Smart Gate Using Android Applications

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Abstract. This paper is about the designing and developing an automatic gate system by implementation Android applications. This is a new improvement to the conventional technique. This project is focused on the development of smart gate prototype in order to improve the current automatic gate that used among the residential houses. The smart gate was controlled by using Android application on a smartphone that connected via a wireless connection. The wireless module ESP8266 was used to set up a server. An Arduino microcontroller was used as an interface between the input and output. The input is the user’s selection from the Android application while the output is the motion of the gate that generated by a DC motor. When the wireless module receiving the incoming signal from the smartphone, the microcontroller will read the signal and trigger the pin to turn on or turn off the DC motor. The ultrasonic sensor was used to detect any intruder that passes through the gate and trigger the buzzer. The limitation of this project is focused on smart gate prototype made of acrylic glass with the base size of 48 cm x 20 cm and a DC motor was used to open or close the gate.

1. Introduction
In this modern era, the crime cases such as burglaries and robberies can occur almost anywhere at any time but tend to occur more often in anticipated settings and expected times such as in residential area. According to the 2006 FBI Uniform Crime Reports, 447,403 robberies were reported to the police at the rate of one per minute in the United States [1]. One of the factors that these crimes occur because of the failure of security system at the entrance gate.

In word, a gate can be defined as a hinged barrier that used to close an opening in a wall, fence, or hedge. Meanwhile, the automatic gate systems can be defined as the integrated gate with the electronic components such as proximity sensors and actuators with the purpose to reduce the human effort in opening and closing of gates [2]. With increasing the number of industrial and residential sectors, automation gates have become one of the main concerns for end-users [3]. Most the automatic gates at the market use a radio frequency (RF) transmitter device to control the opening and closing the gate by different of various radio frequencies. With the growing speed of technological advancement, it is very important to utilize to the current technology of a smartphone especially in remote applications by using their integrated hardware such as Wi-Fi and Bluetooth [4]. The smartphone is playing an important role in the domain of automation [5].
The aim of this paper is to develop a prototype of a smart gate opening system where a smartphone was used to remotely control the opening and closing of the gate which is connected through the wireless system. Instead of fully automatic where everyone can access through the gate, the users can use their smartphone to control the opening and closing the gates. The smart system was built by using Android application. The wireless connection must have to use this application. Compared with the previous smart gate that was sold in the market, the user only needs a smartphone. Everything was installed in the applications compared the manual one, which is the concept of control by a remote button.

The system of Android application was developed as an input to control the motion of the gate by generated a DC motor. The wireless module ESP8266 was used to set up a server and establish a connection between the smartphone and the gate. The Arduino microcontroller was used as an interface between the input and output. When the wireless module receives the incoming signal from the smartphone, the microcontroller was read the signal and trigger the pin to turn on or turn off the DC motor. The ultrasonic sensor will be used to detect any intruder that passes through the gate and trigger the buzzer. With this system, only authorized users allow to access the gate. The significant outcome of this project is to ease the users by reducing their time and effort to manually open or close the gate.

In this paper, Section 2 discusses about the smart home concept. Meanwhile in Section 3 is about the mechanical system involved in this project and Section 4 is about the idea of project based on electrical system include designing algorithm using GUI. Then followed by the results and discussion in Section 5. Finally, Section 6 concludes the project.

2. Smart Home Concept

A smart home, or smart house, can be defined as a home that incorporates with the advanced automation systems to provide the owners with advanced monitoring and control over the building’s functions such as lighting, temperature, multi-media, security, window, gate and door operations [6]. The smart gate by using Android application is one of example of smart home. The system will be monitored by using the technology of automation with “intelligent” feedback and information. There has been a significant increase in home automation in recent years due to higher affordability and advancement in smartphones and tablets which allows vast connectivity [7]. According to the Business Insider's premium research service, the number of smart home devices shipped is expected to grow from 83 million in 2015 to 193 million in 2020 [8].

With the technological advancement, the popularity of Internet of Things (IoT) has increased drastically in recent years. Internet of Things can be defined as a network of internet-connected devices which be able to collect and exchange data using embedded sensors, processors and communication hardware. Smart home is one of the growing applications of Internet of Things. Using wireless technologies such as RFID tags and embedded sensor and actuator, the IoT has become the next revolutionary technology in transforming the internet into a fully integrated home automation [9]. The IoT system consists of sensors or devices which connect to the cloud through connectivity such as cellular, satellite, Wi-Fi, Bluetooth, or connecting directly to the internet via Ethernet. Once the data gets to the cloud, software processes it and then decide to perform an action, such as sending an alert or automatically adjusting the sensors or devices without the need for the user [10]. Figure 1 shows the illustration of smart home system.
In term of smart gate, the possibilities of the IoT will apply to improve the current system of automatic gate. Many applications have been made to design the automatic gates with various types of control devices including card readers, keypads, vehicle tag readers, wireless transmitters and smartphones [11-13]. These projects are developed using various type of technology such as infrared technology, radio frequency technology and many more. Various wireless technologies that can support some form of remote data transfer, sensing and control such as Bluetooth, Wi-Fi, RFID, and cellular networks have been utilized to embed various levels of intelligence in the home [14-15]. Automatic gate is one of the most preferable domestic intended to provide easy access to gate home.

3. Mechanical System

3.1 Methodology of Smart Gate

In this project, the methodology is an important thing before completing the prototype of smart gate. In this situation, the project was divided into two part; mechanical part includes designing the smart gate using CATIA software and implementing by prototype using acrylic glass. Meanwhile, for electrical system, the developing the electrical system using Fritzing and testing the system with Arduino and Android application. The summary of flowchart for both systems as shown in Figure 2 and Figure 3.
3.2 Designing Smart Gate Using CATIA software

The detail drawing of the smart gate prototype was designed using the CATIA. The sliding gate was chosen for this project because of the motion of gate which is suitable to be matched with a DC motor. The rotational motion of the DC motor is converted to linear motion through the combination of rack and pinion gear. The sliding rack was attached to the gate and paired with the pinion gear of the DC motor. Figure 4 shows the mechanical drafting of the smart gate prototype in millimetre unit. The size of this gate is 480 mm x 200 mm with the height of 210 mm.

3.3 Prototype Smart Gate

After drawing the design of smart gate using CATIA, the prototype is built based on the size of 1:1. The smart gate is made from the acrylic glass as shown in Figure 5. The gate is a main part of prototype. The motion of gate will be controlled by sensor and actuated by the motor. In this project, the acrylic glass was chosen because of its strength and easy to shape.
4. Electrical System

4.1 Block Diagram of Gate System

Figure 6 shows the block diagram for the smart gate system. In this project the input is an ultrasonic sensor. This sensor was used to detect any intruder that passes over the gate within the range (45 cm). The data from sensor was sent to Arduino microcontroller to open or close the gate. This microcontroller was acted as the interface between input and output. The motor is the output of the system. The gate will be opened based on the algorithm that was created. Basically, when the car is ON, the smart gate will open. The buzzer was used to show the status of the car. Meanwhile, Figure 7 shows the combination circuit of Arduino, ultrasonic sensor, motor drive, motor and buzzer.

Figure 6: Block diagram for the smart gate system

![Block diagram](image6.png)

Figure 7: Electronic components using Fritzing

![Electronic components](image7.png)
The components for the circuit as shown in Figure 4 were
1- Buzzer,
2- Ultrasonic sensor,
3- Arduino microcontroller,
4- WIFI module,
5- Motor driver,
6- DC Motor
7- Battery 9-V

4.2 Algorithm for the system
In this project, the smart gate system was divided into two sub-systems, intruder detection system and gate controlling system. The algorithm for the intruder detection system is shown in Figure 8. Based on the algorithm, the only input of the system is the object’s distance from the ultrasonic sensor. The output is the beeping sound from the buzzer.

Figure 8: Algorithm of intruder detection system

Figure 9 shows the algorithm for the gate system. The basic concept is the user need to enter the input from the smartphone using Android application. Then the wireless module will receive the incoming signal from the smartphone. After that, the microcontroller will read the signal from sensor and then trigger the pin to turn on or turn off the DC motor.
4.3 Develop the graphical user interface (GUI)

This project was controlled by using Android applications. The application was used to control the motion of gate; either opening or closing the gate. In Android application, the Android studio software was used to develop and design a graphical user interface (GUI) of the application. The Android studio was chosen because it provides the fastest tools for building apps on every type of Android device.

Figure 10 shows the simple of graphical user interface (GUI) of the Android application. The application has a password for security. Then, the user needs to enter a correct password. However, if the user enters the wrong password, a prompt message will appear to ask the user to enter again the password. When the password is correctly entered, the main GUI menu of the application will appear on the screen of handphone1. The connection of Wi-Fi will be implemented between the Arduino microcontroller and the handphone.
5. Results and Discussion

There are two experiments were conducted to realize the efficiency of motor and the strength of wireless. The experiments are
i) Prototype with GUI system
ii) Wireless strength

5.1 Prototype with GUI system

In this part, the GUI system was tested with the prototype. The idea is to show that the Android application can be implemented with the Arduino microcontroller. In this project, the output is the motor, and the input is the ultrasonic sensor.

Table 1 shows the result for opening and closing of the smart gate. The ultrasonic sensor was attached to the gate, then it will be detected the intruder such as a car within a range by a buzzer. When the buzzer was alarmed, then the switch OPEN/CLOSE was pushed via Android application. Meanwhile in Table 2 shows the time taken to open and close the gate.

Table 1: The reading of ultrasonic sensors for opening and closing the gate

| Status | Test | DC motor rotation | Distance of gate motion (cm) | Average distance of gate motion (cm) |
|--------|------|-------------------|-----------------------------|-------------------------------------|
| Open   | 1    | CW                | 19.0                        | 18.9                                |
|        | 2    | CW                | 18.5                        |                                     |
|        | 3    | CW                | 19.2                        |                                     |
| Close  | 1    | CCW               | 18.0                        | 17.9                                |
|        | 2    | CCW               | 18.1                        |                                     |
|        | 3    | CCW               | 17.5                        |                                     |

Table 2: The duration taking to open and close the gate

| Status | Test | Duration of gate motion (s) | Average duration of gate motion (s) |
|--------|------|-----------------------------|-------------------------------------|
| Open   | 1    | 12.6                        | 12.7                                |
|        | 2    | 12.6                        |                                     |
|        | 3    | 12.8                        |                                     |
| Close  | 1    | 12.8                        | 12.8                                |
|        | 2    | 13.0                        |                                     |
|        | 3    | 12.6                        |                                     |

Based on Table 1, the overall distance of the gate motion when closing the gate was shorter than opening the gate. The average distance of the gate motion when opening and closing the gate is 18.9 cm and 17.9 cm respectively. This difference is might be due to the different of friction between the surface of sliding rack and the roller involved when open and close the gate. Meanwhile in Table II, the overall duration of the gate motion has not much difference between the opening and closing the gate. The average duration of the gate motion when opening and closing the gate is 12.7 s and 12.8 s respectively. However, the duration
for the real product may be taken more time compared this prototype. The reason is the rotation of DC motor used in this project was slow which is about 100 RPM. Another factor is the DC motor might not be receiving enough current to rotate at maximum output due to decreasing power supplied from the battery cell.

Figure 11 and Figure 12 is about the situation of the system when opening and closing the smart gate.

**Figure 11: Opening the gate**

**Figure 12: Closing the gate**

### 5.2 Strength of Wireless

Further testing is to test the wireless strength between the smartphone and the Wi-Fi module ESP8266. The signal strength was measured using Wi-Fi Analytics Android application. The signal strength was measured in 1-meter range interval from 1-meter distance of the Wi-Fi module ESP8266. The results obtained was plotted in graph shown in Figure 13.

**Figure 13: The percentage of signal strength versus the range of distance**
From the graph, it shows that the distance from the Wi-Fi module will increase when the signal strength will decrease. The maximum distance to receive the signal is 15 m. More than 15 m, the signal is totally lost, and the device is disconnected from the wireless network. Therefore, it can be concluded that the effective distance to use the smartphone is within 15 m range from the Wi-Fi module. However, the test is carried out in a limited space which the area is separated by walls. Because of the blockage by the walls, the signal of the Wi-Fi cannot travel longer as it should be. Hence, the range of the signal might cover longer if the test is carried out in open area which is not separated by walls.

6. Conclusion

In conclusion, the objective of this project to control the smart gate using Android applications was successfully developed and able to control the system via wireless connection. Therefore, it will make the accessing the gate in more convenient and faster and thus can help many people by using remote control device. For future work, hopefully the security level criteria will be considered in building the system. The idea of face detection, fingerprint, voice recognition will be implemented together with the Internet of Things (IoT). For controller recommendations, the fuzzy logic control (FLC) will be suggested either to use a CNN or ANN concept.

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