the RFID and GSM mobile system but ensures that users are informed about the level of operation of the system by displaying operations on the LCD. [13] designed an automation system based on wireless technologies. Door opening and closing was controlled by RFID, ZigBee and GSM. [9], designed a system in which the user unlocks door using RFID system and SMS code in case of card failure using GSM protocol. The system also uses a live streaming camera. DTMF is used to access the lock of the inside doors of the infrastructure using cell phone of the authorized person. [4] designed a RFID smart system using GSM and password for security purpose in operating the functions of a smart door.

The advancement in technology calls for more security level with smart doors, [25] proposed an automated door control system employing Wi-Fi as well as GSM technology built around Atmega8 microcontroller. [21]design an IoT smart door locking system using finger print sensor, Bluetooth HC-05 and Servo motor interfaced with Arduino board. The system uses finger sensor to read identity to know if there is a match between a scanned and already stored finger print. Then the Bluetooth is used to activate the door control. [27] worked on IOT based smart door lock system their work installed a servo on door and interfaced buzzer and keypad on Arduino board. In the system user is expected to enter a PIN code for a verification system. The PIN is verified and afterward the door is either unlocked or a buzzer sounds an alarm calling attention and the door remains unlock to the visitor. [2] implemented a real-time door locking security systems using Arduino Uno R3 as the main microcontroller interfaced with Fingerprint Reader R305 scratch-resistant sensor with image resolution of 500 pixels per inch and Door lock solenoid (NC-0837L) for opening and closing of smart door.

Considering the trend of global security environment, the importance of good physical security is imperative. Initially, normal key locking was the security locks used to restrict entrance, but were hacked by unwanted people by either duplication of key or physical means. There were several automatic identification technologies including barcode, magnetic stripe and Radio-frequency identification (RFID) system that were applied in security system, though with limitations. With technological advancement, electronic automatic identification systems with varying degree of security feature were deployed to restrict entrance.

This paper presents the development of a prototype RFID-GSM Based security Lock System by presenting the concept of lock system. The development of the basic component to achieve the prototype will also be presented. The experimentation of the device before achieving the desired device will also be presented (in plates) and discussed. The result which was the prototype of the device will be presented (in plates) in sequential order.

III. SYSTEM STRUCTURE

The smart door lock system with embedded spy camera integrated with other wireless components was employed in this system. The system coding and development for the smart door involves integration of both hardware and software system design. The embedded software coding was implemented in Arduino integrated development environment (IDE) using C language. The smart door lock system operates over WIFI network, GSM Module and Mobile App. This system is friendly to operate. When the system is power ON, it initializes all the modules connected to it which includes ESP-32 Cam, solenoid electric door latch, buzzer, SPST and SIM 800L GSM module. The smart door when powered on put a call across to a registered number to alert the home owner that the door in powered on. The smart door systems allow the user to either call the door, use a mobile app or uses the system IP and password before further action is taken. If any of the above step is valid, the door will be opened and if all attempt failed the door remained closed. Figure 1 shows the block diagram of the smart door system embedded with a spy camera.

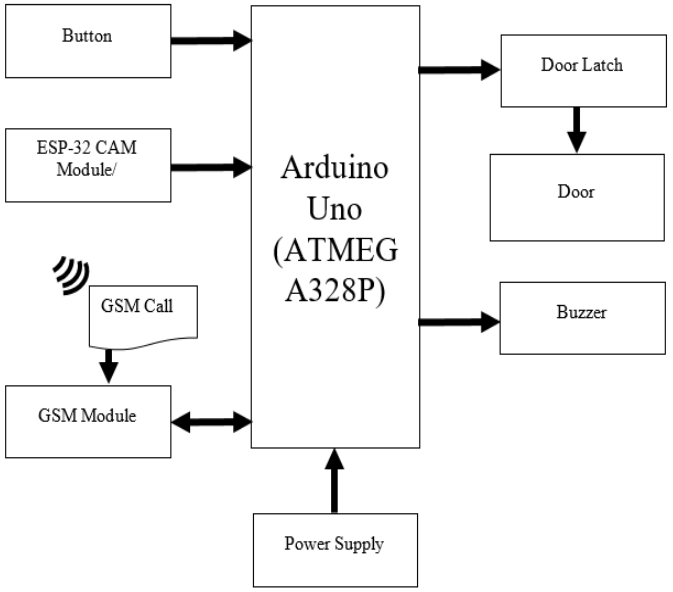

Figure 1: Smart Door Lock System Block Diagram

DEVELOPMENT OF THE SMART LOCK SYSTEM

The whole circuit was developed around a constructed Arduino Uno (ATMEGA328P) board and all the input-output devices including ESP32-CAM, Sim 800L GSM module, Single pole single throw (SPST) button, solenoid door lock and three LED indictors were connected to it via jumper wires. The circuit was powered by +12v AC power supply units and a backup battery in case of power outage. The LEDs were used as indicators in this design, the Red LED indicates Power On status, the Amber LED indicates state of WIFI connection and the Green LED indicates the status of smart Door working. The time of Door Locking operation can be extended or reduced by altering the delay values in the firmware. Initially the experimental set-up was developed as shown below in Figure 2a and 2b.

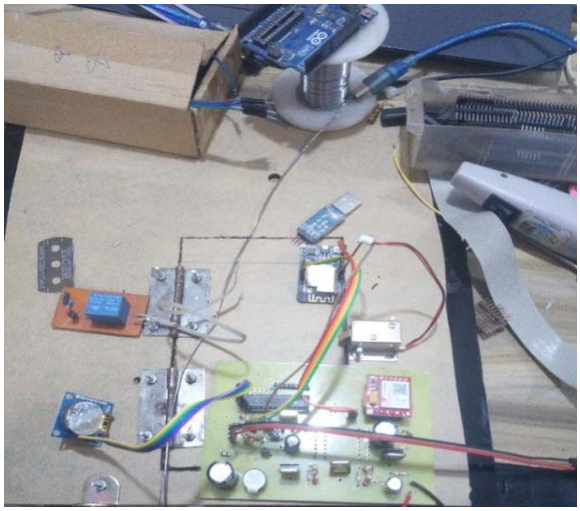

Figure 2a: Construction stages of Smart door lock component

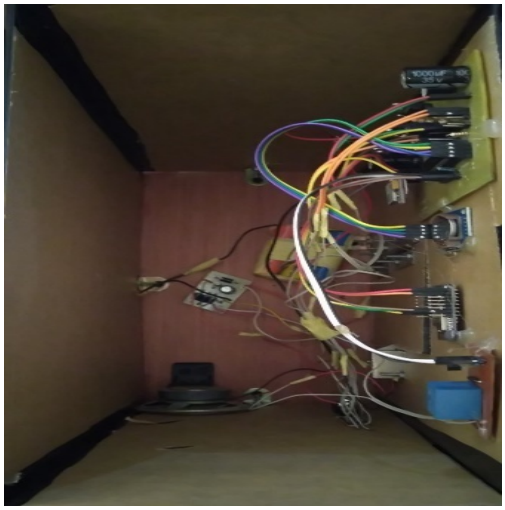

Figure 2b: Construction stages of Smart door lock component

Workings of the Smart Door System

The implementation of the smart door system with embedded spy camera provides a 3-level of user authentication module which can be used to access the door at any giving period of time from any location. This system has been able to implement a system based on WIFI, GSM Call and android mobile Apps-based authorization for system resourceful, privacy and trustworthy of the home users or administrator and provides adequate security level against intruders. These 3-level stages are illustrated below. To enable the working of the door, the power adaptor which is a 12V adaptor is connected to power source and the power button is switched on, the system initialized all other hardware, establish connection with the internet, then give a voice sound “Smart door now ready” and puts a call across to a registered number to tell that the smart door is ready to work.

i. Testing Camera View of Visitor at Door Environment

Plate 1a shows the initial configuration for the door camera view of visitor at the door before the buttons are embedded to be a single button illustrated with Plate 1b. The smart door can be opened to a guest through a defined webpage to the display screen of the visitor or intruder at the door. Here the smart door greets the visitor based on the time of the day; this stage makes use of the ESP-32 CAM and WIFI function to transmit the environment feature to the home owner. Where the home owner wants to grant entrance to the visitor, the home owner automatically opens the door to the visitor by dragging the center button to the right hand side of the screen either on a mobile phone or personal computer, else the owner ignores and watch what action the visitor is about to perform to make a decision of alerting the security agency for prompt action. Furthermore, the camera view option also ensures that a person at the door is not forced to have the door opened to gain unlawful entrance using a visitor as a pass.

Plate 1a: Front view of the smart door prototype

Plate 1b: Side view of the smart door prototype

ii. Opening the Smart Door through Mobile Application

Plate 1 shows the working of the smart door lock IP address and password screen that can be used to unlock the door. Here the user is expected to enter the smart door IP address and password to the door on the mobile app then press the "OPEN" button to enable the door opening from any location. If a valid IP address and password is entered through the phone mobile app by the user, this will control the door opening (access granted). Also, if an invalid IP address and/or password is entered, it will deny guest/user access to the entrance of the building.

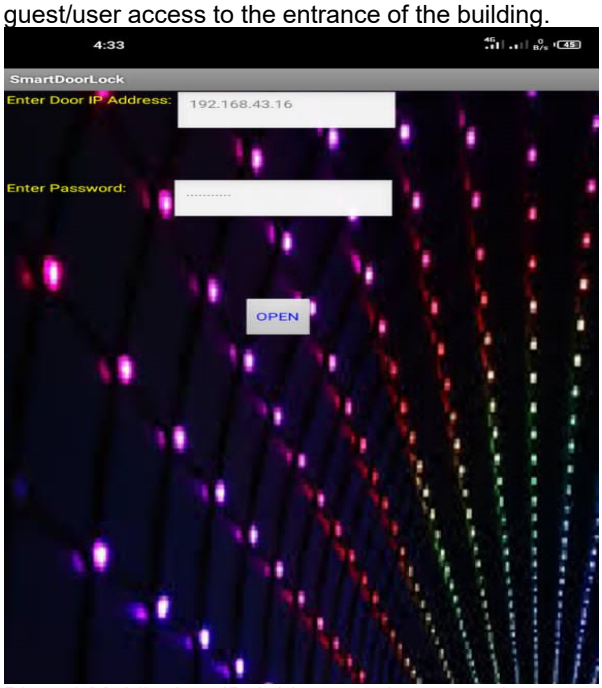

Plate 1 Mobile App IP Address and password screen

iii. Opening the Smart Door Through GSM Call

Plate 2 illustrate the opening of the smart door through a GSM call. The smart door can be opened by simply calling the door through the phone of enrolled user of the smart door. This authentication mode allow access to the door where Internet network connection to the door failed and this gives answers to the problem highlighted in research work on the issue of failed biometric enrollment of a smart lock user. Where a call is made to the door, the microcontroller authenticates to see if the call is from a registered user, where it is confirmed the door is opened and if otherwise, the door remains unlocked.

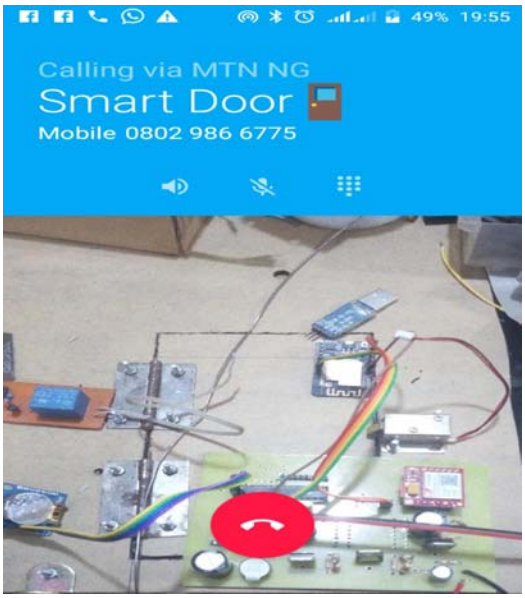

Plate 2: GSM call to Smart Door Screen

iv. Using of SPST (Single Pole Single Throw) Internal Press Button

Plate 3 shows the illustration for the opening of the smart door from the inside to a visitor when the home owner is inside the building which is another mode of operation of the door. This allows the user to press a SPST (Single pole single throw) button without necessarily using the other mode of operation available for the opening of the smart door. Although with this level the user may choose to view the video of the guest at the door before making decision to open the door or not to open the door to the quest. The use of press button also relieves the user from using other options from inside.

Plate 3: Button function of the smart door from the inside

IV. DISCUSSION

The smart door lock system was implemented by integrating the ESP-32 CAM an AI thinker with spy camera with Arduino Uno (ATMEGA 328P) as illustrated in Figure 1. This system is strictly design for access control of opening and closing of door through WIFI, GSM Call, SPST Button or web app authentication/authorization techniques.

In gaining access to enter through the door, the home owner uses either of the four (4) methods to grant access. If a call is received from a registered number this will control the door opening and grant access else if an unregistered number calls the registered number of the door, the door remains locked. Also, when command is received from the camera view button from a browser using the right IP address the door also grant access. The door can also grant accessed through a mobile app installed on the registered owners phone by entering the IP address and Password of the smart door. As a mean of granting entrance access to the home when home owner is within the building, a SPST (Single pole single throw) button can be pressed from within the home from the inside to grant access. The first three methods allowed owner to be able to remotely access the smart door from any location while providing proper monitoring mechanism for the door. A prototype of the designed smart door is shown in figure 3 while .Plate 4a and 4b showed the camera view of a visitor both at the door environment and on the webpage

Figure 3: Smart door prototype front and side view

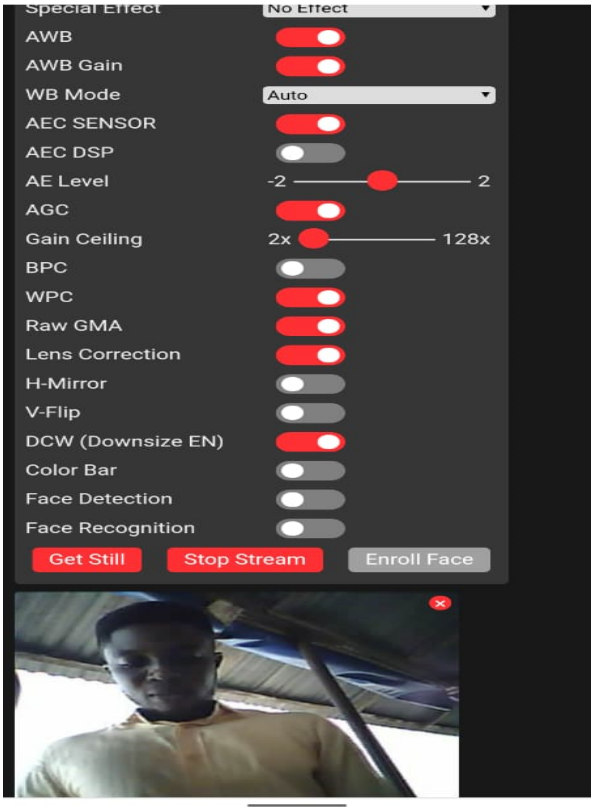

Plate 4a: Camera View of visitor at Door environment

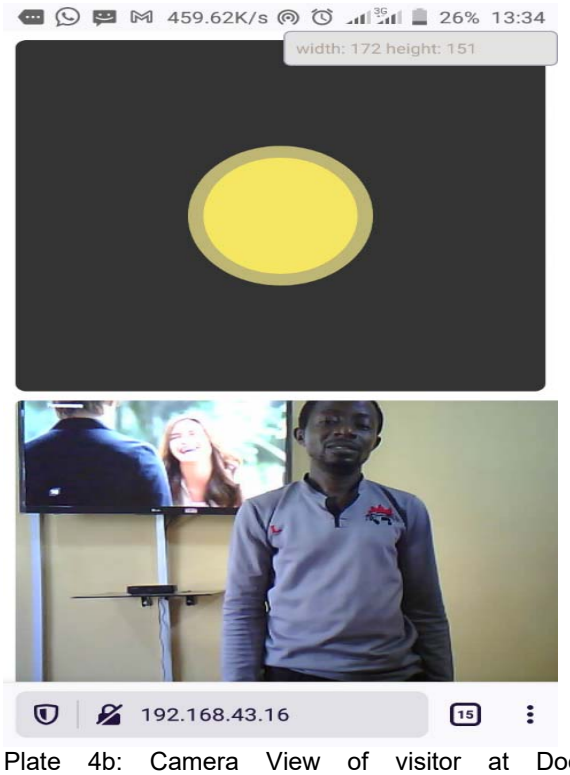

Plate 4b: Camera View of visitor at Door environment on webpage

V. CONCLUSION

In this paper, the design and construction of a Prototype smart door lock with an embedded spy camera was presented. The methodology used in achieving this smart lock system was also discussed using block diagram. The various methods of the door operations using Camera view and button, STSP button, GSM call, and Mobile App were tested and it was successful. Plates of the prototype of the smart lock system were presented and discussed. Though it may be impossible to guarantee absolute security, threat identifying and risks of this system are vital steps toward improving security.

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