Design and Implementation of a Digital Sliding Gate Using RFID Technology

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Abstract- Security of human life and property is one of the paramount challenges facing any corporate organization or nation. Security systems are necessary everywhere especially in residential buildings, industrial area and public offices. The need for automatic sliding gates has been on the increase in recent times because it does not require manual operation. The digital sliding gating system described in this work uses the Radio Frequency Identification (RFID) technology for access control. The RFID module, which is the sensing unit of the system, is interfaced with the processing unit (Atmega8a microcontroller) for controlling the actuating unit (sg90 servo motor). The sliding gate opens partially when the valid card for human access is brought closer to the reader, it opens fully when the valid card for vehicle access is brought closer to the reader while an invalid card brought closer to the reader activates the buzzer. The time taken for the reader to read the tag is 3 seconds for both human and vehicle access while the waiting period between the opening and closing of the gate are 10 seconds and 21 seconds for human and vehicle access respectively. These operations are made possible by the programmable microcontroller used and the pivot joint mechanism for the fast opening and closing of the gate. The developed system was tested and it performed as designed.

Keywords- Microcontroller, Pivot joint, Radio Frequency Identification, Sliding gate, Tag

1 INTRODUCTION

Over the years, several security measures have been employed to combat the menace of insecurity of lives and property (Oke *et al.*, 2009). So, a daunting challenge in modern security is controlling access to a facility while upholding the level of protection required. The traditional solution is a security gate built in the centre of a perimeter fence or other structures. While it is always possible to have human-powered security gates with guards who check and clear those seeking entry and allow or deny access, it is not cost efficient or easily managed. It is an outdated system in the face of emerging technology. This is because there is the risk of human error and fraud that can allow unauthorized person to gain entry into a facility. The same can be said of the flaws and challenges of remote control devices that can come up with an untold number of glitches, from dead batteries to outdated systems that can allow security codes to be stolen right out of the air.

Sliding gates are commonly used nowadays at residential and industrial areas. Rather than having a gate that opens inwards or outwards, sliding gates either run on tracks or a trackless cantilever system (Singh, 2017). It is mounted parallel to the inner wall of the fence and slides horizontally back and forth across the gate opening while rollers underneath the gate serve as support and aid its movement. Some of the different technologies used for access control of an automatic gate are Remote Control Access, Automated Gate Card Readers, Keypad Access and Telephone Entry Access.

The automatic gate described here automates the entrances to parking lots of residential homes, organizations, automobile terminus and public car parks using Radio Frequency Identification (RFID) technology as access control systems to allow only the entry of authenticated and authorized personnel. RFID is a technology which utilizes radio waves for receiving and transferring data, with the capability of sending and receiving information without human involvement (Batool & Sima, 2015). It works on the principle of inductive coupling. Inductive coupling is the transfer of energy from one circuit to another through a shared magnetic field which is produced due to mutual inductance between two circuits (Komal & Dhiraj, 2015). It is a wireless technology capable of automatic and unambiguous identification without line of sight by extracting a unique identifier from microelectronic tags attached to objects. It makes use of electromagnetic waves to receive and read transmitted data. The information is electronically stored on a tag that is attached to an object or to the carrier, and that tag's chip is activated to share its information when it's near a reader. These tags can be detected from several distances away by the receiver, making them useful in access control.

The RFID system used in this work consists of three components in two combinations: a transceiver (transmitter/receiver) and antenna combined as a RFID reader. A transponder (transmitter/responder) and antenna combined to make a RFID tag. A RFID tag is read when the reader emits a radio signal that activates the transponder, which sends data back to the transceiver (Ajami & Arab-Chdegani, 2013; Wu et al., 2011). RFID has many perfect features such as completely non-contact, high recognition rate, bulk-storage memory, securely access that can be easily integrated into the existing management information system (Yan et al., 2012; Hua et al., 2010). A basic RFID system consists of three components: an antenna, a transceiver (reader) and a transponder (RF tag) electronically programmed with unique information. These systems communicate via radio signals that carry data either unidirectional or

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bidirectional. When a transponder is in a read zone, its data is captured by the reader and can then be transferred through standard interfaces to the programmable microcontroller for storage and action. Two different transponders (RF tag) programmed with unique information are used in this work, one for the access of a human and the other for access of a vehicle. RFID system is used in our design because it allows easy and fast data collection directly in digital support, removing paper-based registers. At the same time the number of errors and their associated costs is reduced, and a better use of employees' time is achieved (Isabel & Iñigo, 2013). The sliding mechanism of the digital gate described here was implemented using a pivot joint mechanism for fast and swift opening of the gate which is an added advantage over existing digital sliding gates implemented using rack and pinion gear mechanism.

This paper is organized as follows: after the introduction, a brief review of related works occupies Section 2. Section 3 is centred on the design and implementation of the sliding gate system. Section 4 presents the test and discussion, which is followed by the conclusion section.

2 Related Work

As technology is evolving every second, intelligent security systems have been developed and implemented to prevent invasion. In line with this move, Anaza *et al.*, (2017) carried out the design of a campus access management system based on RFID technology. Data from the RFID reader was transmitted to a centralized remote computer or server located in the administrative office of the college through a RS-232 interface. The centralized server determines the authorization & access control rights. Access codes were entered through a keypad while the entire program code was written in Microsoft Visual Basic 6.0 Software. This approach presents a highly coordinated attendance system, but lacks the secured security feature and alarming mechanism to alert the security post.

Gangi & Gollapudi (2013) designed and implemented a security lock based on RFID, fingerprint, password and GSM technology. The RFID reader reads the ID number from the passive tag and sends it to the microcontroller. If the ID number is valid, then it gives access to the fingerprint scanner otherwise it stops the process. If the fingerprint is matched then the microcontroller sends the password to the authenticated person mobile number then the authenticated person enters the passwords in the keyboard which was already given to the user and that received from the microcontroller. If these two passwords are matched then the locker opens otherwise the microcontroller sends a warning message to the person's mobile number and it will remain in lock position. The system is highly secured due to its multiple security features but the program in the microcontroller does not contain auto-code generation routine.

In their work, Shafin *et al.* (2015) designed a RFID Based Access Control System where magnetic door lock is administered via RFID reader that initiates the authentication as well as validation of the user or controls the access. The system also maintains evidences regarding the access and exit records of each user in the form of a log report against every access. The administrator of the central sub-system can terminate the validity of any user at any time to avoid unexpected situations. A double layer of security was applied. First, the user needs to get permission from the system administrator to access and then comes the combined process of authentication and validation.

In another system designed (Ravi et al., 2013), the RFID module reads the data in the card and displays it on the LCD. The data in the card is compared with the data in the program memory and displays authorized or unauthorized messages. The RFID module actuates a buzzer whenever it reads the data from the RFID card. The system is simple and thus the failure rate is minimal. Meanwhile, the system has no registration mode, no true user identification and notification system in case of an intruder. An improvement can be made by adding more security features. Jaykrishan *et al.* (2014) designed a system in which the user unlocks the door using RFID system. If a wrong card is entered, then an SMS via GSM protocol would be sent to the user while an indication would be given to the security man by a buzzer with a live streaming using a camera. It is a simple and affordable security lock system but the system lacks no registration mode to allow for change of RFID ID number. Modification can be made by adding another security feature such as biometric system to increase the security reliability.

Anushri *et al.* (2015) designed a GSM based attendance monitoring systems which lock/unlock the door whenever the student sweeps the RFID tag near RFID Reader. The student details will be indicated on the LCD and sent through GSM SIM 300 Modem to parents to display whether the student is present or not. It is a reliable attendance system especially with the feature of parent notification. Meanwhile, the system lacks registration mechanism and true identification system to alert the administrator of any intruder. The system can be improved further by adding registration mechanism, alarm mechanism and true identification system.

Umar *et al.* (2014) designed a RFID Based Security and Access Control System. The system combines RFID technology and biometrics to accomplish the required task. When the RFID reader installed at the entrance of hostel detects a number, the system captures the user image and scans the database for a match. If both the card and captured image belong to a registered user, access is granted, otherwise the system turns on the alarm and makes an emergency call to the security van through GSM modem. Manasee & Reddy (2013) worked on an automation system based on wireless technologies in which door opening and closing is controlled by RFID, ZigBee and GSM. When a user wants to enter the room, he/she can place his/her valid RFID card on the reader. If valid RFID card is detected by the system, the gate opens and closes after some delay. If an invalid card is detected, alarm system gets triggered immediately. It is a highly secured system but the system is not programmed to

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make the maximal use of the incorporated GSM technology. The system can be expanded with further security measures by sending information to the emergency call centre using GSM technology.

3 System Design and Implementation

The design and construction of a sliding gating system describe here uses Radio Frequency Identification (RFID) as its access controller which was implemented by the pivot joint mechanism attached to the motor. The work involves the design of the access control system by interfacing the microcontroller used with the RFID module, connection of some passive and active component for power supply, motor control and indication, and also the construction of the sliding gate. The system architecture is divided into hardware and software components. The hardware components include RFID cards, micro-controller (ATMEGA8A), LCD 1602 module, RDM6300 reader and tag 125khz, L298n motor driver module, buzzer, Sg90 Servo motor, 7805 voltage regulator, connection cables etc. The schematic block diagram of Figure 1 provides an outline of the major components involved.

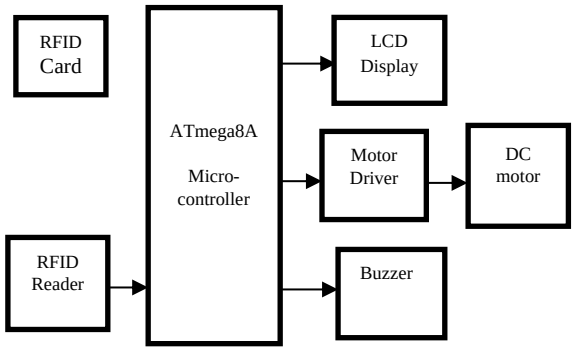


Fig. 1: Block diagram of the system

Construction of the prototype of the sliding gate was carried out using a set of track and jam aluminium plate for the framework. A plain sheet and some sets of rollers were used to construct the gate so that it would be able to slide to and fro on the track of the frame work as shown in figures 2 and 3. The sliding gate was constructed with the following dimensions; height = 30cm, length = 28cm and length of the rack = 40cm.

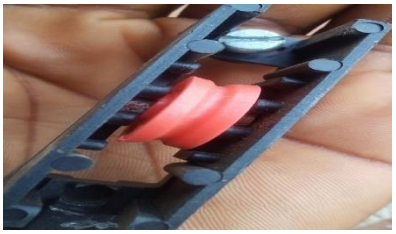
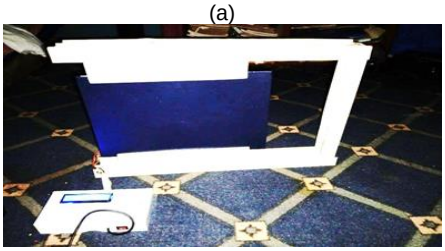


Fig. 2: Roller

Fig. 3: Fitting operation

Afterwards, a set of ply wood was used to construct the pivot joint mechanism that was attached to the servo motor for the automatic opening and closing of the slide gate. The implemented prototype is shown in figure 4.

(a)



(b)

Fig. 4: Implemented Prototype (a) back view (b) front view

4 Result and Discussion

The digital sliding gate completes the entire operation of opening and closing of the gate in a number of steps shown in the flow chart in figure 5 below:

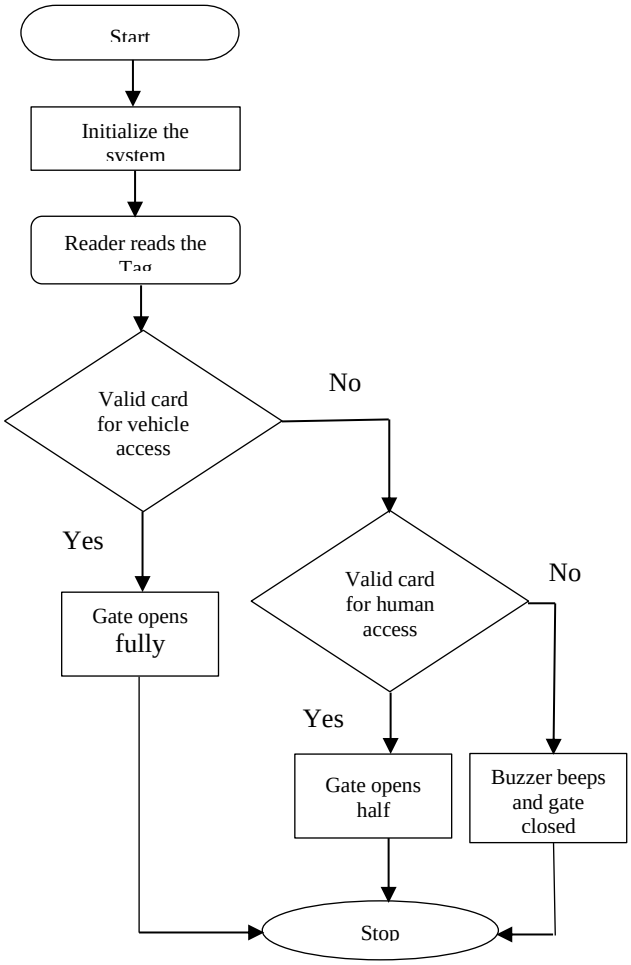


Fig. 5: Sequence of digital sliding gate operation

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The sliding gate opens partially when the valid card for human access is brought closer to the reader, it opens fully when the valid card for vehicle access is brought closer to the reader while an invalid card brought closer to the reader activates the buzzer. The time taken for the reader to read the tag is 3 seconds for both human and vehicle access while the waiting period between the opening and closing of the gate are 10 seconds and 21 seconds for human and vehicle access respectively. The positions of the pivot joint when the gate is closed and partially opened for human access are shown in figures 6 and 7 respectively.

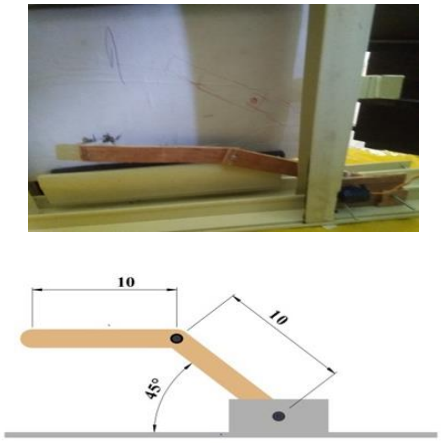

Fig. 6: position of the pivot joint when the gate is closed

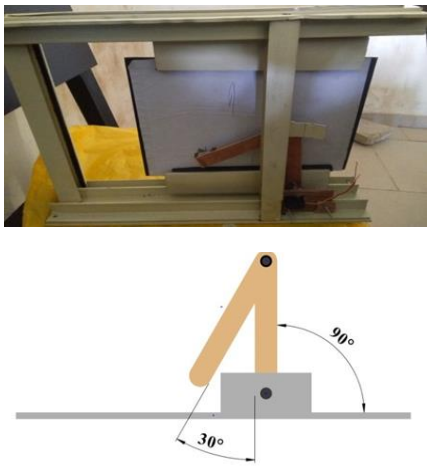

Fig. 7: position of the pivot joint when the gate is partially opened for human access

5 Conclusion

This work described the design and implementation of a digital sliding gate system using RFID technology. The sliding mechanism of the gate was implemented using a pivot joint mechanism for fast and swift opening of the gate which is an added advantage over existing digital sliding gates implemented using rack and pinion gear mechanism. ATMEGA8a microcontroller was used as the control unit interfaced with the RFID module basically because it is rugged, fast and cost efficient. The time taken for the reader to read the tag is 3 seconds for both human and vehicle access while the waiting period between the opening and closing of the gate are 10 seconds and 21 seconds for human and vehicle access respectively. The result obtained from this work shows that the sliding gate opens partially when the valid card for human access is brought closer to the reader; it opens fully when the valid card for vehicle access is brought closer to the reader while an invalid card brought closer to the reader activates the buzzer.

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