Efficient lock and home security system

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Abstract: This work deals with lock and home security systems. First, Motion sensors detect movement indoors and outdoors to guard against intruders, protect valuables and more. Thus, if any movement, RFID reader will be activated and database will be scanned to identify the persons who have the access to the home. This enhances the effectiveness of the security system and provides the user with the complete, whole-house protection he needs. An RFID badge can be used to unlock the door and access to the home. Alerts also are received on the smart phone if motion is sensed in a protected area inside or outside; giving the user the information it needs to act quickly. The door can also be remotely locked/unlocked. A microcontroller (ATmega2560) is used to control the entire system, and GSM is used to send alerts to the Smartphone. An Ethernet shield that connects the microcontroller to the database (DB) is also added.

Keywords: door security, remotely locked/unlocked, RFID badge, GSM, Smartphone.

1. INTRODUCTION

Owing to the improvement and advancement of science and technology over the world, there is a subsequent boost in the rate and cleverness of crime and violence by thieve and ruffian.
As a result, it is necessary to ensure security of oneself and one's valuable belongings, besides to that, home security systems are an important feature of modern residential and office setups. These systems must be affordable, reliable and effective to satisfy owners' needs.
Conventional systems such as alarm based security were very popular in past decades. Currently, embedded system based on microcontrollers and advanced technologies like FPGA, GSM, GPRS (General Packet Radio Service), IoT (Internet of Things), USN (Ubiquitous Sensors Network) is designed to afford security [1], [2]. Hence, several home automation systems have been developed in literatures such as the ones based on FPGA and GSM using internet and Speech Recognition [3], [4]. Moreover, IoT has provided a lot of opportunities to invent the connectivity of devices within the home; thus, enhanced the home security facilities [5], [6], [7].
Generally, in these existing systems, the house gateway is based on the internet which involves personal computer (PC). Nevertheless, it is hard to handle PC and maintain it ON all the time; thus, consumes more power [8].
This paper has the aim to surpass previous systems drawbacks and make the system more powerful and enhance security and safety using the new technologies available in the world of electronics. To this end, the design of a cheap and effective security system for buildings and home doors and gates to prevent unauthorized person from having access to one's properties is described in this work.
A prototype system is designed for detecting intruders and informing the owner by sending a phone message. It is based on the Internet of Things (IoT) concept, everything in IoT is considered as a smart thing that can sense and communicate with others [9].
A system to control the home entrance by interfacing and combining RFID and GSM technologies is created. ATmega2560 microcontroller is used as a controller of the system that monitors everything.
The system is predicted to scan RFID tags at the door knob for automatic door lock purposes, if the card is an authorized one the door will be opened and a welcome message

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will be displayed, otherwise, an intruder detection message will be displayed, a buzzer starts to sound and a message will be sent to the home owner to alert him about the presence of a thief.

2. HOME SECURITY

Speaking about home security leads directly to door security; it is the first step to ensure that no unauthorized persons enter the home. According to crime statistics, front doors are burglars' preferred point of entry into homes [10]. Therefore, when considering enhancing security around the house perimeter, front doors should be one of the top priorities. By increasing security on the entrance door, you are making it harder for an intruder to break into the home and that what is known as "the prevention is better than cure". Crime is ultimately high at the national level, leaving many people feeling less and less secured. It turns out that most intruders will enter a home right through the front or back door. As such, it is important to have good security door locks in place.
Considering this high rate of crime and insecurity, there is an urgent need to design a security door system that takes proper measures to prevent intrusion, unwanted and unauthorized users.
This paper deals with the design of door security system which is composed of: RFID sub system, door opening subsystem, alarming subsystem, displaying subsystem, motion detection subsystem and GSM subsystem. The hardware as well as the software design of the door security subsystems will be described in the following subsections.

2.1. RFID subsystem

The number of the RFID tags depends on the family members if this system will be installed in a home, or the workers in an office if it will be installed in a company etc...; They are these readings of the serial numbers (or The User Identifiers UIDs) that are burned into the tags. This step is critical in the construction of our database that determines the different persons that have access to the building and thus taking the appropriate action when reading a specific tag.
The RFID reader is connected the microcontroller board via its serial pins (MISO, MOSI and SCK) to the predefined SPI pins of the ATmega2560.

In this subsystem, an algorithm is created to check the presence of an RFID tag and read its serial number (ID) that is burned in its memory to build our own database. First, the algorithm includes all the needed libraries which are the SPI and MFRC522; then, it configures the needed pins and initializes the RFID. In the setup function, it opens the serial communication and set the baud rate to 9600 to initialize the serial communication with PC and configures its settings by using the default ones which are 8 bits as data bits, no parity bit and one stop bit.
After that, it will keep checking if a serial port is opened or not yet till a serial port is opened. Thus, it goes to initialize both the SPI bus by setting SCK, MOSI, and SS to outputs, pulling SCK and MOSI low, and SS high, and it initializes the MFRC522 RFID also. In the loop function which runs continuously, it keeps checking the presence of an RFID tag; if so then, it will check the ability of the reader to read one card. Once everything works fine then, it will display the UID number of the card and other information which are burned in the microchip memory in the serial monitor of the microcontroller IDE. The program flowchart is shown in Fig. 1.

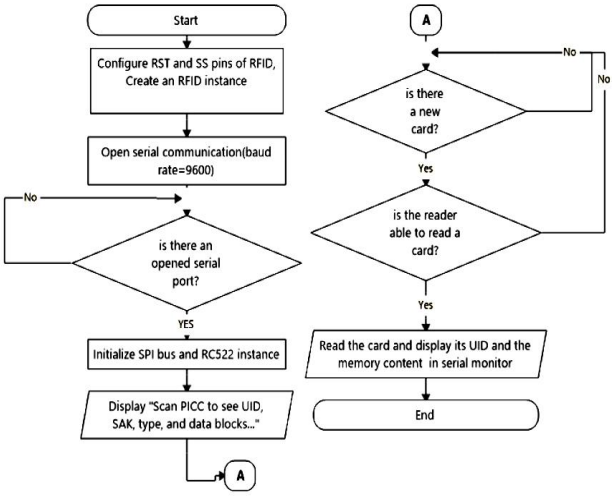


Fig. 1. Flowchart of the RFID tag reading system

2.2. Door open/close subsystem

In our system, a servo motor is used for door opening and closing.
For this subsystem, an algorithm is created to open and close a door using a servo motor. First, the algorithm includes the servo library and sets the pins associated to both the servo and the green LED that is used to indicate the state of the door, whether it is

opened or not. Also, it sets the opening and the closing position in degrees; these positions will indicate the angle to which the servo will move after it receives a PWM signal in its control line. The width of the pulse determines the angular position. In the setup function, it contains configuration of input/output pins used for connection with peripherals which is in this case the LED pin and attach the servo to the predefined pin. In the loop function, the servo is positioned to the opening and the green LED glows, after a delay of 5 seconds, the servo will return back to the closing position and the led will turn off.

2.3. Alarm subsystem

The alarm subsystem is too simple, it is implemented by connecting the negative thread of the buzzer to the ground, and the positive one to the microcontroller digital pins, a red LED is added to indicate the presence of a buzzer sound.
This subsystem is added to make an alarm sound as a sign of intruder detection. After setting the pins associated to both the buzzer and the red LED, the buzzer sounds by applying a square wave of a specified frequency (50 % cycle) on the pin, this is done by calling the tone function. The duration can be specified in the called tone function, otherwise the wave continues until no_Tone function is executed. After a delay of 10 seconds, the sound and the LED will turn off.

2.4. Display subsystem

In order to simplify the understanding of what is happening in the system, and to provide a simple way of communication between the user and the system, an LCD display is interfaced to provide the user with the current status of the door.

2.5. Motion detection subsystem

PIR sensor is used to detect motion near the door. First, the algorithm sets the pins associated to both the PIR sensor and the blue LED, and initializes the PIR state as LOW. The microcontroller reads the value from the control pin of the PIR and assigns it as variable; then, it checks whether the read value is high. If so, the LED will turn on else a motion detection message will be displayed in the serial monitor indicating that an output change exists. When the read value is LOW the led will turn off; else, a motion ended message will be displayed in the serial monitor indicating that an output change exists. The program flowchart is shown in Fig. 2.

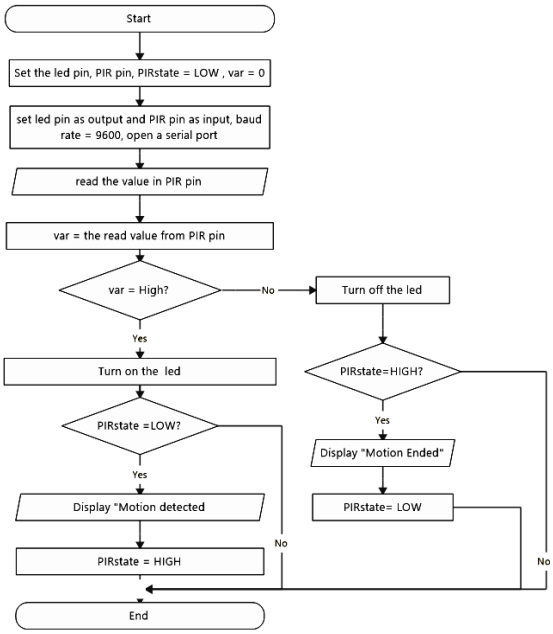


Fig. 2. Flowchart of motion detection

2.6. GSM subsystem

Using the alarm system as a sign of intruder detection seems to be a bit meaningless if the homeowner is far away from the house, or no one is present in the home area. Thus, to raise the performance of the intruder detection system, GSM module is added, which plays the role of an interface between the homeowner and the door security system. Whenever, a fault card is scanned the homeowner will receive an alerting message in his mobile phone.
An algorithm is created to send a message to a mobile phone when a condition is satisfied. First, the algorithm includes the soft serial library and initializes the receiving and transmitting pins to the corresponding pins in the ATmega2560 microcontroller board; then, it creates a soft serial instance.
In the setup function, it opens the serial communication with PC as well as with the GSM module and set their corresponding baud rate and serial communication settings. After that, it configures the GSM to send messages using an AT command. In the main program, it checks the condition; thus, if it is verified, it will send the message. To do that, it first sends the phone number of the receiving person to the transmit pin of the software serial port using AT commands; then, it sends the message, after that it sends

a stop character which is “ctrl+Z” character to end the message. The program flowchart is shown in Fig. 3.

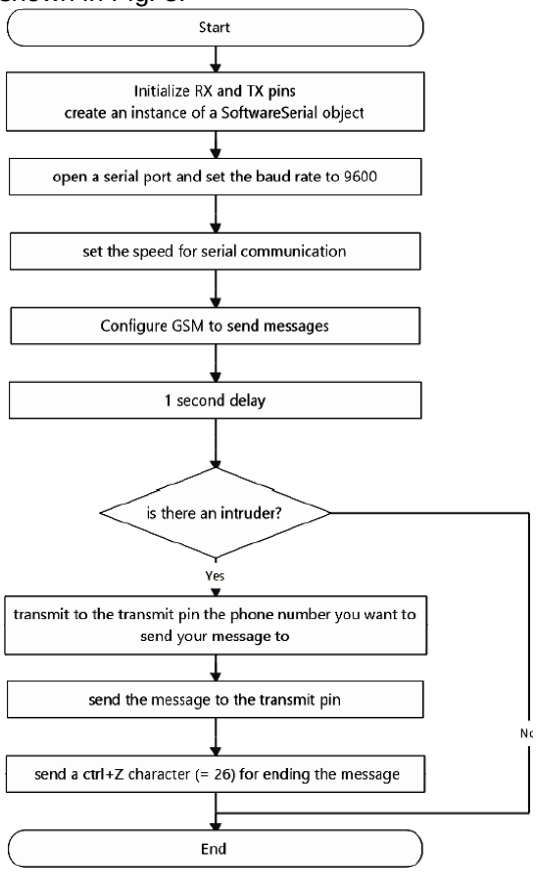


Fig. 3. Flowchart of message transmission via GSM system

3. SYSTEM GENERAL DIAGRAM

The general block diagram of the proposed microcontroller based door lock security system is shown in Fig. 4. It consists of three sections which are input, controller and output sections. At the initial state, the controller section remains at waiting mode until receiving a signal from the input section which includes PIR sensor and RFID sensor. In input section, an RFID module is interfaced with the microcontroller to unlock the door of the system when an authorized card is scanned. The motion sensor is placed at door entrance to activate the system when a motion is detected. According to the pulse of the RFID input device, the controller section takes decision and activates the output section which includes LCD display, GSM Module, Servo motor, LEDs and Buzzer. The activation of the output devices depends on the activity of input section that indicates the state of the user who unlock the system either it is authoritative or non-authoritative. For authoritative user, controller sends a pulse signal to the servo motor that is also connected to the door. After 90 degree rotation of servo motor the door will open. At the same time, a welcome message is displayed at the LCD display; also, the controller sends a signal to the green LED to glow indicating an authorized operation, after 5 seconds delay the door will be closed automatically. Conversely, in non-authoritative user, the controller sends a signal to the red LED, Buzzer and GSM module simultaneously. LED is placed at the entrance which indicates an unauthorized access to the system. Consequently a Buzzer produces sound signal and GSM module sends an alerting message towards the owner’s mobile phone, an alerting message as well will be displayed on the LCD. The system is provided with an Ethernet shield that functions as an input output device, it is used to communicate with the microcontroller, and connect it to the database, to check whether the scanned tag has an authorized ID or not. Those activities are easily aware both the owner and security guard and increase the rate of security.

The proposed system includes two parts which are: software and hardware. At software part, a flowchart is created in accordance to the functional sequence of block diagram (see Fig. 6). In agreement to software instruction a suitable circuit diagram is designated for hardware implementation (see Fig. 5).

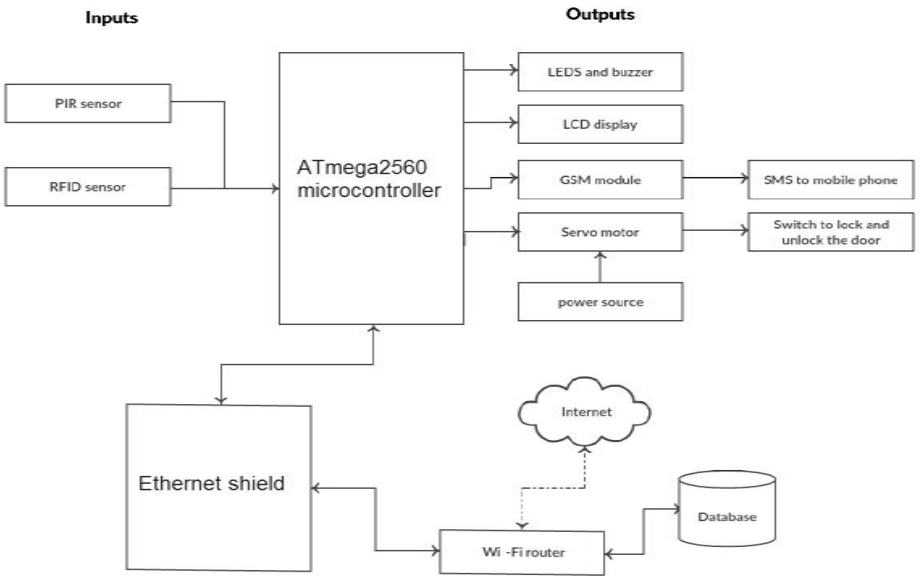
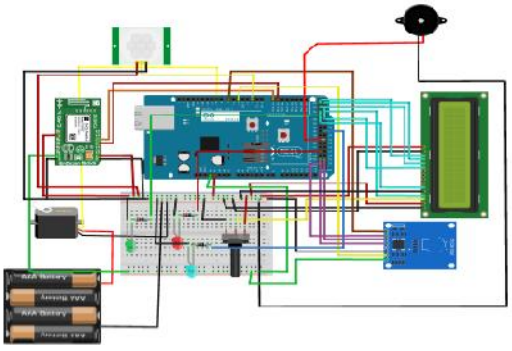


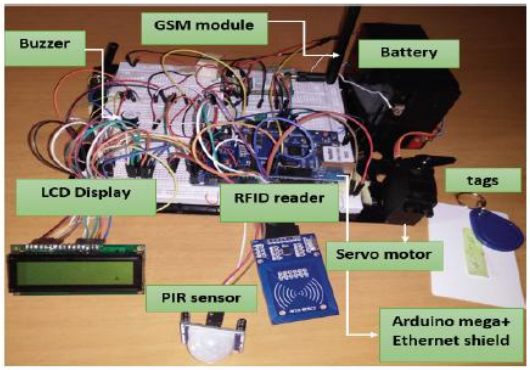
Fig. 4. General block diagram of the proposed door lock security system.

3.1. Hardware settings

In the circuit diagram shown in fig. 4, the ATmega2560 microcontroller is the main component which is used for controlling other devices (RFID module, PIR sensor, Ethernet shield, GSM Module, LCD Display, Servo Motor, Buzzer and LEDs). First, a PIR sensor is used to detect motion and thus activating the system. RFID reader is used to communicate with tags that are within its field of operation. The reader uses an attached antenna to capture data from tags. Then, it passes the data to the controller that checks from a predefined database the state of the UID; after that, a decision making will take place which will affect the output devices. Servomotor consists of three major parts: a motor, control board, and potentiometer (variable resistor) connected to the output shaft. The motor utilizes a set of gears to rotate the potentiometer and the output shaft at the same time. The potentiometer controls the angle of the servo motor and allows the control circuitry to monitor the current angle of the servo motor. In this system, the servo motor is used to control an angular motion between 0 and 90 degrees, it is used to open and close the door if an authorized person try to access home. Moreover, GSM, which is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe protocols for second generation (2G) digital cellular networks, is used by mobile phones is used to make a strong wireless communication network between the owner and the security system, and it will alert the owner if any intruder try to access the system. In general, the system receives signals from input devices (RFID module and PIR sensor) and sends signals to the output devices (LCD Display, Servo Motor, GSM module, LED and Buzzer) in order to maintain security as shown in Fig. 5.



(a)



(b)

Fig. 5. Hardware setup of the door security system. (a)System circuitry. (b) picture of the built prototype.

3.2. Software settings

The entire program flowchart of the proposed door security system is shown in Fig. 6. Primarily, the program initializes all peripheral devices (RFID module, PIR sensor, Ethernet shield, GSM Module, LCD Display, Servo Motor, LEDs and Buzzer). Subsequently, the program initializes serial communications with the PC by setting the baud-rate to 9600 and serial communication bit settings to 8 bits as data bits with one start and one stop bits and no parity bit. Also, it initializes the serial communication between the microcontroller and GSM module and configures this last to send SMS. Moreover, it configures the input/output pins used for connection with peripherals. Then, the program checks the presence of an opened serial port, if there is no one, it keeps checking; otherwise, it will initialize the SPI bus and RFID, and display an opening message to indicate the starting of the system. After that, the microcontroller reads the PIR sensor input, if any motion has been detected, a blue LED will glow and a message to scan the RFID card will be displayed; in that case, it will check the presence of an RFID card and the ability of the reader to read the tags, if everything is all right a decision making will take place according to the read UID. If it is a UID of an authorized person, a welcome message will be displayed, the door will open and a green LED glows. After 5 seconds, the door will be closed automatically. If the card is of unauthorized person, an alerting message will be displayed, a red LED glows and the alarming system will be activated with a message sent to the home owner.

3.3. Data base building

To enhance our system's security and flexibility, an Ethernet shield that connects the microcontroller to the database (DB) is added. This constructed DB will replace the in-built microcontroller database which will provide more flexibility and authenticity to the system since it will provide to the home owner the ability to access the DB and perform the needed changes (e.g, adding a new authorized card UID to the list if a new member comes to the family or giving access to somebody to the house, deleting a car UID from the list of authorized cards if a card is lost or stolen, if a camera is added we can add pictures to that DB which will provide the system with a tight authentication). The DB also contains a tracking list that will provide the homeowner with all the attempts to access the door during the day.

In this work, WAMP server is used as a web development platform that contains both MySQL and PHP. MySQL is used to create our own DB using the SQL language and PHP is used to build the communication between client (which is the microcontroller board) and our server and connect it with the constructed DB. The microcontroller board makes an HTTP request through a PHP file to contact with the DB. Fig. 7 illustrates the diagram of the two tables of our constructed DB.

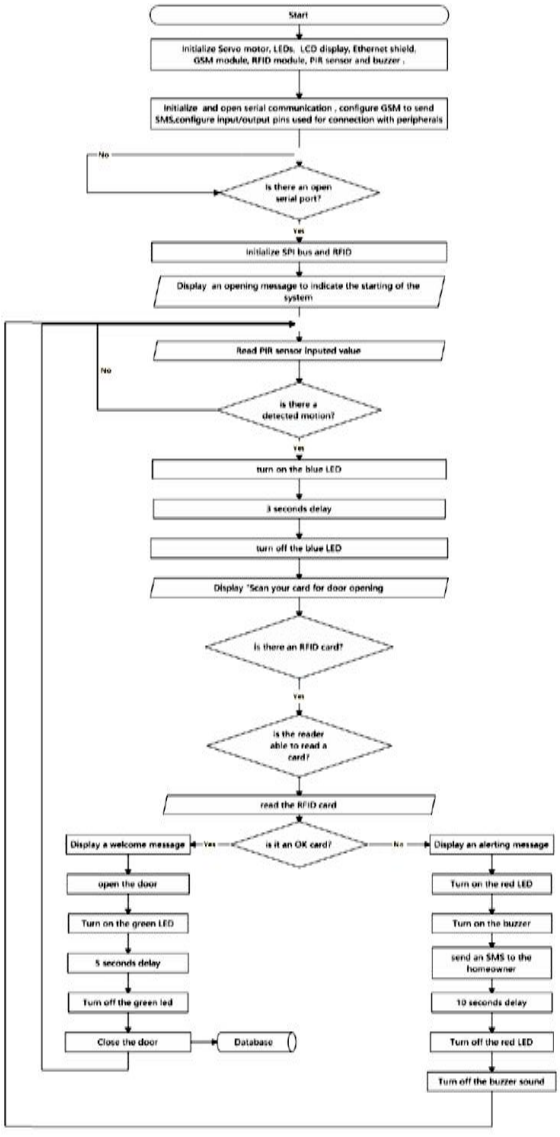


Fig. 6. Door security system flowchart.

A web application is created for system administrator to access the DB using both HTML, CSS and Javascript; HTML is used

for the overall and basic structure, CSS is used to control presentation, formatting, and layout and JavaScript is used to control the behavior of different elements and tells the browser how to change the web page in response to events that happen (like clicking on something).

Tracking Table
ID (INT; auto increment)
Full Name (String)
RFID card ID (a string of length 8)
State (Boolean; True for authorized and false for unauthorized)
Time (TIMESTAMP; to give the current time)

(a)

Authorized Users Table
Full Name (String)
RFID card ID (String of length 8)
Phone Number (String)

(b)

Fig. 7. The created DB. (b) Tracking table contents. (a) Authorized users table contents.

Concerning the connection of the Ethernet shield with the microcontroller, it is simply done by plugging the shield on the top of the microcontroller board. Since, they communicate with each other using the SPI bus (through the ICSP header), and in our application we have used another SPI device which is the RFID RC522 module; thus, chip select pins must be different, the SS of the Ethernet shield is pin 10 by default, we need also to explicitly deselect one of the SPI devices when the other is working. Fig. 8 illustrates the flowchart to connect the Ethernet shield with the microcontroller.

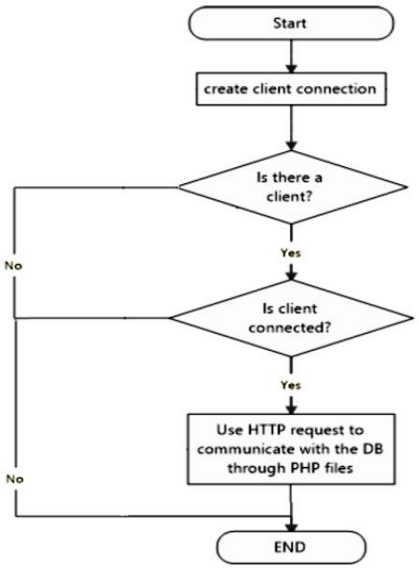


Fig 8. flowchart to connect the Ethernet shield with the microcontroller.

4. RESULTS AND DISCUSSIONS

After the implementation of the required prototype, the RFID tags' serial number (UIDs) must be displayed in the serial monitor. These read values are the first and critical step in this work since they are fundamental in the construction of our database and the program flow will dependent on it.
The scanned tags ID displayed on the serial monitor are illustrated in Fig. 9.

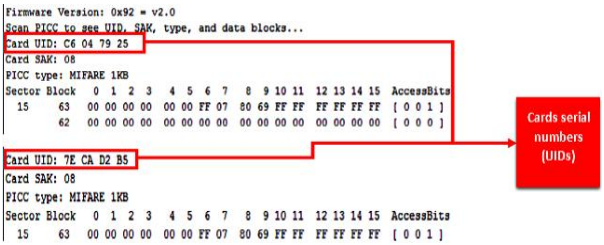


Fig. 9. Tags serial number displayed on the serial monitor.

The first scenario, illustrated in Fig. 10, validates the case where an authorized person tries to access the door. The user needs to scan his card at the RFID antenna, which will reads the card's information and send it to the microcontroller board to make a decision. As the scanned card is of an authorized person, the servo motor rotates for an angle of 90 degrees (or whatever is the rotation requirements for practical purposes) and keep in that position for 5 seconds. After that, the motor will rotate back to its previous position and thus the door will be closed, a welcome message is displayed with a green LED glowing during the door opening.

Fig. 10 Authorized access.

The second scenario, illustrated in Fig. 11, validates the case where an unauthorized person tries to access the door. After scanning an unauthorized card, the screen displays an alerting message with a red LED glowing. Hence, the servo motor will not rotate. The attached buzzer also will start making noise indicating unauthorized attempt and a GSM message will be sent to the home owner.

In the last part of our work, a web application was created to enhance the system's authentication and flexibility by connecting with the constructed DB. Fig. 12 illustrates the overall list of the persons who tried to access the door including the list of the authorized and unauthorized persons.

The overall designed and tested system seems to function perfectly and it ensures a high rate of affordability and reliability; as well as, efficiency since it is both easy to implement and provides a more secure environment.

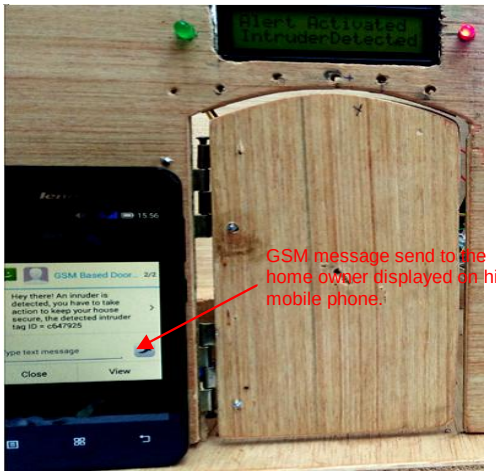


Fig. 11. Unauthorized access.

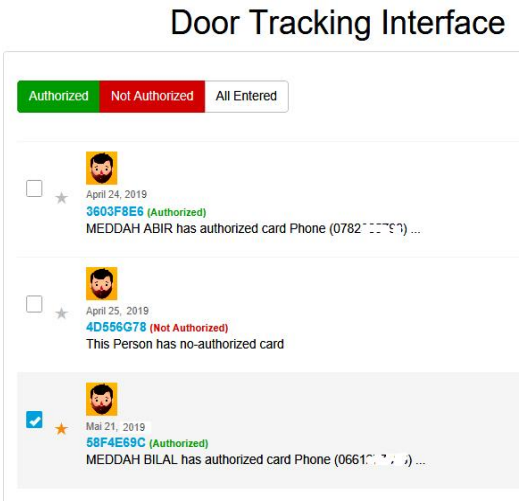


Fig. 12. Accessing the database via the web page.

5. CONCLUSION

In this paper, a design and implementation of a low-cost door security system based on microcontroller board, RFID and GSM technologies is presented. The system is designed to enhance the home security system that can be used in different buildings like homes, offices, hotels and so on.

The contribution of this work was to create a more secure system that combines some IoT techs to automate the door access and enhance authentication and security sides by using both RFID and GSM, this full system can minimize the risks of burglars attacks specially those problems that are caused by an unauthorized duplication of keys or passwords that are entered by chance correctly. Moreover, this system is created to enhance the alerting system by supporting the traditional alarming system with a GSM based alerting system.

This home security system can be installed easily in different buildings. It provides improved convenience, comfort, energy efficiency and security and life quality as well.

As an extension to this work is the interfacing of a camera with the built system. This will enhance the security side of the system, since most of the intruders generally did not try to break in the door by using a fault card. A camera will be used as a part of authentication such that no one can access the door till both the card serial number as well as the picture is already defined in the home database. Here, even a lost card that is found by an intruder or stolen will not permit the person to access the door, since there is a tight authentication system.

Moreover, this security system can be enhanced if it is combined with the police services to take action if the home owner is far away, by adding a GPS module to the system, when an intruder is detected, the police will be informed by SMS (using GSM) and the location will be determined as well using the GPS module.

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