Door Automation System Based on Speech Command and PIN using Android Smartphone

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Abstract—**Home automation is the implementation of information technology and control system to facilitate the daily life easier. The growth of technology make smartphone can control the home appliances. An automated device can work more flexible and efficient, including the use in unlocking door. For busy family or busy people, it is not easy to get out of the seat only to reach the door for unlocking people that already have known and made appointment before. The proposed system presents friendly expense design and implementation of home automation to unlock the door with authentication through speech command or pin via smartphone application. So, it is not only the open button from smartphone application that anyone can control, but also it is added an interface for speech command or pin which also can be useful as security. Users can change the password used by themselves. Thus, only users who know the password can control to unlock the door. The smartphone application designed facilitate the users to be free to choose the authentication between speech command or pin. In speech command, users can easily open the door with say it. Another work being tried is open the door with pin. It can help disabled people with speech impaired to be still able use the application. The design of proposed method is based on Android smartphone application, Bluetooth module and Arduino Board. Android smartphone application is used for serial communication to the Bluetooth module which is connected in Arduino Board to unlock the door. Besides it has low cost, Bluetooth based wireless home automation system can be easy implemented in the home. The suggested system is tested and it gives the expected system with more feature as authentication, either with speech command or with pin. Speech command enacted to the system is also tested the Bluetooth connectivity. The farthest range is 14 m to the controlled hardware system.**

Keywords—*home automation; door automation system; door lock system; speech command; pin code; android; arduino*

I. INTRODUCTION

There are many possible approaches towards the sophisticated technologies. Home automation is one of revolutionary technology nowadays. Toward realizing home automation, home appliances are made as easy as possible to be controlled by user. Several work of controlling home appliances have been done, such as turn on the lights, fan, even also open the door via smartphone that is controlled by on off button, open button or short messages service [1][2]. Besides controlling, home automation can be implemented in profitable way by adding security.

The implementation makes door automation system integrated with smart devices technology that will help people to increase the quality of life. Moreover, nowadays everyone already has smartphone and more aware of the existence of the smartphone. No more forget to bring the key, forget to put the key and no need to duplicate a lot of key for each member, but still keeping in mind the key security level. Sometimes it is hard to move from the seat when already concentrate on work only to unlock the door which a little far from the table. So it will easy to open the door without move from the seat. The user can easy understand of these new concepts in the daily life.

Smart devices have been used with various approaches to control home appliances [1]. Here, the use of smart devices is made not only to simplify, but also to give a simple authentication to open the door with more friendly use via speech command or can also via pin. Both of them can be used as additional security. So, although the smartphone is held by other people, it still cannot use to open the door. Only people who know the password can open the door, both using speech command or pin method.

The development of the mobile application and the home automation are also use various wireless technology with more intelligent processes [3]. In wireless technology based home automation system several approaches deployed such as ZigBee [4], Global System for Mobile (GSM) [5], General Packet Radio Service (GPRS) [6], Infrared [7], Wireless Fidelity (Wi-Fi) [8] [9] and Bluetooth [10]. These all wireless technology have their own advantages and disadvantages to be applied. From those wireless technology, Bluetooth can be easily integrated into new device and also has effective cost [11]. So besides smartphone application and Arduino board, the design of proposed method is also based Bluetooth module.

The feature of the proposed system is not only a touch screen button then it easily to open the door without any authentication so that everybody can open the door with once touch. For make it more safe, the security is added. The authentication is using speech command or pin code. Users can choose one of it from the android application. The spoken word or pin code is then send by android smartphone application via Bluetooth as a command to be authenticated then make the actuator on automated door move so that the door will be unlocked then open.

Especially for speech command authentication, the system is controlled by voice. The detection voice will be converted to text. That spoken word will be sent to the hardware system from the smartphone via Bluetooth to be authenticated. In this part of work, the distance between the speaker mouth and the smartphone to detect the voice will be tested how long it can recognize the spoken word. Also, the Bluetooth connectivity will be tested how far it can reach the range for connectivity.

The structure of this paper contains as follows. Section two explain about related works that have been done. Section three is system design that consist of hardware architecture and software design. Section four describe about implementation and discussion of door automation system based on android smartphone and Arduino. In section five, conclusion and recommendation for the future work in this scope are discussed.

II. RELATED WORKS

Several works of control based home automation systems have been studied in order to actualize home automation itself. Various approaches have been deployed in the implementation. SMS based solution was offered in [12]. The research work from H. ElKamchouchi and Ahmed ElShafee provided full functionality to control home appliances uses SMS technology to exchange data via GSM Network. But, SMS based technology lack of Graphical User Interfaces (GUIs). Also, wireless communication via Bluetooth based solutions for control home appliances have been explored in [10] [13]. The research work from R. Piyare and M. Tazil control home appliances via Bluetooth by using Symbian OS phone. This system unable to support Java based application because Symbian OS phone only support Phyton language scripts. These days mostly smartphone applications are developed in Java.

Another study already presented home automation using android application [3]. However, it was designed to control home appliances only with on off button without authentication. The method like on off button is not really secure to be implemented to the gate or door. Hence, this work utilize more feature to control the door by adding authentication via speech command or pin. Through the GUI of android mobile application, the flexibility is in the hand. Additionally, the user will feel more secure because it has authentication and also the android mobile application is still user friendly to be used. Generally, a simplified secure architecture is provided in this work for realizing home automation.

III. SYSTEM DESIGN

This work is more favored on speech command method. User can use speech command to control the system. When the microphone button is touched, it will call google voice to text function. Then, a special window from google will appear to the android screen. In that time, user can say the command to the phone. The microphone icon of google voice to text will flash, showing that it tries to detect the spoken word. It will change from voice to the text. Detected word will print on the android screen in the text formed, so the user will know if it is the correct command or not. The detected text in the android

application directly send to the microcontroller via Bluetooth. The text will be received by microcontroller and directly check if it is proper command or not. The automation system will run as its function when the microcontroller designated it as a proper command. Figure 1 below shows the speech command system design of door automation system design.
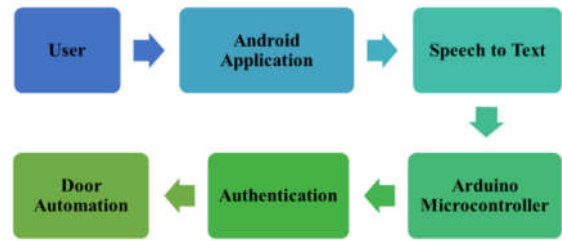

Figure 1. Speech Command System Design

The distributed proposed work of home automation system in automate the door consists of two main components, the hardware interface based home automation system and its software control components.

A. Hardware Architecture

The proposed home automation system to unlock the door consist of three main hardware components: Android smartphone, Bluetooth Module and Arduino board. Smartphone is used to communicate with Arduino board using Bluetooth technology via android application. Arduino is a microcontroller to control the door lock solenoid via relay which already activated by power supply. Bluetooth HC-05 is a module wireless technology standard that is used to exchange the data between two Bluetooth devices within the range approximately 10 m. It is used for wireless communication between Arduino and android smartphone. Hardware architecture of door automation system is shown in figure 2.
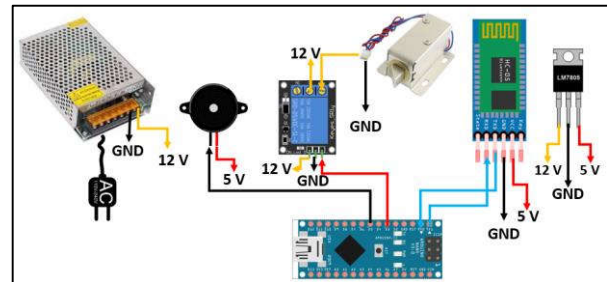

Figure 2. Door Automation Hardware System Design

The system of automated door utilize a wireless technology. Bluetooth module HC-05 is selected to be installed to the Arduino board. HC-05 is designed to ease the use of Bluetooth Serial Port Protocol Module (Bluetooth SPP). HC-05 is a serial connection setup. The connection between Arduino Nano and Bluetooth module is via transmitter and receiver pin. The microcontroller is using Arduino Nano, an ATmega328 board based. Arduino Nano has six analog inputs and 14 digital input/output pins which the six pin of the 14 pin can be applied as PWM outputs. It has automation reset and USB Connection,

so it is easy to connect the Arduino Nano to the computer. It can also start the Arduino Nano by give it power from battery or AC to DC adapter on recommendation 7-12 Volts. Besides it is easy to use, the small size of Arduino Nano is convenient to be implemented in the circuit design.

The door automation system needs a supporting component for operating the system besides Arduino Nano microcontroller. Relay module is needed as an executor and interface between the microcontroller and the lock door solenoid. Relay control the solenoid door by operate it to close the normally open contact of the lock solenoid door. So when the applied voltage is given, the normally open relay will close which make the lock solenoid door open.

The system also uses the solenoid in the door. The solenoid lock door is devoted to automatically lock the door when the door is close. The door will open when the solenoid slug pulls. It works on 9-12 Volts DC controlled via relay module, as explain before. The solenoid uses electromagnets based. The slug will be pulled into the middle of the coil when relay energize the coil. To make it more user friendly, the system has the sound indicator when an event occurred, like failed to unlock the door. The sound will out via buzzer for warning the user if there is something wrong. So, the user will easily aware of it. The buzzer is also easily implemented and the cost is cheap.

B. Software Design

The software is also needed to manage how the system run. The hardware will not run without the software design. The software helping to control the component. This research work uses two software: Arduino Integrated Development Environment (IDE) and MIT App Inventor web based.

The Android application, is used for user interface as the key of the door. Application is created with MIT app inventor web based. This door automation project is controlled using Android smartphone application. So, it is needed to make an android application that will correlate with the hardware system to control the door. There is a convenient web based tool to develop the android application, MIT App Inventor. The app inventor uses the blocks-based tool to create the program code. Its application is more simple drag and drop.

Then, the Arduino program to set the hardware of door automation rules is used Arduino IDE 1.8.5. Arduino Integrated Development Environment is a desktop software that is used to program the Arduino as microcontroller in this research work. This Arduino programming language consists of functions for computations and control, variables that comprises constants and data type, then the structure which contains C++ code. Entire programming for proposed system is done in Arduino IDE tool. Baud rate is set to 9600 bits per second for serial communication between Arduino board and smartphone. Before compile and upload the program, the proper board in tools bar is chosen to correspond with the board of Arduino Nano hardware.

IV. IMPLEMENTATION AND DISCUSSION

This research work makes a system for unlocking the door by android phone. Two methods are tested for door automation system, speech command authentication and pin authentication. Users can choose one of them from the android application which is preferred to be used for control to unlock the door.

A. Speech Command

1) Android Application

This research work tested the automation via voice. Speech command is used for control to unlock the door. The android application of this work is created with MIT App Inventor web based. It already has google speech to text library, called speech recognizer. This program is using the speech to text of google library. The spoken word as a command to unlock the door is converted to text uses google speech function in MIT App Inventor.

The serial connection between android application and Arduino microcontroller is also using Bluetooth. The both Bluetooth address must be paired first until the interface of android application turn become connected from not connected. Then the text from the speech command will be sent to the Arduino microcontroller via Bluetooth and will be authenticated if it is the correct command or not. The speech command password to unlock the door can be changed according to the user's wishes. So, not everyone will know.

Figure 3 shows the design of android application when it is selected speech command methods. The default setting of the speech command is for open door in the first tap. Here the spoken word from user directly recognized as command to unlock the door. While, the long pressed will change the mode to the change password. Here users can change the command that will be used to unlock the door to be saved as new password. This research work has two function to be applied to the android application, for speech command and pin. The top left corner button is used to switch from speech command to pin, vice versa.
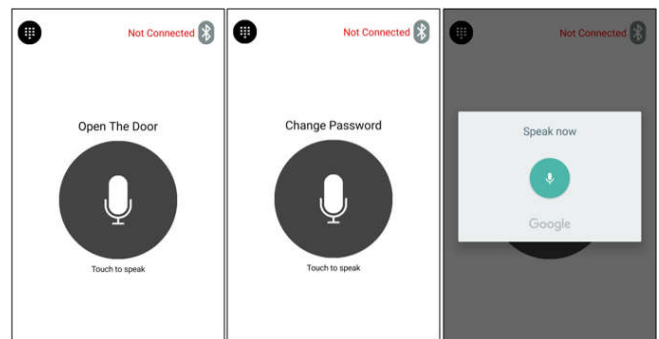

Figure 3. User Interface for Speech Command

The experiment tests the android application to detect the voice. The distance between smartphone and speaker is observed. This experiment is tested with normal volume voice to talk and with normal indoor noise, not too crowded but not too quiet also. On 25 experiments with distances speaker mouth to the phone ranging 2 cm to 10 cm, successfully detect correct word as many as 21 experiments, while 4 experiments failed to detect the word. The result in the table 1 below shows that the longer distance between speaker mouth and the smartphone, the longer time that the application need to detect the word spoken

or even it cannot be detected. It will be different if the voice volume increase along with the increase distance. Sometimes it also will detect the wrong spoken words. It depends on the diction of the user.

Table 1. Time Detection

Distance Speaker mouth to the phone (cm)	Time (Second)
2	2
4	2
6	3
8	4
10	4

2) Hardware Implementation

The main part of the door automation hardware is the Arduino microcontroller. It receives the data from the android application and control the supporting components. Speech command data, which is sent by the android application via smartphone Bluetooth, will be received by the Arduino microcontroller via Bluetooth module which has been installed on it. Arduino microcontroller has non-volatile memory storage, EEPROM. This memory is used to save the command password in order to the stored memory will not lose even when there is no power supply give in. The whole algorithm of door automation with speech authentication is shown in the figure 4.

Speech Command Algorithm
1. Initialize the password of speech command
2. Call speech to text google library
3. Send the text from spoken word via Bluetooth
4. Receive the text data in the Arduino microcontroller
5. Check the protocol, if the first input character is #, the data is true for the system
6. If not, do nothing
7. If true continue check, the next flag must be 0 to indicate the use of speech command authentication
8. Then continue check, if the next flag serial setting is 1, it is the command to set new command password, then update the received detected text in the next serial data as saved password in the EEPROM
9. If the next flag serial setting is 0, it is the command protocol to open the door.
10. Do the authentication, If the command password received are exactly the same with the saved password, the relay will turn HIGH to control the solenoid to open the door
11. If not, shows the warning in the android application

Figure 4. Speech Command Algorithm

The protocols are defined correlated with the android application. In the android application, 1 is defined for setting the password and 0 is defined for open the door. The Arduino microcontroller in the door automation hardware will know the sent data from the phone is a command for setting password or a command to open the door. The data from the android phone is sent using serial communication. In the Arduino microcontroller, it can use the function of serial available to check if there is a received data or not. The corresponding received data is identified by the header data, using #. Data with different protocol will not be processed. Data with the # header

will continue to the next authentication. For the authentication using speech command, the next flag is signed by 0 after header #. Then, if the next flag after #0 is 1, continue for the change command setting process. If it is 0, continue to the open door process. So, the protocol of speech authentication will be like #0 then 0/1 followed with sign of the command password.

The implementation of the hardware is tested 25 times for each open speech command to check the sustainability of the system. The range tested between the hardware and android application is 9 meters with normal obstacles, such as table, chair, cupboard, and light bulkhead room. Then, the distance between mouth of the speaker and the android application is about 10 cm. The data is shown in the table 1 below.

Table 2. Implementation System Running

Time to	System Running	
	Android Application	*Hardware Implementation*
5	Well	Well
10	Well	Well
15	Well	Well
20	Slow	Well
25	Slow	Well

From table 2 above, the android application starts running slow in the experiment on 20. The speech to text function becomes slow to detect. This is affected by the running program repeat continuously makes the phone easy to heat, then run slow. But for the hardware system is still running well until 25 experiment. After the data received, the hardware system run as usual without any sudden close connection problem.

Next experiment is checking the Bluetooth connectivity with distance comparison. It is tested with the increment of the distance is 1 meter. The distance between hardware and smartphone start from 1 meter until 15 meters. There are two scenario applied. First scenario is using normal obstacle, such as table, chair, cupboard, and light bulkhead room. Then second scenario is using hard obstacle, the closed door or thick wall.

Table 3. Bluetooth Signal Connectivity

Range (m)	Scenario	
	Normal Obstacle	*Hard Obstacle*
1	Succeed	Succeed
2	Succeed	Succeed
3	Succeed	Succeed
4	Succeed	Succeed
5	Succeed	Succeed
6	Succeed	Succeed
7	Succeed	Succeed
8	Succeed	Not Succeed
9	Succeed	Not Succeed
10	Succeed	Not Succeed
11	Succeed	Not Succeed
12	Succeed	Not Succeed
13	Succeed	Not Succeed
14	Succeed	Not Succeed
15	Not Succeed	Not Succeed

From table 3 can be seen that the Bluetooth signal can reach 14 meters with normal obstacle, such as table, chair, cupboard, and light bulkhead room. But, the Bluetooth signal can't reach 8 meters for the connectivity between two rooms which are separated by closed door and thick wall. It is affected by the obstacle makes the signal fading and scattering.

B. PIN Authentication

1) Android Application

Another work besides speech authentication, the application gives another choice to unlock the door by pin authentication. Same as in the speech command interface, the GUI of the android application is made first. When a new project started, the view of MIT app inventor web based will be in the designer tab. Layout and user interface can be drag from palette column and drop to the screen viewer in the middle. The properties also can be set through the properties column. Not only layout and user interface which can be dragged and dropped, but there are also many other components. In this door automation project, the android application has connectivity of Bluetooth client in order that the smartphone can search the nearest other active Bluetooth in the range. The purpose is connecting the android smartphone with the Bluetooth module in the door automation hardware. When it is connected, the door can control from the application via android smartphone.

There are also other components like Tiny DB for storage, Notifier for notification or warning, and many more that can be picked from palette column, adjust the usability. The button pin can be gotten from column palette user interface. The shape of the button can be changed in the properties column. Password text box is also needed to save the number touched. The android application of door automation system has two modes, is change pin mode and open door mode, also in the button display.

After design the GUI in the designer tab, the code of how the program run is made in the blocks tab. MIT app inventor is different with android application development environment in general which is using script based. To arrange the program, MIT app inventor use blocks code program. It is easier to understand and more interesting for new learner android programming.

The Bluetooth connection between android smartphone and the door automation hardware is very important. When the android smartphone Bluetooth is turn on, the Bluetooth client function of the program start to make list all paired Bluetooth and save the address and name. It can be saved using Tiny DB component. From that paired Bluetooth list, the address and the name of Bluetooth hardware is selected in order to make connection between the both. There will appear warning text if the connection failed.

The modes of pin authentication can be changed by touch the mode button in the figure 5. Change pin mode and open door mode have each different protocol to make the both easier to distinct and process in the next, especially in the hardware implementation. If change pin mode is selected, the new input pin is saved. Same as in the speech command authentication,

change pin mode is set as 1, while open door mode is set as 0. Those two number serve as distinguish protocol.
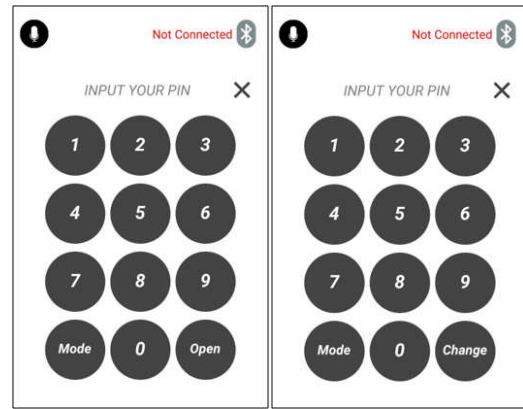

Figure 5. User Interface for PIN Authentication

2) Hardware Implementation

The pin data, which is sent by the android application via smartphone Bluetooth, will be received by the Arduino microcontroller via Bluetooth module which has been installed on it. Arduino microcontroller has non-volatile memory storage, EEPROM. This memory is used to save the pin password in order to the stored memory will not be lost even when there is no power supply give in.

The protocols are defined correlated with the android application. The corresponding received data is identified by the header data, using #. Data with different protocol will not be processed. Data with the # header will continue to the next authentication. The next flag is used to distinguish the speech data or pin data. As explained before, speech authentication uses 0 as flag, while pin authentication uses 1 as flag. The password setting is sent through protocol 1 after #1. While the open the door function is sent with 0 after #1. So, the protocol of pin authentication will be like #1 then 0/1 followed with the pin. The whole algorithm of door automation with pin authentication is shown in the figure 6.

PIN Authentication Algorithm
1. Initialize 4 digits pin code in the Android Application
2. Send the pin data via Bluetooth
3. Receive the pin data in the Arduino microcontroller
4. Check the protocol, if the first input character is #, the data is true for the system
5. If not, do nothing
6. If true continue check, the next flag must be 1 to indicate the use of pin authentication
7. Then continue check, if the next flag serial setting is 1, it is the command to set/update the pin code, then update the received 4 digits pin code in the next serial data as a saved pin in the EEPROM
8. If the next flag serial setting is 0, it is the command protocol to open the door.
9. Do the authentication, If the 4 received digit pin are exactly same with the 4 digits pin saved, the relay turn HIGH to control the solenoid to open the door
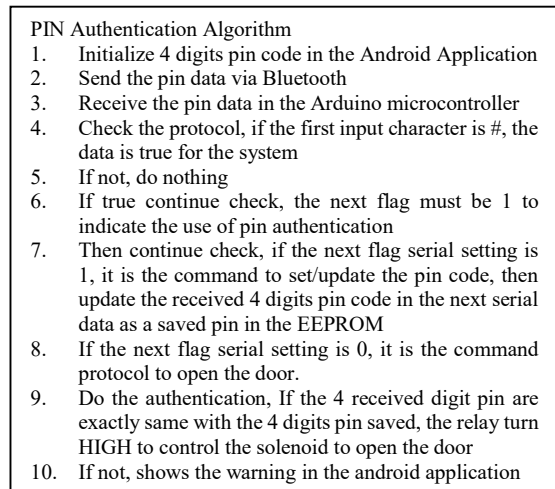10. If not, shows the warning in the android application

Figure 6. PIN Authentication Algorithm

The pin only can be sent when the Bluetooth is connected. If the Bluetooth is still not connected, the warning will appear in the screen to notice. If the connection success, the data of protocols and pin will be received by the Bluetooth in the hardware. After the header authentication, the received pin as the key to open door will be checked the sequence of the pin digits, is that the same with the stored pin or not. For the pin setting, it is need parsing the serial received data to be stored in the microcontroller of every new digit pin, which next is used to be recognized as a new pin for authentication.

By this application, users can choose the preferred authentication that is wanted, speech authentication or pin authentication. Users can also change the password that is wanted for unlock the door. The prototype implementation of door automation system is shown in the figure 7.

Figure 7. Prototype of Door Automation System

V. CONCLUSION

This work applies the common trend of smart home by integrating smart devices with home appliance to be automated. A user friendly technology is deployed to render the entirety door automation system with its process to be controlled. Automation work is tested with speech command authentication and pin authentication. In speech command authentication, google speech library helps the spoken words to be converted to text. By this speech command interface can simplify the use of the application and also speech command can add security function, so does with the pin. The password can be changed by the user as desired. To ensure communication between smart devices are corresponding, the data communication protocol is established. The header used in this door automation system is #. To distinguish the application run in speech command or pin method, it gives more flag in the protocol after #. Flag 0 as a sign for speech data use, while 1 is for pin data use. The protocol of setting the password is signed by header 1 after #0/1. While, the protocol of open door is signed by header 0 after #0/1. The design and implementation of door automation system is running well and secure with speech and pin authentication.

This work also tests some experiment. The Bluetooth connectivity between android smartphone and the hardware can reach 14 m in range with normal obstacles, such as table, chair, cupboard and light bulkhead room. However, it only can reach 7 m in range for Bluetooth connectivity between two different rooms which are separated by the closed door and thick wall with 6 cm usually used distance between speaker mouth and the smartphone, voice can be detected in 3 seconds.

FUTURE WORK

For the next research work, the implementation of the prototype can be modified in the authentication. The authentication can be integrated by voice user recognizer. So, the security of the door automation system will be more unique and more interactive.

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