DESIGN ON RADIO FREQUENCY IDENTIFICATION (RFID) BASED SMART DOOR LOCK SYSTEM

Win Moh Moh Maung[1], Hnin Yu Khaing[2], Kyaw Kyaw[3]

Abstract

A smart door lock is an electric lock that allows unlocking and locking without keys. Classical locking systems, such as lock and key, Deadbolts, Door chain and Mortise locks, have usages and security limitations. The main objective of this research work is to design and construct RFID-based smart door lock system with Arduino UNO development board. When a predefined or programmed ID card was located and swiped in front of an RFID reader module, the lock was slide and opened and short pulse of alarm sound produced through the buzzer. When there is no RFID card, the door could be opened with Bluetooth protocol from the mobile phone. The duration of the open and close condition is assigned as 5 s for proper door crossing. It could sense the human and big thing which are passed through the door for longer than 5 s, the constructed system automatically adjusted the duration of the door for opening and closing. By using this system, the security of the home can be enhanced and smart living style can also obtain with very low cost.

Keywords: Smart door lock, RFID, Arduino, Bluetooth, duration

Introduction

Today's technology age, people want their life is completely automated in electrical appliances. Along with the increasingly rapid development in microcontroller, it encourages to innovate and create a tool that is more effective and efficient [Ajami, S., *et al*]. The smart door lock is the one type of gate, known as door, which is used in a building to pass in and out [Anaza, S. O., *et al*]. This door has been used as a gate for building to enhance the security. The sliding doors are used for narrow spaces and they are looked more comfortable. The problems discussed in this research work are the absence of electrical applications to manipulate the open and close conditions of the sliding doors with RFID card, and the absence of a conventional door security system that can strengthen the home security. The investigated sliding door system is now applied conventionally and automatically. Conventional sliding doors are also door which are equipped with the sliding door for human entering or exit. The smart sliding door does not require human intervention to open or close the door, because it is equipped with a passive infrared sensor (PIR). The door would open and close immediately when the human's infrared radiation was detected. The smartcard based security system implemented a smart card, such as RFID and Magnetic cards, for opening and locking doors, which replaces the manual lock [Batool, A., *et al*]. In this study, RFID technology was used to access the door for opening while the closing would be automatic. This research also uses a Bluetooth connection to open the smart door with mobile phone automatically. The door sliding system uses L298N drove DC motors, RFID module, LCD display and ATmega328P microcontroller (MCU) based Arduino Uno R3 development board. Radio Frequency Identification (RFID) is a technology that uses radio frequencies to identify objects [Gangi, R. R., *et al*]. The main objective of this research work is to design and construct a smart door lock system (automatic sliding door) that can detect an RFID card to access the door for opening automatic. RFID system supported to

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strengthen the security level of a building's access. In this study the smart door security control system that has been built based on analyzing the hardware and software based system. The performance tests were carried out to investigate the feasibility of working hardware and control programs of the smart door control system. The performance efficiency of the automatic sliding door control system was analyzed and the system performance was quite efficient.

Materials and Method

A block diagram of the smart door implementation system was illustrated in Fig.1. The input block consisted of a RFID module and Bluetooth modules. Whereas in the process section, there was a microcontroller that conducted as a brain of the constructed system. On the output portion, there was a DC motor as a door opener, LCD 16x2, which was implemented to display notifications about the condition of the door and alarm sound produced from the buzzer and indicator LEDs.

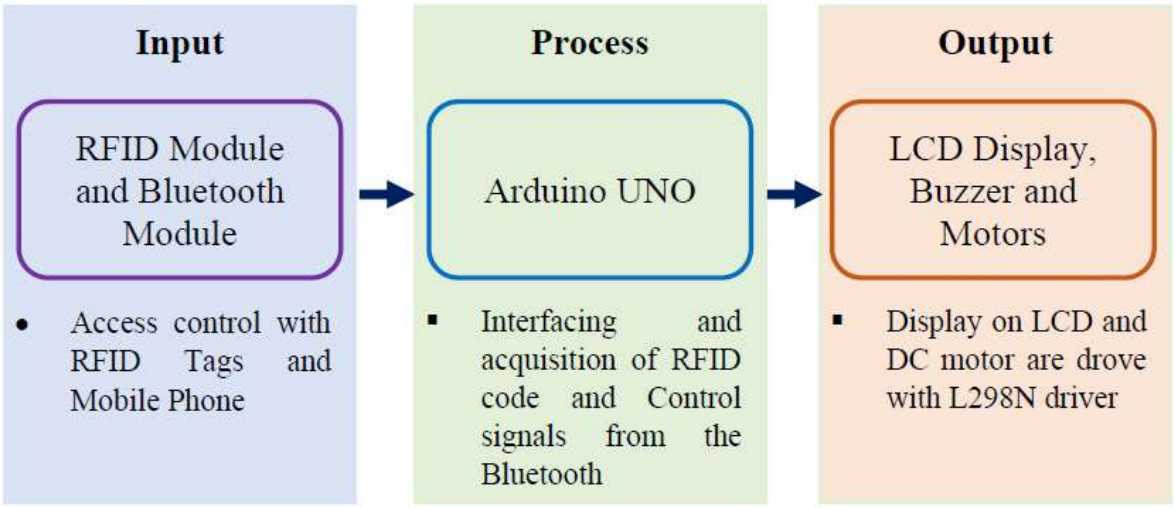

Figure 1. The block diagram of the smart sliding door lock system.

The system architecture presented in Figure.2 explained the control process of the constructed system being built. The system architecture was used to define components that were more specifically structured so that they could address current and future needs. The system architecture flow explained the process of data input, data processing, and data output.

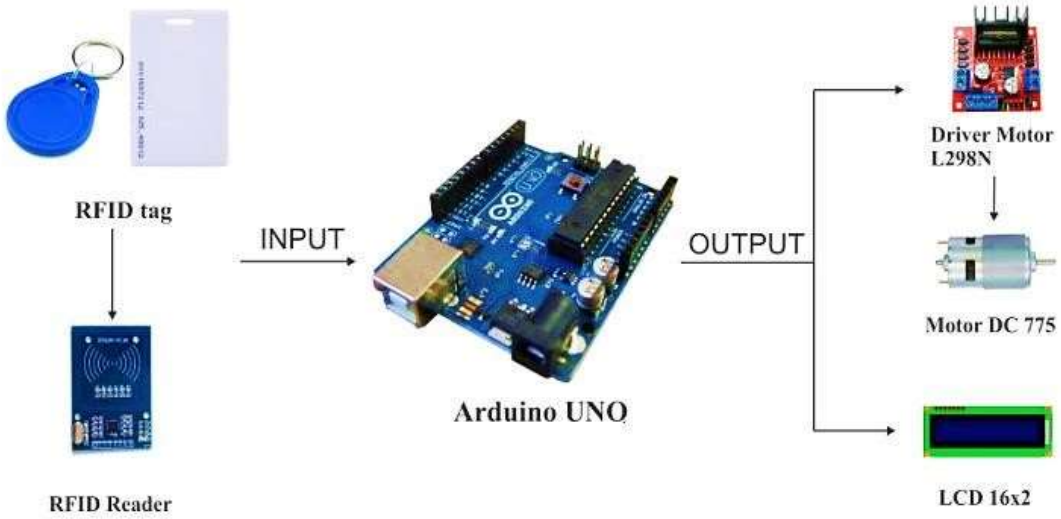

Figure 2. The system architecture of the constructed system.

The smart door control algorithm presented in Fig.3 is based on the security requirement. It was programmed in Arduino IDE and uploaded into the microcontroller to obtain the objective of the research work. This constructed program was based on a process model and formulated with artificial intelligence. The design of the mechanical sliding mechanism for smart sliding door is presented in Fig.4. This system consisted of several electronic components to make smart sliding doors. This constructed system consisted of an RFID reader module for detecting RFID data and DC motors for slide door movement. Based on Fig. 4, the function of each component was explained in Table 1. Arduino IDE was conducted to write programs, compile, and upload to Arduino boards. Arduino IDE was embedded with the AVR-dude program to convert executable code into a hexadecimal encoding file that was uploaded into the Arduino main program memory by the loader program.

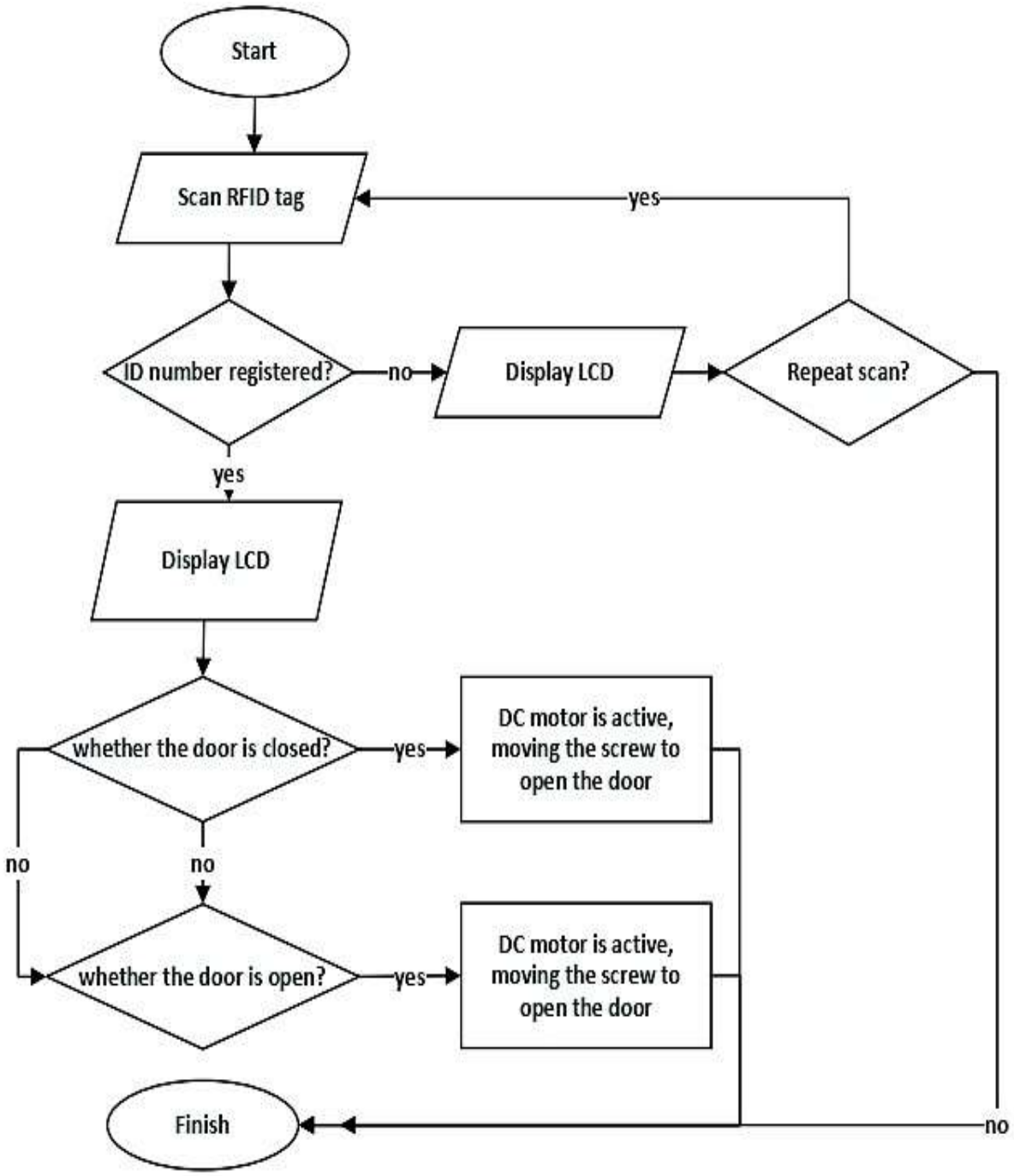

Figure 3. The flow chart of the smart door algorithm.

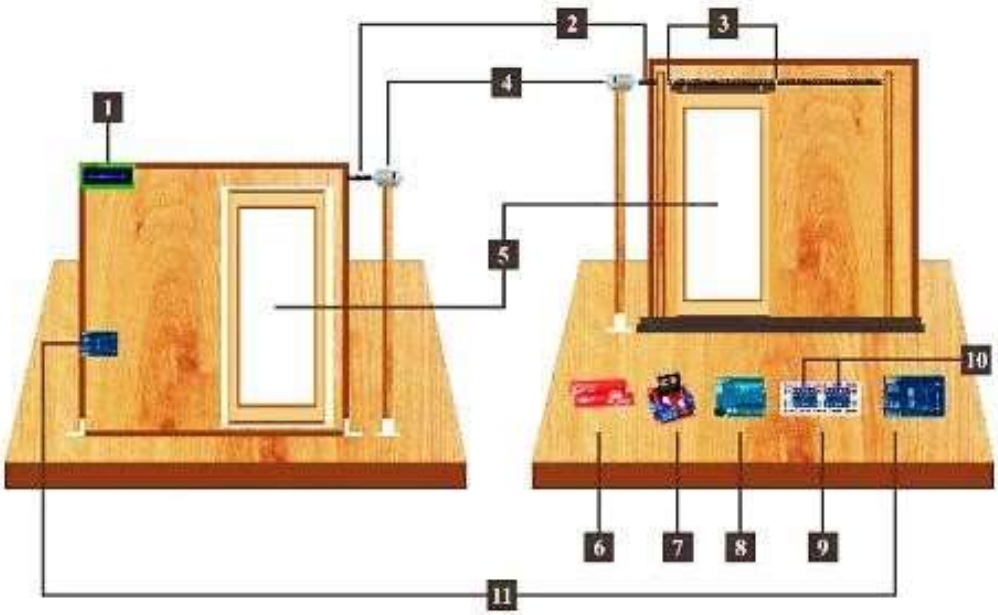

Figure 4. The mechanical hardware system for the constructed smart door.

Table 1. The functions of the individual electrical components.

No.	Name	Function
1	LCD 1602 Display	Functioning as information display
2	Outer Thread	Functioning as sliding door mover
3	Inner Thread	Functioning as sliding door mover
4	DC Motor	To drive the door open or close
5	Sliding Door	To work as the gate for the room
6	12 V Power Supply	To provide the DC supply to the system
7	L298N Motor Driver	To drive the DC motor with speed and direction control
8	Arduino UNO	Serves as the main controller
9	PCB Board	Using for interconnection of the circuit components
10	Bluetooth Module	To communicate with mobile phone
11	RFID Reader	To read the predefined RFID tags and cards

Experimental Circuit Operation

The Sliding Door was a gate where people give boundaries or areas that could provide insider understanding, entry and exit, and here and there. The sliding door was one type of door used in a building. In addition to being a security, the door also showed the character of a building. The sliding door was a door that opened the lid by sliding the door left or right. For movement, rails and wheels were setup above and below the sliding door. This type of door was the right solution to make the room look more spacious. In this research work, the smart door

was constructed as automatic sliding door with touchless and mobile phone controllable capability.

RFID technology was a wireless system that allowed tag information to be read by placing the electromagnetic field closer. RFID was a general terminology for non-contact technology that used radio waves to identify objects automatically. The combination of antenna and microchip was called an RFID card or RFID tag and worked in conjunction with an RFID reader module. They were properly interfaced with Arduino UNO development board. Arduino Uno was a microcontroller board based on ATmega328P. This board had 14 digital input and output pins, 6 of which could be used as PWM signal outputs for DC motor speed control, 6 analog input able pins, 16 MHz quartz crystals resonance, USB header, DC power outlets, ICSP headers, and reset button. The control program for the constructed system was designed with Arduino IDE. DC motor was an actuator that converted direct current electrical energy into mechanical energy and it was used to activate the sliding door. The speed and direction of the sliding door was controlled with Arduino and L298N motor driver module. The speed control was controlled with the PWM out of the Arduino and it was set to 50 % duty cycle for normal speed of door opening and closing. The information system of the constructed system was implemented with 1602 LCD display. It was interfaced with MCU in serial mode. To obtain the desired contrast level of the LCD display, the wiper V_0 pin was adjusted with the 10 kΩ potentiometer.

All of the interfaced electronics components were assembled on the PCB copper clad. The PCB artwork was designed with Pad2Pad PCB design software. The components layout and PCB Trace layer are illustrated in Fig.5. The bottom layer was copper trace layer and top layer was designed for components layer. The PCB was constructed as single layer PCB to reduce complexity for assembling and soldering.

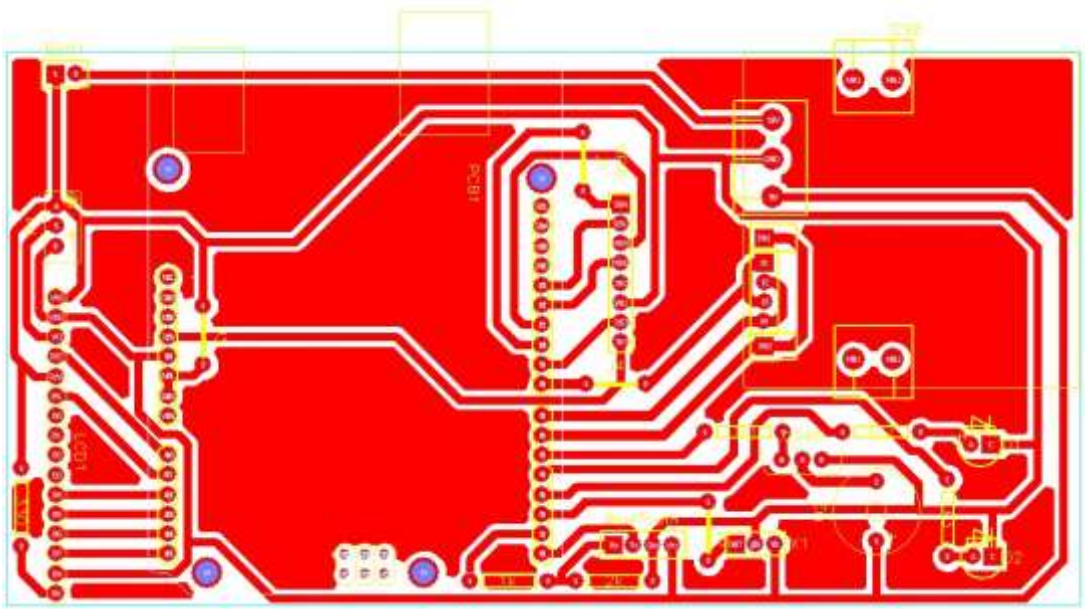

Figure 5. The components layout and PCB trace layer of the constructed system.

Results and Discussion

Performance analysis was a trial based on the correctness of input and output criteria, and the action of the smart door security control system and also included data validation and input error handling. The trial in Fig.6(a) was a standby (closed) condition of the system (wherein the experiments to be carried out that the sliding door was in a closed condition and also had not received any input or input from RFID tags or cards.

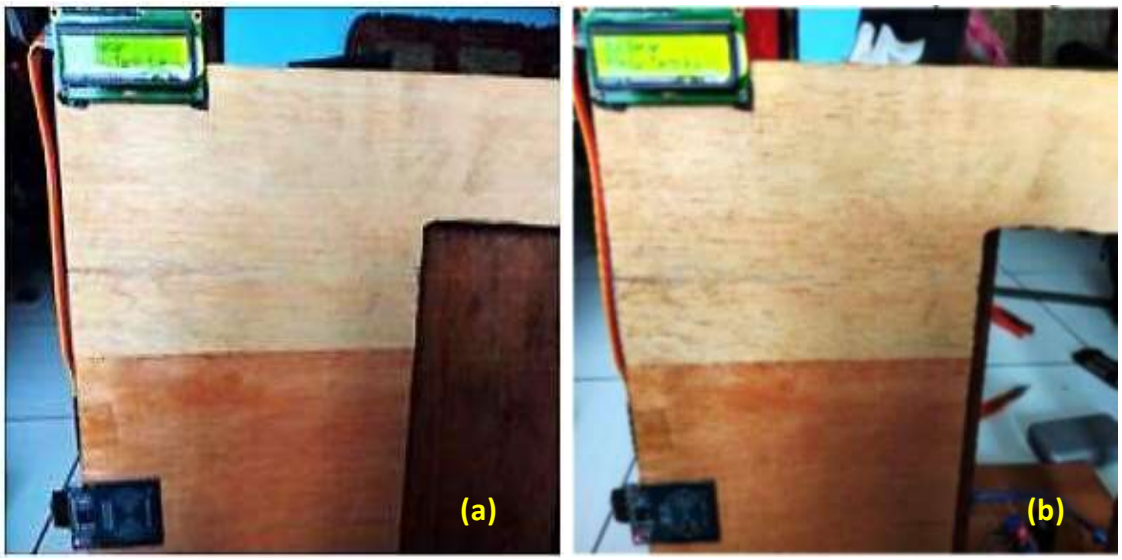

Figure 6. The standby condition of the system

Test in Fig.6(b) was to give an open door command. The scanned ID number would then be detected by the RFID reader module. When the RFID card information were sent correctly, the LCD displayed the notification in the form of "Open Door" and followed by an active DC motor moving the axial to open the door.

The system test on the door command could not be opened or closed. When the ID number that had been scanned was wrong. The system would send to the LCD display a notification "Incorrect ID" so that the DC motor would not be active and would not be able to move the axial to open and close the door.

The ID number "4BEC450B" was predefined in the RFID tags and these ID number could be used to open and close the door. The results of the RFID tag trial are presented in Table 2.

Table 2. The ID detection analysis with different tags and cards.

No.	RFID Tags	Detected ID	Detected Speed (s)	Conditions
1	Tag1	4BEC450B	0.9	Correct
2	Tag2	EBC3EC0A	1.4	Incorrect
3	Tag3	4BECEC0A	1.6	Incorrect
4	Card1	4BEC450B	0.7	Correct
5	Card2	EBC3EC0A	1.6	Incorrect

The constructed system could function with a supply voltage, as evidenced by the standby 16x2 LCD displaying "Smart Door Lock" in the first row, "Scan Your RFID" in the second row, and the digital multimeter showed the consuming DC voltage of 5 V DC. The system could not function when there was no supply voltage, as evidenced by the state of the 16x2 LCD not displaying anything.

Based on the study's results, it was concluded that the overall work process of the prototype system, especially the smart door using Radio Frequency Identification ID-12 technology based on Arduino Uno R3 ATmega328P, produced by the system could be used for intelligent door locking system. Person, who do not have to enter the door without RFID tag or card. System development added several supporting components that were used to reduce the occurrence of problems with relays that affected the drop bolt lock or solenoid door lock.

Conclusion

Implementation of smart automatic sliding door using RFID, Bluetooth and Arduino made it easy for home owner to open and close the door without using human power, without using conventional door locks, and the door can be tightly closed and cannot be shifted manually. The heavier the load was on the door; the sliding power of the door would be reduced. With the use of this system, the security of the home was more awake. Based on the results of the study, the implementation of smart automatic sliding doors would indicate visually with LED and produce an alarm, when the ID received by the RFID module did not match. The time taken for the RFID reader to read the tag was 2 s for human access while the waiting period between the opening and closing of the gate are 10 s. This innovation gives a progressive automation in different procedures running from modern divisions to home control.

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References

Ajami, S., and R. Arab-Chdegani, (2013) “What are the most important Barriers to Implementing Radio Frequency Identification Device (RFID) in Healthcare System”, *Journal of Info Technology and Software Engineering*, vol. 7: E004, pp. 34-39.

Anaza, S. O., J. D. Jiya, and Y. S. Haruna, (2017) “A Review of Intelligent Lock System” *American Journal of Engineering Research*, vol. 6(6), pp. 9-15.

Anushri, J., L. K. Vijay, and N. Barkha, (2015) “RFID and GSM Based Attendance Monitoring System using Door locking/unlocking System and Its Hardware Implementation”, *Journal of Management Engineering and Information Technology*, vol. 2(3), pp. 5-10.

Batool, A., and A. Sima, (2015) “Radio Frequency Identification and Rescue Victims in Earthquake”, *International Journal of Health System & Disaster Management*, vol. 3(5), pp. 1-5.

Expresscorp (2022) How Does RFID Work for Vehicle Gate Entry, express identification made simple, https://www.expresscorp.com (Accessed Date 10.9.2024)

Gangi, R. R., and S. S. Gollapudi, (2013) "Locker Opening and Closing System using RFID, Fingerprint, Password and GSM", *International Journal of Emerging Trends & Technology in Computer Science*, vol. 2(2), pp.142-145.

Hua, L., W. Hong-jun, S. Zhen, L. Qing-hua, and W. Xiao, (2010) "Application of RFlD in Agricultural Seed Quality", *The 8th World Congress on Intelligent Control and Automation*, vol.6, pp.9.