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Centralized Control with Smartphone for Voice Command and Facial Recognition on Smart Home System

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Abstract— *The development of the world of technology will actually make human life easier. With so many developing technologies, smart home technology is one technology that continues to be monitored for its development. In Indonesia itself, the use of smart home technology is still not very visible. Most people think smart home products are still not needed, because smart home products are expensive and still not needed. This research will conduct an experiment by designing a smart home with voice commands to control door locks and house light and also camera control for facial recognition and control the automatic door lock, both of which can be done on a smartphone. The system is made using Firebase Web Database, Raspberry Pi 3 as the processing brain, Pi Camera, Relay, Solenoid Door Lock, and light Bulb. The design made successfully executes all commands and provides information feedback for the user. This design also provides affordable smart home technology options that have the potential to be developed.*

Keywords— *Smart Home, Raspberry Pi 3, Voice Command, Facial Recognition, Firebase.*

I. INTRODUCTION

The development of the world of technology will actually make human life easier. Various aspects of human life have now been touched by technological developments. Aspects of health, work, information, home needs, perhaps are some aspects that are close to humans, which have now experienced developments in the world of technology. Of course, we as humans, must be able to keep pace with the development of technology to get the maximum benefit. With so many developing technologies, smart home technology is one technology that continues to be monitored for its development. Today's modern smart home is a residence that connects several devices to work in harmony to offer convenience, comfort, and security for those who live in the house and who visit the house.

In Indonesia itself, the use of smart home technology is still not very visible. Quoted from the Investor Daily Indonesia page by the author Mashud, it is said that in developed countries, the use of smart homes has been applied everywhere because of the benefits that are functional, efficient, safe, and can also be controlled and monitored remotely. Unfortunately, Indonesia is still considered very underdeveloped and ignorant about this smart home product. In addition, he continued that most people think smart home products are still not needed, because smart home products are expensive and still not needed.

Several studies have been carried out for smart homes, among them: smart home system that can be controlled via a smartphone, especially for on and off control [1]. Control on the smartphone using the url access ip address to be able to enter into the interface that has been created. But, accessing url ip address to control smart home will look less efficient. Next, making a voice command to control a bluetooth socket [2]. They use the help of Google Home to practice the given voice commands. But, there are some suggestions that the author put forward, namely to make this system used remotely and can be used by different users. Next, creating a system for observing guests who come to the house [3]. The study used a camera module to take pictures of people who came to the house and an audio amplifier to send voice replies to guests who came. But, taking pictures of guests who come has not been made in real-time and the results of the pictures taken must be accessed by themselves in the database.

Based on these sources, the design of a smart home system that develops an existing design can be a solution. Creating a smart home system with voice commands from the user's smartphone using technology such as on and off control, monitoring guests with cameras, and monitoring home conditions, is considered sufficient for a breakthrough in smart home technology.

This research is also based on previous research conducted by myself using ESP8266 technology. The system successfully controls home devices, such as lights and door locks through voice commands given via the user's smartphone [4]. The development of the previously designed system, including the addition of features used, as well as processing tools that previously used ESP8266 to become a raspberry pi. That way, the designed system will fulfill the purpose and usefulness of this research.

II. SYSTEM DESIGN

The scheme of designing a smart home system starts from the user who uses a smartphone to give orders. At the same time, the pi camera detects in real-time the incoming input. The process continues to the firebase web database for commands from the smartphone and is forwarded to the raspberry pi 3. Meanwhile, the input from the pi camera will be directly processed by the raspberry pi 3. And at the end, the user's smartphone can be used to see the output from the pi camera, and the raspberry pi 3 will control relays to control several components, such as door lock solenoids and light bulbs. For

Mochammad Faishal R. and Nur Sultan Salahuddin, "Centralized Control with Smartphone for Voice Command and Facial Recognition on Smart Home System," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 1, pp. 23-30, 2022.

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more details, Figure 1 describes the block diagram and device placement scheme of the system created.

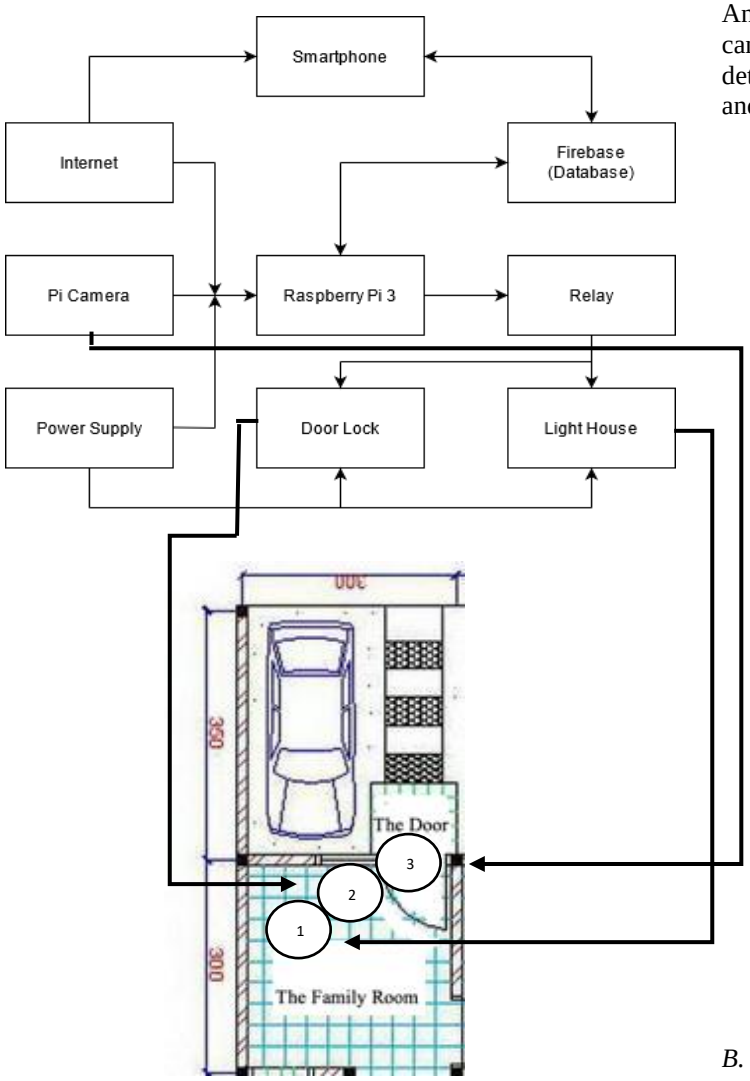

Fig. 1. block diagram and device placement scheme

In this study, we designed and built the control of a home device with voice commands and door monitoring via smartphone consisting of several components: software, database, and hardware.

A. *Software Design*

The software design for the smart home system is made on a web-based platform, MIT App Inventor 2 (https://appinventor.mit.edu/), which will look like the image below.

The software design will display 3 main screens consisting of a home screen display, a voice control screen display, and a camera control screen display. The home view allows the user to select the controls to use, voice commands, or camera controls. Next, the voice control screen displays, which lists the commands the user can give with the user's voice by pressing the microphone image.

There are 6 main commands on the voice control screen display, commands 1 and 2 to control the door of the house, then commands 3 and 4 to control the house lights, and commands 5 and 6 to control the two devices simultaneously. And lastly, the camera monitoring screen display, which users can use to view the camera monitoring results, whether the detected person is a recognized person or not, and get the date and time data of the camera monitoring results.

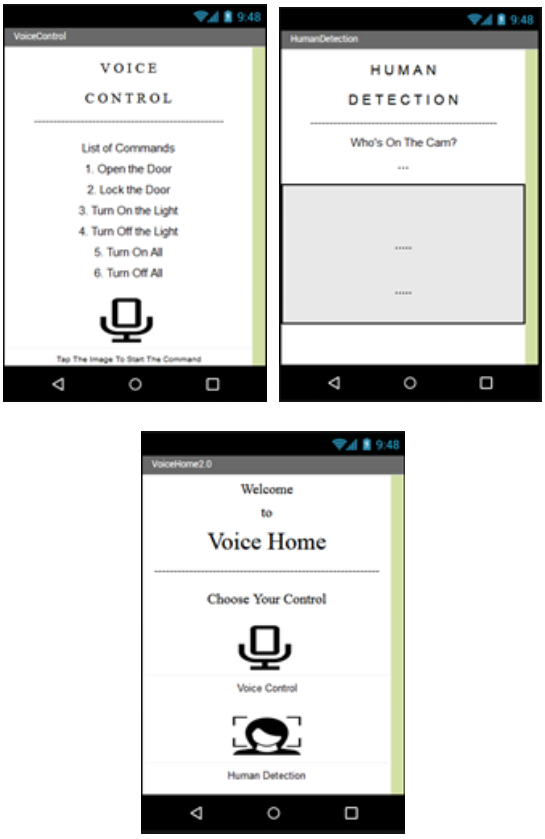

Fig. 2. Design of the Smart Home System Application Display

B. *Command on Database*

The command for this smart home system will use a web-based database platform, Firebase (https://firebase.google.com/?hl=en), which will look like the table below.

TABLE 1. Command Details on Firebase Web Database

Tag on Firebase	Meaning	Command Content	Direction
Perintah	User-given commands via voice detection	DoorIsOpened	Raspberry pi 3
		DoorIsLocked	
		LightIsOn	
		LightIsOff	
		All_Is_On	
		All_Is_Off	
DoorStatus	Current state of the door	Door Is Opened	Smartphone
		Door Is Locked	
LightStatus	Current state of the house light	Light Is On	Smartphone
		Light Is Off	
DoorCam	Identify who is at the door	(User)	Smartphone
		Unknown	
DateTime	Date and time from "DoorCam"	(The current date and time)	Smartphone

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Commands on the firebase web database are made in real-time database mode. The commands given as input to get to the raspberry pi 3 are 6 commands. Meanwhile, the commands given as output to the smartphone are 8 commands. The database on this firebase web database will also be designed "Update by Real-time", which means that the command will be updated directly and overwrite the previous command in the firebase tag.

C. Hardware Design

The hardware design for the smart home system that is made, will look like the image below.

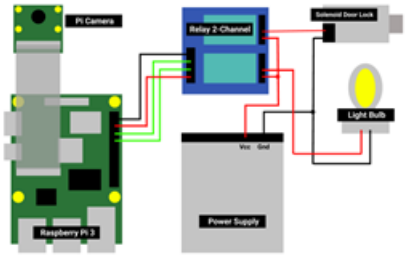

Fig. 3. Hardware Design and Cable Path

Based on Fig 3, In designing hardware, the components used are; The Raspberry Pi 3 is used as a central system that processes all commands, Pi Camera, a 2-Channel Relay used to control several home appliances, a light, a solenoid door lock that is used as a door lock for the house, and a power supply used for component voltage sources.

1) Raspberry Pi 3

The Raspberry Pi, often abbreviated as Raspi, is a single-board circuit (SBC) computer the size of a credit card that can be used to run various application programs. Raspberry Pi was developed by a non-profit foundation, the Raspberry Pi Foundation consisting of developers and computer experts from the University of Cambridge, England, namely, Eben Upton, Rob Mullins, Jack Lang, and Alan Mycroft, from the Cambridge University Computer Laboratory in 2009.[3]

Fig. 4. Raspberry Pi 3 Model

2) Pi Camera

The Pi camera board 500W Pixels is a 5 MP camera module with 1080p video recording capabilities. This module can be connected directly to the Raspberry Pi via a ribbon cable to the Raspberry Pi's CSI (Camera Serial Interface) port.

Physically the shape of the Pi Camera board is shown in figure 2 where this module measures about 25 x 20 x 9 mm and weighs about 3g. The sensor used has a native resolution of 5 Megapixels, with a fixed focus lens.

This module is capable of capturing images with a resolution of 2592 x 1944 pixel static images, and also supports video recording of 1080p30, 720p60, and 640x480p60/90. [3]

Fig. 5. Pi Camera

3) Relay

Relay is an electronic switch that can be controlled from other electronic circuits.[4]

Fig. 6. Relay

4) Light Bulb

LED lights have been found for a long time, but now as technology advances, LED lights have better benefits and can be produced at lower costs. When you use electronic devices such as TVs, computers, and various other electronic furniture that has a small light that will light up as a sign that the device is in an on position, the small light is called an LED that stands for light emitting diode. LEDs can be interpreted as semiconductors that convert electrical energy into light when passed by an electric current.[4]

Fig. 7. Light Bulb

5) Solenoid Door Lock

Solenoid is one type of coil made of long wires that are tightly wrapped and can be assumed that the length is much larger than its diameter. In the case of the solenoid, the ideal length of the coil is infinite and is built with coinciding cables in the coil, and the magnetic field inside is uniform and parallel to the solenoid axis.[4]

Fig. 8. Solenoid Door Lock

Mochammad Faishal R. and Nur Sultan Salahuddin, "Centralized Control with Smartphone for Voice Command and Facial Recognition on Smart Home System," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 1, pp. 23-30, 2022.

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6) Power Supply

Power supply is an important device in the world of electronics. Power supply is generally used to supply electronic devices that require DC currents. So that with the development of technology that requires DC voltage, the power supply is also developing to increase its performance. As is the case with the power supply that used to be used, namely conventional power supply. Where this conventional power supply has the disadvantage of having a low efficiency because it takes the voltage from the result of rectifying the sine signal. To increase the efficiency of the power supply the signal that is rectified must be a box signal. In this case a new power supply system appears with a switching method called a switching system.[4]

Fig. 9. Power Supply

III. RESULT AND TESTING

Figure 10 shows the centralized control with smartphone for voice command and facial recognition on smart home system.

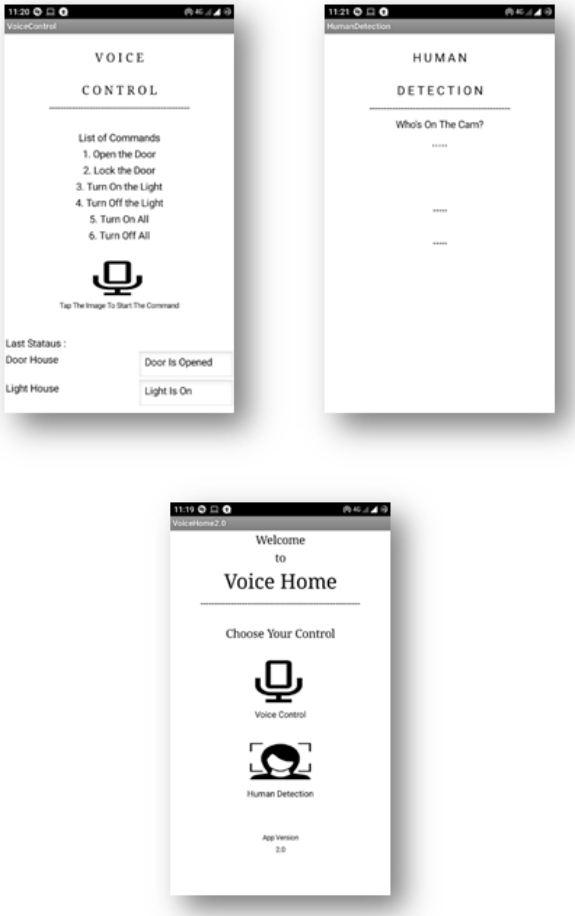

Fig. 10. Display of the Android Application

The main flowchart below explains how the system in the application runs. In short, the user has 2 main menus, namely monitoring the camera at the door and giving voice commands. The two menus run concurrently, so the user can choose whichever control the user wants to choose. The flowchart of the camera monitoring section at the door of the house and the voice command section will be explained in the next discussion.

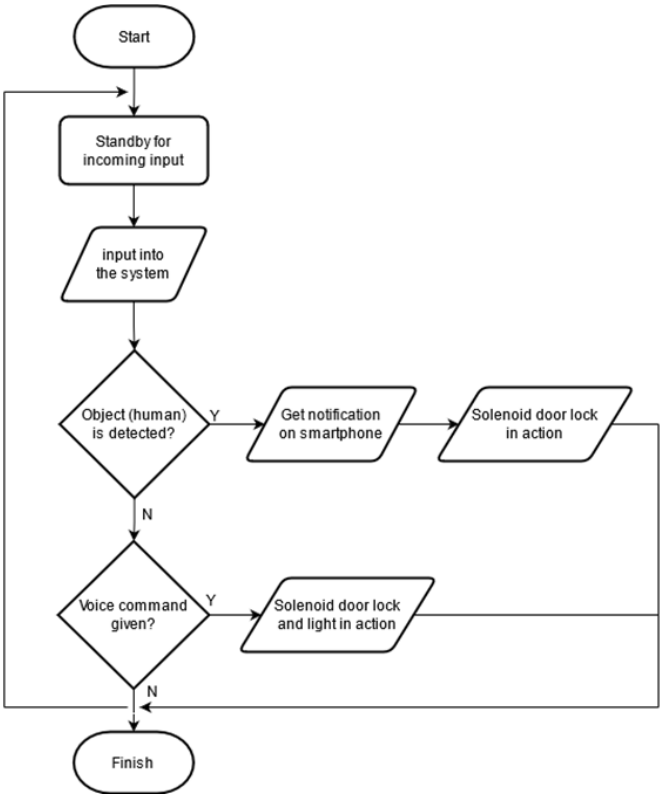

Fig. 11. Main System Flowchart

Figure 12 below explains how the voice command works on the system.

There are two conditions that will refer to the lights and doors used in the design of the device, namely on and off. If the command given is to turn on the light, then the light will be active. If the command given is to turn off the lights, then the lights go out. The same applies to the door of the house. If the command given is to lock the door, then the door will close the lock. If the command given is to open the door, then the door will unlock it.

If the command given is to turn on all devices (lights and doors), then all devices in this system will be active (lights on and door locks open). And if the command given is to turn off all devices (lights and doors), then all devices in this system will be disabled (lights off and door locks are closed). If the user has obtained the desired result, such as a light or door lock that is on or off, or the user wants to enter the camera monitoring menu, the user can return to the main menu and return to the initial process.

Figure 13 below explains how the camera monitoring works on the system.

Mochammad Faishal R. and Nur Sultan Salahuddin, "Centralized Control with Smartphone for Voice Command and Facial Recognition on Smart Home System," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 1, pp. 23-30, 2022.

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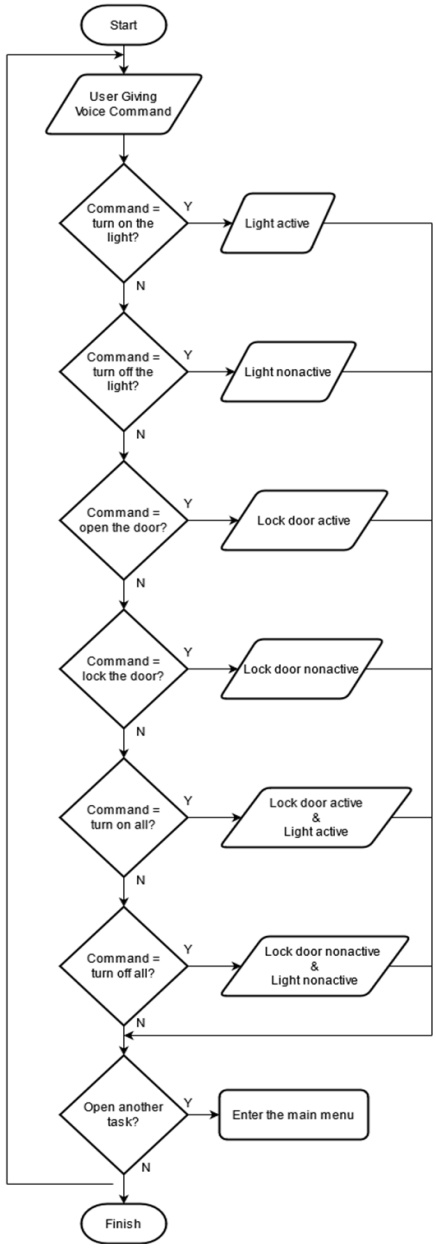

Fig. 12. Voice Command Flowchart

Cameras installed on the door of the house will actively detect who is in front of the door. This is interpreted as a person who will enter the house. If the person at the door is a person recognized by the system, a notification will be sent to the user's smartphone as a recognized person and the door lock will open. After that, the system will wait for 7 seconds to wait for the user to enter the house, then the door will be locked again automatically. If the person at the door is a person who is not recognized by the system, a notification will also be sent to the user's smartphone as an unknown person and the door lock will remain locked.

After getting a notification that someone not recognized by the system is at the door, the user can take actions such as notifying the person at home or leaving it alone. In addition, if the user wants to know when the recognized or unknown person was detected, the user can open the human detection menu in the application that has been created. If the user has got the results according to his wishes and or wants to give a voice command, the user can go to the main menu in the application to open the voice command menu.

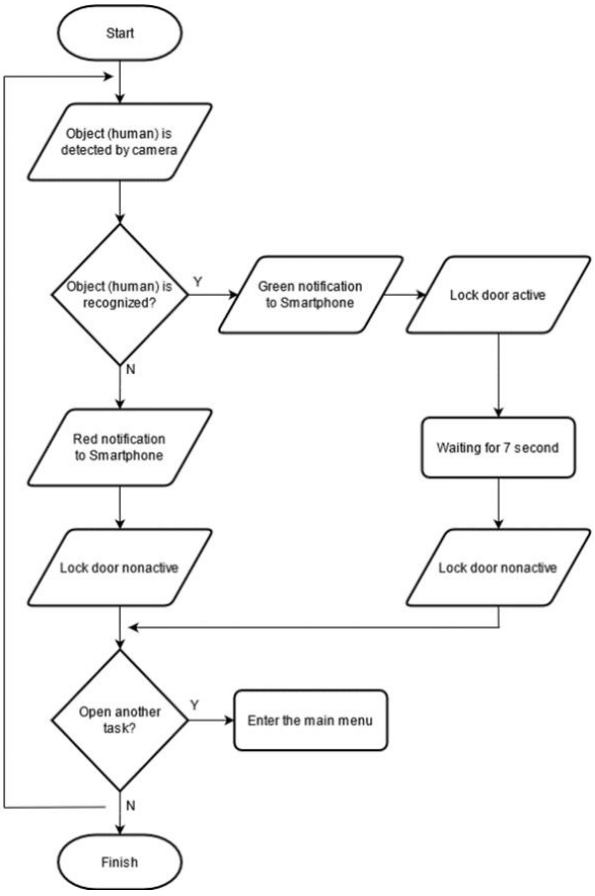

Fig. 13. Camera Monitoring Flowchart

Testing is carried out on a system that includes the ability of the Raspberry Pi 3 to execute commands given via a smartphone, voice control execution time, camera monitoring, and system development expense.

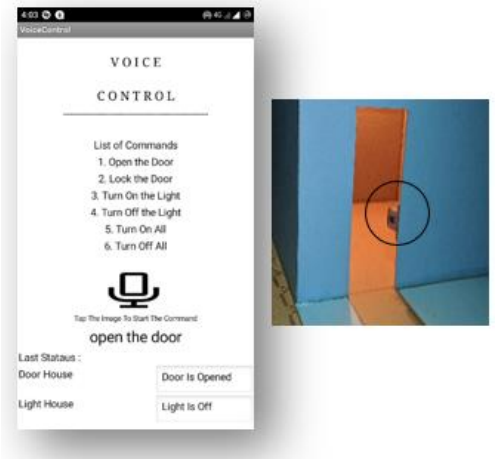

Fig. 14. Testing of system open the door command on smartphone

Mochammad Faishal R. and Nur Sultan Salahuddin, "Centralized Control with Smartphone for Voice Command and Facial Recognition on Smart Home System," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 1, pp. 23-30, 2022.

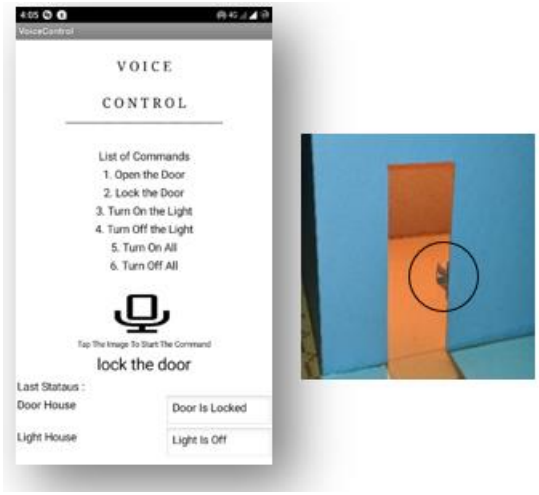

Fig. 15. Testing of system lock the door command on smartphone

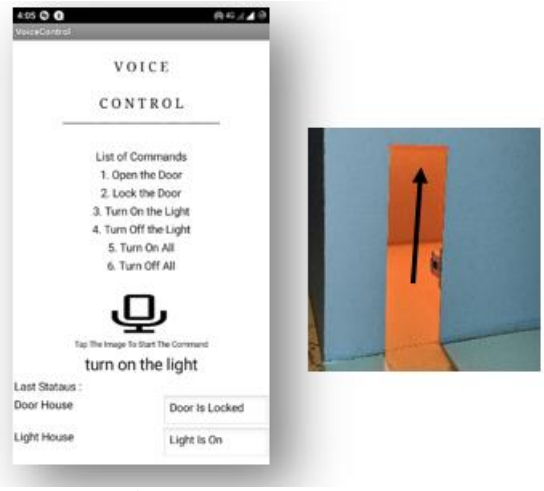

Fig. 16. Testing of system turn on the light command on smartphone

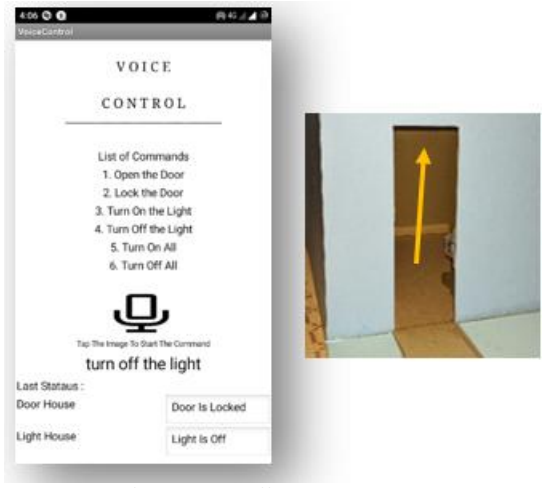

Fig. 17. Testing of system turn off the light command on smartphone

The experiment above shows the performance of voice commands on the system that has been created. The attached end device, can respond to all commands given by the user. The "last status" section will describe how the last state of the end device used and will continue to be updated along with the commands given by the user.

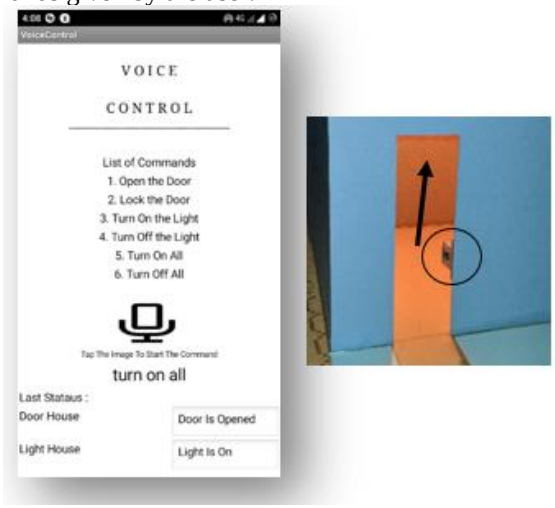

Fig. 18. Testing of system turn on all command on smartphone

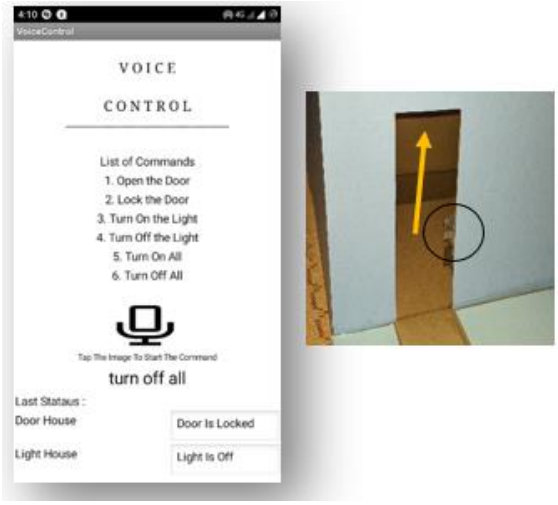

Fig. 19. Testing of system turn off all command on smartphone

The execution time of voice commands is presented in the table below.

TABLE 2. Voice Control Execution Time Result

Command	Result	Execution Time
Open the Door	Works	0.60 second
Lock the Door	Works	0.50 second
Turn On the Light	Works	0.60 second
Turn Off the Light	Works	0.50 second
Turn On All	Works	0.60 second
Turn Off All	Works	0.40 second
Average Time		0.53 second

The experiment shows the performance of the human detector on the system that has been created. The end device installed and the application created, can provide the output that the user needs. When a human object is detected, the end device responds immediately and the application can show the time when the human object was detected.

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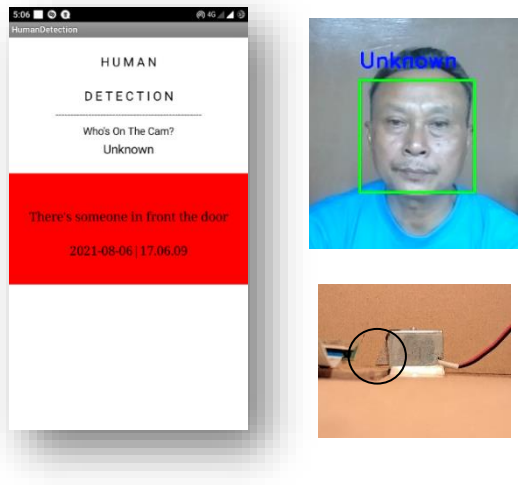

Fig. 20. Testing of system other people at the door

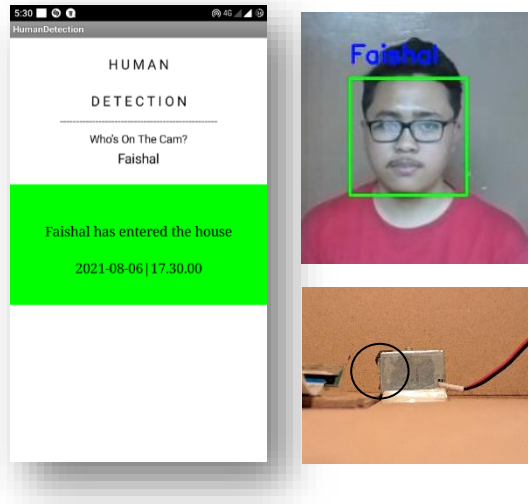

Fig. 21. Testing of system user at the door

Previously, on the user's smartphone, you would get a notification for every person detected by the camera, as shown in the image below.

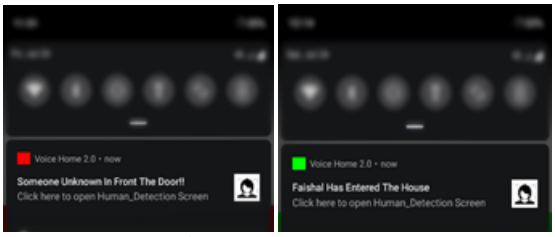

Fig. 22. Notifications on the user's Smartphone

Table 3 below will describe the expenses incurred to build this system.

Based on table below, the cost incurred to make this system is not more than one million rupiah (Rp 1,000,000,-). When compared to existing technologies, such as smart home technology from *Aqila*, the system made is much more affordable. Smart home products from *Aqila* set a price of two million six hundred and fifty thousand rupiah (Rp 2,650,000,-) for the device and an additional fee of about one hundred and fifty thousand rupiah (Rp 150,000,-) to five hundred thousand rupiah (Rp 500,000,-) for the addition of other sensors.[5]

TABLE 3. Total System Component Expenditure

No	Component	Amount	Price
1	Raspberry Pi 3	1	Rp 695.000
2	Pi Camera	1	Rp 80.000
3	Relay 2 Channel	1	Rp 12.500
4	Adaptor 220V to 12 V	1	Rp 26.000
5	Solenoid Door Lock	1	Rp 35.000
6	Light Bulb + Fitting	3	Rp 30.000
7	Memory Card 16GB	1	Rp 50.000
8	Cables	-	Rp 16.000
Total			Rp 944.500

In addition, the smart door lock technology from *Dings* also set a price of around one million four hundred ninety thousand rupiah (Rp 1,490,000,-) to one million six hundred ninety thousand rupiah (Rp 1,690,000,-). When compared to the system created this time that embeds smart door lock technology, of course it will be more affordable.[6]

The costs incurred for the devices in the system designed this time are still in the form of basic costs and include the microprocessor. Which is still possible to add other technologies with additional costs which will certainly be more affordable in terms of total costs and development potential.

IV. Conclusion

Based on the results of the design and trials that have been carried out, the system created this time can execute all commands properly, especially voice commands. The end device can provide the expected output. In camera monitoring, the system can distinguish between users and other people and provide information on the human detection menu. The system can also provide feedback to users in the form of the latest status of the end device and notifications on smartphones when someone is detected by the monitoring camera.

Although the system that was made can run well, there are some weaknesses that were found when the trial was carried out. Applications made on the user's smartphone are still open. So, anyone who has it, can give orders to the system. In addition, in voice commands, the commands that are made are pre-arranged, so that the user cannot give other commands even if the intent is the same. Clarity of pronunciation is also still a factor that must be considered in voice commands. This is because, if the command given is unclear, the system will not execute the command. Although other factors, such as noise and the user's internet speed can still have an effect. Face recognition can also detect faces of similar users, such as siblings and twins.

For a better system design, there are several suggestions given by the author. Create a security system for smartphone applications, so that not everyone who has the application can use it. Improved accuracy in facial recognition to detect siblings and also twins. And finally, adding some additional technology or sensors to make the system more user-friendly and complex in terms of benefits.

Mochammad Faishal R. and Nur Sultan Salahuddin, "Centralized Control with Smartphone for Voice Command and Facial Recognition on Smart Home System," *International Research Journal of Advanced Engineering and Science*, Volume 7, Issue 1, pp. 23-30, 2022.

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