Design and Build Automatic Home Door Security Using IoT-Based PIR and RFID Sensors

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Abstract

Security is the main thing for humans. Along with the rapid progress of technology, crime is increasing, one of which is theft which often occurs in houses that are left empty. To increase the feeling of security, a prototype home security notification system was built. This prototype tool utilizes RFID (Radio Frequency Identification) which is equipped with a PIR sensor, Blynk, and Email applications as a notification information system, where all systems can be managed on a Node MCU microcontroller. The aim is to provide more optimal protection for homes and the like because the IoT (Internet of Things) based home security notification system also uses RFID and Cards as a substitute for manual keys so that they are more difficult to tap and copy. This research uses qualitative research and uses the Research and Development (R&D) method. Based on the test results, it can be seen that the door is not only accessed manually with an RFID card but can also be accessed using the Blynk application. RFID testing is known to be able to read cards from a distance of 0.0 cm to 4 cm. Testing the response time for email notifications sent can be seen to be around 1 minute or 1000 delays when there is movement on the PIR sensor.

Keywords: Design, Sensors, Security, RFID, Node MCU ESP8266, prototype, Based on Internet of Things (IoT)

Abstrak

Keamanan merupakan hal yang utama bagi manusia. Seiring dengan pesatnya kemajuan teknologi, tindakan kejahatan semakin tinggi, salah satunya ialah pencurian yang sering terjadi di rumah yang ditinggalkan dalam keadaan kosong. Untuk meningkatkan rasa aman maka dibangunlah sebuah alat prototipe sistem notifikasi keamanan rumah. Alat prototipe ini memanfaatkan RFID (Radio Frequency Identification) yang dilengkapi dengan sensor PIR, aplikasi Blynk dan Email sebagai sistem informasi notifikasi, di mana semua sistem dapat di kelola pada sebuah mikrokontroler Node MCU. Tujuannya adalah dapat memberikan perlindungan yang lebih optimal untuk rumah dan sejenisnya dikarenakan sistem notifikasi keamanan rumah berbasis IoT (Internet of Things), juga menggunakan RFID dan dan Card sebagai pengganti kunci manual agar lebih susah disadap dan disalin. Penelitian ini menggunakan jenis penelitian kualitatif dan menggunakan metode Research and Development (R&D). Berdasarkan hasil pengujian dapat diketahui bahwa pintu tidak hanya di akses secara manual dengan kartu RFID tetatpi juga dapat di akses menggunakaan aplikasi blynk. Pengujian RFID diketahui dapat membaca kartu mulai dari jarak 0,0 cm hingga 4 cm. pengujian waktu respon

notifikasi email dikirimkan dapat diketahui sekitar 1 menit atau 1000 delay ketika setiap adanya pergerakan pada sensor PIR.

Kata kunci: *Rancang Bangun, Sensor, Keamanan, RFID, Node MCU ESP8266, prototipe, Berbasis internet of things (IoT)*

Introduction

In this day and age, science is increasingly advanced, and the development of modern technology is closely related to humans. Modern technology is the process of a person changing from a traditional lifestyle to a more complex lifestyle. One innovation that is currently progressing is the use of the *Internet of Things* (IoT). IoT makes it easier for humans to interact with electronic devices connected to microcontrollers via the internet. The use of the *Internet of Things* is much the same in aspects, they are used to manage security systems remotely from long distances [1].

Everyone wants to have a good level of home security. Nowadays, many homeowners only rely on security officers in their residential areas. However, this is still considered not very effective, because many houses have to be guarded but the number of security officers is limited, so a home security device is still needed. Homes require excellent security equipment that can make homeowners feel comfortable and protected. Homeowners feel helped because this security system will limit the movement of foreigners entering their houses [2].

Residential door security systems, one of which uses RFID *(Radio Frequency Identification)*. A web system that sends notifications via email with *Node MCU*, can bring security and convenience to homeowners. In this home security, the use of *Radio Frequency Identification* (RFID) is a tool that can be connected to a *magnetic door lock* to open or lock the door. RFID technology is widely used in various sectors, especially the security sector, where an object can be identified. This technology offers more optimal protection for homes and the like than manual technology because IoT-based RFID is more difficult to intercept and copy.

The purpose of this RFID work is to open and close house doors automatically, which can be monitored via email. This system uses NodeMCU ESP8266 as the microcontroller used. The components used are RFID, magnets, *buzzers,* and email for notifications. In this system, RFID cards that have been registered in the database are connected. As a result, the door can be opened and information about registered RFID users can be displayed online. If the RFID card is invalid, *the buzzer* will sound and the door will not open, if you lose the card it can be opened via the controller using the *Blynk application*.

Based on the above explanation, this research aims to design a home door security device that uses IoT-based RFID and produce a product in the form of *a prototype* that is suitable for use and can be used by the public.

Literature Review (optional)

The relevant research regarding design theory regarding IoT-based RFID home security is as follows. Research conducted by Hendi Suhendi et al. in December 2022, with the title " Home Security System Using RFID, PIR Sensor and GSM Module Based on Atmega328 Microcontroller". The research results show that for home security a home security system was designed using RFID technology equipped with a PIR sensor and a GSM module as an SMS warning information system, where the entire system is processed in an ATmega328 microcontroller. This design aims to replace conventional

locks with solenoid locks so that they are difficult to duplicate and reduce the opportunity for theft when the house is empty. The research methods used include data collection (observation, interviews, and literature study) and tool creation (planning, analysis, design, and testing). Based on the test results, it was found that the solenoid lock can work according to the RFID access card provided. The PIR sensor and GSM module can work well when thieves break into the house so that the house becomes safe when left by the owner [3].

Further research was carried out by Manase Sahat H Simarangkir and Agung Suryanto in 2020, with the title " Automatic Door Lock Prototype Using RFID (Radio Frequency Identification) Based on Arduino Uno Microcontroller". The result of this research is the creation of an automatic house door security system using RFID which has a better level of security compared to manual security, so that it can overcome acts of theft in houses that are often abandoned by residents. Apart from that, the use of RFID can also minimize all the locks in the house, so that each family member only needs one tag card/key to open all the door locks in the house. Keywords: Arduino Uno, RFID, Servo Motor, Solenoid Abstract--Manual home door security systems have many disadvantages including difficulty in opening the lock when used, ease of breaking into, and keys that tend to be duplicated, thereby reducing convenience and security [4].

Another research was conducted by Nurwijayanti Kusuma Ningrum and Abdul Basyir in 2022. The research is entitled " Design of an Automatic Room Door Security System Using RFID Based on *the Internet of Things* (IoT)". The research results show that the system on this tool can work well and by the orders that have been made, by providing information on an average time of 4.59 seconds when the system sends messages to the Telegram application with a distance of ± 27 KM. And when the system will provide exit access for people who are in the room by using an infrared (IR) sensor which is used for the exit button. Furthermore, research was carried out by Abdul Malik Shafar in 2023, with the title " Design and Development of an Automatic Lock Unlocking System with RFID (Radio Frequency Identification) Based Notifications ". This research aims to design *a prototype of* an automatic unlocking system with RFID-based notifications. The working system of this *prototype* is controlled using NodeMCU ESP8266 as the brain of *the prototype* which is equipped with an RFID RC522 sensor, servo motor, and Touch Sensor to open the door from the inside. This research uses qualitative research and uses the Research and Development (R&D) method [5].

In automatic home security, especially when the door *registers* RFID, the PIR sensor will detect movement and the system will send a message notification via email. This system design is equipped with a PIR sensor that is connected to IoT *(Internet of Things)* via *Buzzer* and email. If the owner loses the card and misses it, the door can be accessed or controlled via the *Blynk application*. This is to provide information to homeowners when there are strange and dangerous signs of movement inside the house. Therefore, it is important to implement a security notification system that provides a sense of security and comfort for home residents. Security system utilizing RFID and PIR sensors, using NodeMCU and IoT-based RFID cards.

From this, it can be concluded that the difference between previous research and the research to be carried out is the focus on developing a home door security system using RFID technology based on *the Internet of Things* (IoT). This system will control the door and carry out home security functions via the *Blynk* smartphone application which supports sending notifications via email. This research aims to create and apply a home security system in a miniature model using the Internet of Things as a base, combined with one sensor, namely a Passive Infrared *Receiver* (PIR) to detect the movement of objects.

The aim of designing this security system is to provide convenience for homeowners when leaving their housing empty. This is important to prevent the possibility of burglary or theft.

Method

In this research, the method used is Research and Development (R&D). This method creates a product in a special area of expertise, which is accompanied by creating an effective product or work result. By referring to the quote above, the researcher attempts to gain an understanding of the principles contained therein. In this development method, Sugiyono provides procedural instructions applied by researchers to ensure that the device being designed has quality that meets the established standards [6]. So based on the quote above, the researchers tried to design an IoT-based RFID home security door system to reduce or minimize home theft.

In the model research method, *Research and Development* Borg & Gall own ten steps.

1. *Research and information collecting* (research And collection data), carried out through initial studies by collecting information on the contextual conditions in which the research will be carried out, literature reviews, and field, classroom, and laboratory observations.
2. *Planning* (planning), determining goals, identifying skills, and determining the subjects to be taught.
3. *Develop a preliminary form of product* (develop product draft), develop an initial product, and prepare learning materials, learning methods, and learning assessments.
4. *Preliminary testing* (test try field beginning), validate model the initial (product) produced in stage 3.
5. *Main product revision* (revising test results), revising the product based on input from initial testing. Conduct interviews, observations, and questionnaires with 6-2 people as subjects.
6. *Main field testing* (field trials), conducting field trials involving 30-80 people as product user respondents and conducting quantitative data.
7. *Operational product revision* (refinement of products resulting from field trials), revising products based on input from field trials.
8. *Operational field testing* (field implementation test), conducting field trials involving 90-200 respondents (product users), and collecting quantitative data.
9. *Final product revision* (final product refinement), revise the product based on operational field testing input *until* the final product is produced.
10. *Dissemination and implementation* (dissemination and implementation), making a final product report, and presenting research results through seminars.
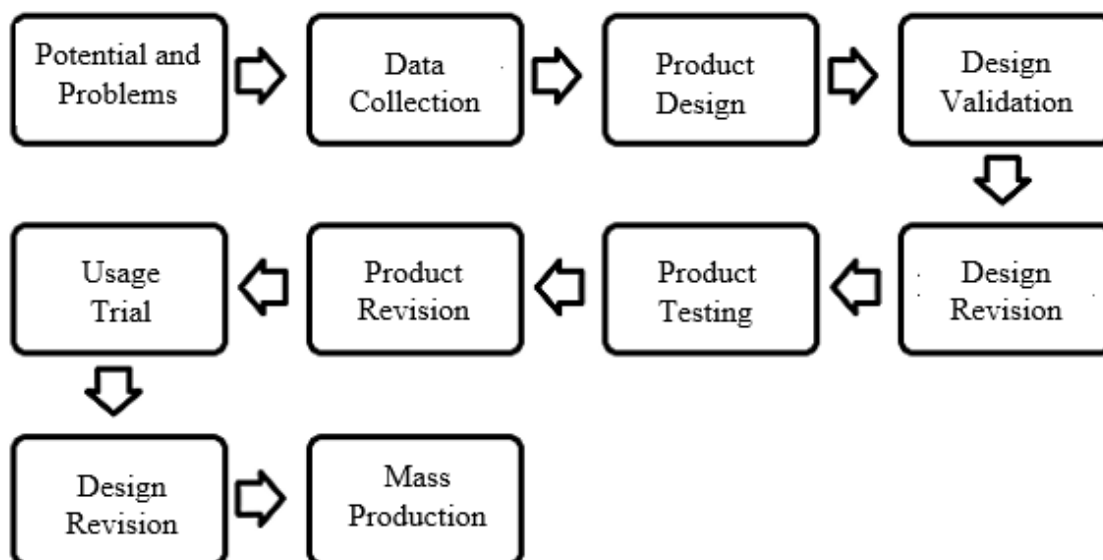
Picture 1. Chart Channel Model Borg & Gall

On study, this step study simplified by the need study. These ten steps will limited by researchers to suit research and design needs. The research progress is adjusted into stages of potential problems, data collection, product design, design validation and use trials.

Research that has been simplified by researchers has research and development steps or changes that are indicated, including 1) Potential and problems. The potential is anything that, when used, will have added value. Meanwhile, problems are deviations between what is expected and what happens; 2) Collection of data or information. The process of collecting information is carried out factually and can be used as material for planning certain products as expected; 3) Product design. The design stage of this research includes creating a suitable automatic home door security product design and also the designed functions. The product design needs to consider factors such as needed user, ease of use, and effectiveness. The design process was carried out by considering the results of literature studies and data that had been collected in the previous stage; 4) Validate the design. The validation stage is the stage of assessing the suitability of the design of the automatic home door security device. At this stage, the assessment is carried out by media experts, to ensure that the product being designed can be used as a media tool that is suitable for use; 5) Test use. At the trial stage, the use of automatic home door security equipment. The product will be repaired and perfected if there are still weaknesses found in the test results on the subject. This is done to ensure that the product is ready to be implemented and used optimally and is also suitable for use. The research stages that have been simplified by the researcher can be seen in Picture 2.
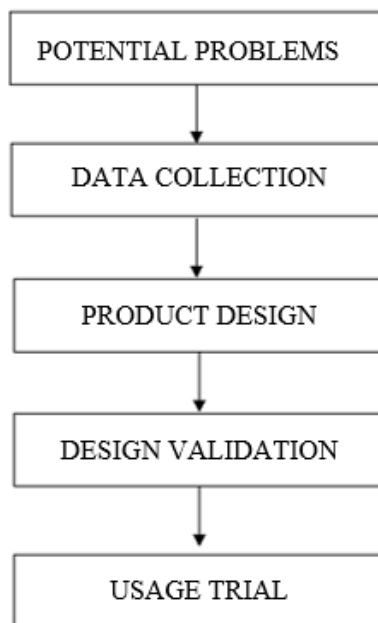
Picture 2. Stages of the R&D Method

This research will be carried out in the electronics laboratory of Electrical Engineering Education, Ar-Raniry State Islamic University, Banda Aceh. This research focuses on the subject of home door security as a tool for home security. This research aims to evaluate the level of feasibility of the tool that has been designed. As a tool for securing the home, the IoT-based RFID home door security *prototype* is expected to help students and become a reference in learning in the field of sensor practicum and those that require cognition about technology and further development in understanding it.

In this research, the instrument used was a media expert validation sheet in the form of a media expert validation instrument sheet. Used to measure the suitability of the media used in this research. The media expert validation sheet contains questions regarding criticism, suggestions, responses, and expert opinions on the product being developed. The grid of the media validation questionnaire can be seen in Table 1 below.

Table l .1 Sheet from Media Expert Validation

No.	Aspect	Indicator
1	Accuracy Draft	Can explain draft material
		Can explain draft material more real
2	Appearance	Form props
		Attractive appearance
3	Multifunction	Explain 6 gates of basic logic
		Explain gate Note
		Explain gate logic in One tool show
4	Material	Easy to get
		Own price Which cheap

The validation data collection technique is to provide validation sheets to Baihaqi, MT, Muhammad Ikhsan, MT, and Muhammad Rizal Fachri, MT as media validators to give input information and suggestions for the suitability of a house door security design as a *prototype tool* that is suitable for use and can be used by the community. This activity was carried out at the Electrical Engineering Education Laboratory.

After data is collected through sheet validation from expert media, then the data will be processed through analysis techniques. In this research, the data analysis technique used is a combination of qualitative analysis and quantitative analysis. By using this analysis technique, researchers will gain an in-depth understanding of product quality and student responses in a comprehensive and structured manner.

In this research, there are two types of data analysis used, namely qualitative and quantitative data analysis. Qualitative data analysis uses data obtained from interviews, and observations, as well as input from experts in the form of words, responses, suggestions, and criticism. This qualitative data is used as a guide in improving product development. Next, an analysis is carried out sheet validation expert. The researcher validated the data by presenting the teaching aids in front of material and media experts, then giving each of them a validation sheet expert as instrument testing appropriateness in matter material and automatic security door media.

Results

a. *Prototype* Design Results (Hardware)

Assembly is carried out after all the necessary equipment has been collected complete with acrylic materials. The results of the assembly can be seen in Picture 3.
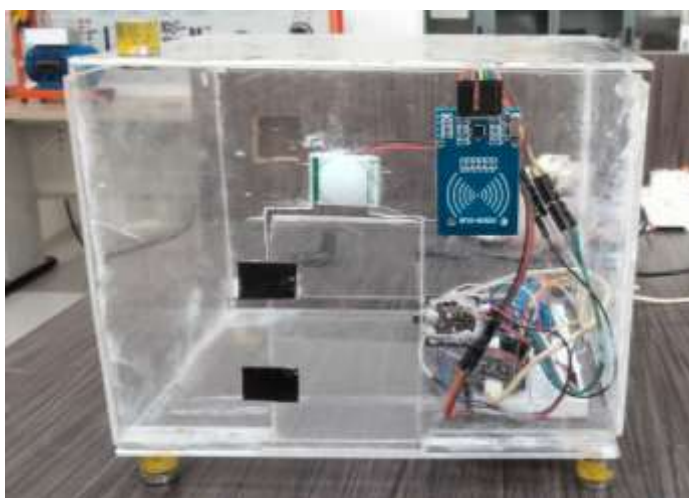
Picture 3. Complete RFID Automatic Door Security Suite

In Picture 3 you can see a picture of a series of RFID-based home door security *prototypes with several* of the components mentioned. This *prototype* is run using an ESP8266 and connected to the *Blynk* and Email applications to receive notifications when there is movement and the IoT controller can also be accessed via the *Blynk application.* Regarding the working system, when the TAG and KTM cards are attached, *the buzzer* will sound and the solenoid will work and the door can be opened, and if it is not detected, *the buzzer* will sound twice and indicate it is not registered.

b. Discussion

The prototype has gone through a validation process by media experts. In the media test, media experts gave several percentage results of 88.6, 97.1, and 96.4%. By Because Overall, the Automatic Home Door Security *Prototype* is considered to have been suitable for use by the public and also by students as a reference in sensor and microprocessor practical courses.

Research with the title "Design of Automatic Home Door Security Using IoT-Based PIR and RFID Sensors ". To achieve this goal, researchers used the Research and Development (R&D) method with research steps that broadly include potential problems, data or information collection, product design/planning stage, design stage, and use trials. The planning stage is the initial step taken to build an automatic door-opening system in *prototype form*, which includes preparing the tools and materials to be used.

The next stage is designing *a prototype* where after all the equipment is sufficient, an Arduino IDE software circuit is created in the form of a physical circuit so that it can be programmed into a computer. Next, product testing is carried out which is the final step taken to build a system where *the prototype* that has been built will be tested starting from the RFID card, PIR sensor, NodeMCU ESP8266, *Blynk application*, and *the buzzer* will sound and every minute it will send a notification. Then you will see the results of *the prototype* that has been tested to see whether it has worked as expected. Testing is carried out in three stages, which consist of testing the *Blynk* application program to determine whether or not it is successful in entering the *Blynk application*. The second stage is to test the distance between the RFID card and the RFID, which is done by bringing the RFID card closer to the PIR sensor which detects movement from a certain distance. If the RFID sensor reads or identifies the ID number on the card according to the program, the NodeMCU ESP8266 will give a command. To open the door and send a notification to the email application when someone accesses it.

The tool built is said to be successful, from the test results it is known that the sensor can read cards from a distance of 0.0 cm to 4 cm. The next stage is to find out the results of the success of the PIR sensor and the operation of the PIR sensor in detecting movement and sending notifications within a period of 1 minute, one notification which can be sent via email. From the test results it is known that some of them work as desired and also from the tests there are obstacles and shortcomings in carrying out the research process from what was carried out in various stages and trials finally the RFID door system with sensors that detect movement sent via email application and also the door can Accessed by using the *Blynk application* as a controller to open the house door at the desired distance.

Home security notification system that will send information in the form of a *Buzzer notification* that will sound and a message sent in the form of an email, if a movement signal is detected in the home area and the use of an unregistered RFID tag, but if the RFID tag is registered automatically the Solenoid Door Lock will open. This security notification system uses PIR and RFID sensors based on *Node MCU*, this tool is assembled in one box using acrylic material. In this case, the work process is regulated by a program that works in the microcontroller. When started, the program will work and the RFID will start identifying the attached card.
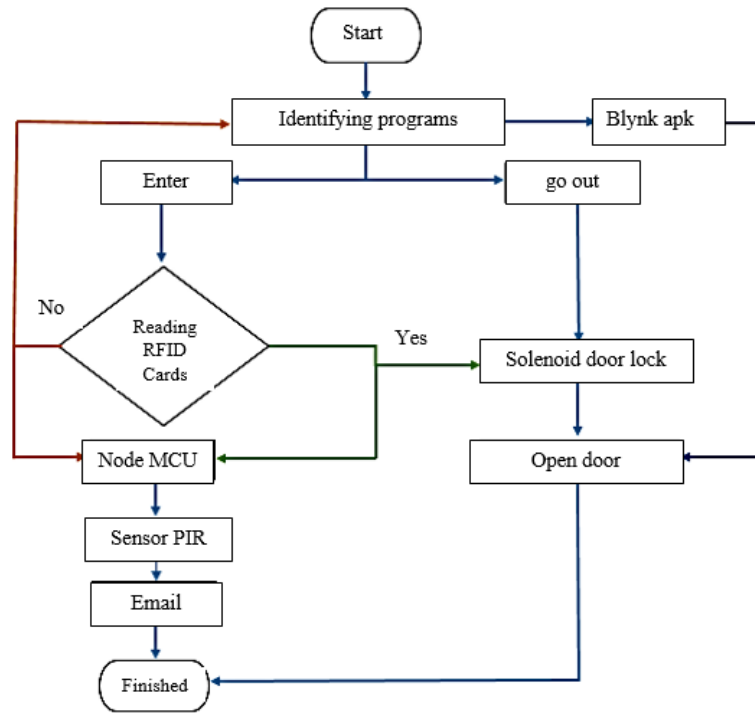
Picture 5. Flowchart of how the tool works

In *the flowchart of how the home security notification prototype* tool works, it will send information in the form of a *buzzer notification* that will sound and a message sent in the form of an email, if a movement signal is detected in the home area and the use of an unregistered RFID tag, but if the RFID tag is registered automatically. *The Door Lock Solenoid will* automatically open. This security notification system uses PIR and RFID sensors based on *Node MCU*. For assembly, the PIR sensor is installed on the terrace of the house, the RFID reader is installed on the door, the Solenoid Door Lock is used as a home locking tool to replace the manual key, and *the Buzzer* is installed in a hidden place but can be heard in the home environment to attract attention if there is movement detected by the PIR sensor and there is the use of unregistered RFID tags. On the security notification system.

Picture 6. Manual Design

The data from the card will be read by RFID and sent to the NodeMCU ESP8266, if the data from the card matches the program then the solenoid on the door will open and the NodeMCU ESP8266 will send a notification to the Email notification application that the door is open. If the RFID card is wrong, the solenoid will not open so the NodeMCU ESP8266 also sends a notification to email that the card used is not registered. To open the security that covers the RFID, it must be in front of the card scan The RFID will be detected by the PIR sensor and the RFID scan cover will open automatically.

In this research, the test carried out was black box testing. With this black box testing, it is hoped that if there are errors or deficiencies in the application or tool work, researchers can quickly identify them. The *Blynk* application is for controlling or accessing logins and opening doors from the desired distance.

Table. 2 Testing the *Blynk* application

No	Test cases	Scenario Testing	Expected results	Test result
1.	login with an email: 190211015@student.ar-raniry.ac.id	Login successfully then press the open button on the *Blynk application*	It works and the door opens	It doesn't work or doesn't meet expectations because the email doesn't support / or require permission.
2.	Log in with email: apismaulana165@gmail.com	Login is successful and continues to open the button on the *Blynk application*	It works and the door opens	It was successful and the email can be accessed with the *Blynk application* and the door can open automatically.

From the results of testing the *Blynk application* and logging in using an email account, it was found that not all email accounts can work in the *Blynk application* because they have to get permission first.

Picture 7. Web *Blynk*

In testing, the RFID distance is measured using a distance-measuring instrument that can determine to what extent the card can be accessed and read by the RFID.

Table. 3 RFID Card Distance Testing

Testing stages	Card distance	Solenoid condition
First	0 cm	Read
Second	1 cm	Read
Third	2 cm	Read
Fourth	3 cm	Read
Fifth	4 cm	Read
Sixth	5 cm	Cannot be read
Seventh	6 cm	Cannot be read

From the test results in Table 4.2 above, it can be explained that RFID can read the chip in a card if the card is brought close from a distance of 0.0 cm to a distance of 4 cm to the RFID system.


Picture 8. RFID Distance Testing

The testing carried out on this system aims to find out whether this system is functioning properly and can send notifications or notifications in the form of messages in the form of emails via the *Blynk application.* Testing is carried out using the email address registered in the testing system twice at different times. The test results for sending notifications can be seen in Table 4 below.

Table. 4 Test Results and Email Notifications Via the *Blynk Application*

Sensor type	State of the tool	Device status	Notifications	*Delay*
PIR sensors	Life	Capture movement	Sent	1,000
	Dead	There is no movement	Not sent	-

Testing notifications or notifications in the form of messages sent to email via the *Blynk application* aims to find out that notifications can be sent and received by registered email and function properly without any obstacles or interruptions when used. From the test results in Table 4.3, the system will send a message notification in the form of an email via the *Blynk application* and if the PIR sensor catches a movement signal and is given a high signal, the notification will be sent in the form of an email via the *Blynk application*. However, if the PIR sensor is given high power but does not capture a movement signal, it will not send a notification, and the PIR sensor will not send a notification if the input signal is low. In the image below there is the content of the message notification in the form of an email via *Blynk* from the explanation above. The notification can be seen directly in Picture 9. Which displays notifications captured by the PIR sensor every minute.
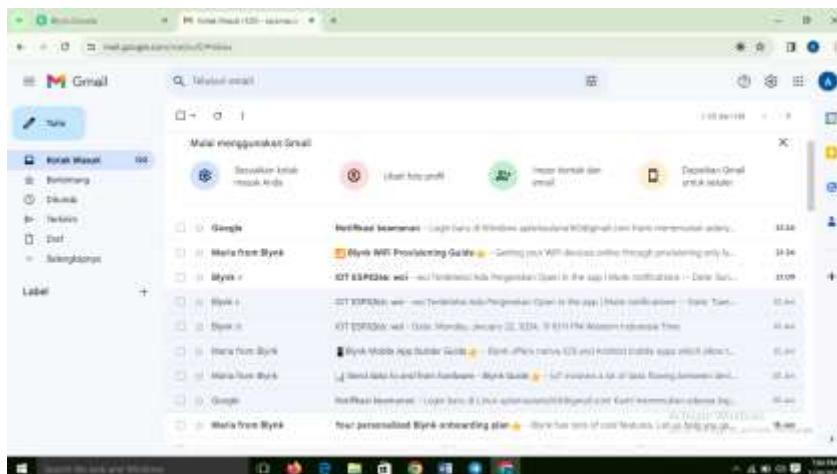
Picture 9. Email notification from the PIR sensor
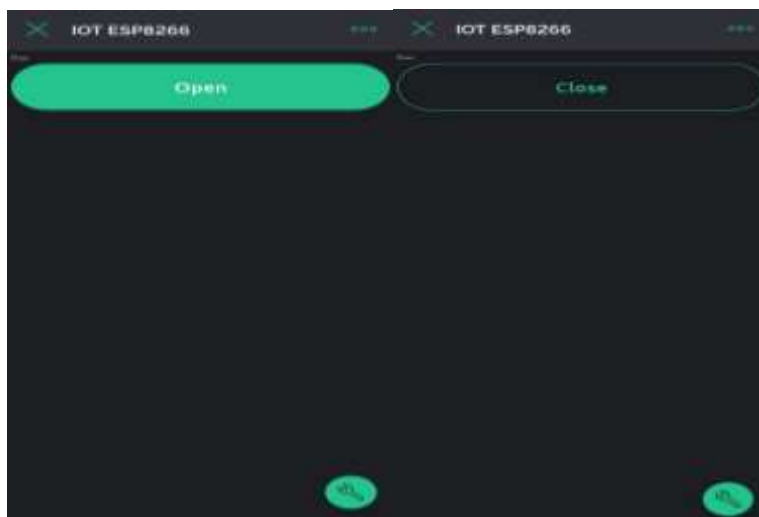
Picture 10. Open/close *the* control page in the *Blynk* application

In Picture 10. There is an *open/close* control page on the *Blynk application* where the door can be controlled to open and close from the desired distance just by using *a smartphone* equipped with the *Blynk application*. The benefit of this research is that it makes it easier for home users to leave the house when traveling long distances because the security lock for the house door can not only be accessed using an RFID card but can also be used by using the *Blynk application* to control opening and closing the automatic door lock.

In the study, these results validated the feasibility of automatic security doors as a tool *prototype* and obtained through a validation questionnaire sheet instrument filled out by three media experts. Three experts selected to validate the suitability of automatic security doors as a *prototype tool* are lecturers who understand technology. In this validation process, experts were asked to provide an assessment of certain aspects of the automatic security door device, such as completeness of features, clarity of appearance, and ease of use. After being filled in and collected, the validation questionnaire sheet is then analyzed to determine the suitability of the automatic security door *prototype tool as a prototype tool* that can be used by the public.

Validation of the automatic security door *prototype* as a security tool used on house doors was carried out by Baihaqi, MT Muhammad Ikhsan, MT and Muhammad Rizal Fachri, MT The aim is to get input, criticism, and suggestions from validators about the feasibility of the automatic security door *prototype* in terms of media. This aims to ensure that *the prototype* can fulfill the feasibility test in terms of media and can be developed into a quality *prototype tool product in terms of media. To evaluate the suitability of the media for the* automatic security door *prototype was carried out* validation by providing an assessment questionnaire to the validator. This questionnaire loads 7 questions that evaluate aspects appropriateness of media such as work concept, appearance, multifunction, and materials. This media validation is carried out to ensure that the automatic security door *prototype works* tool which can be useful for society also has good media quality and can be developed into a quality tool product in terms of media.

Based on the results of media feasibility validation by media expert validators, it is known that the automatic home door security *prototype* received a percentage

from media experts Baihaqi, MT (88.6%), Muhammad Ikhsan, MT(91.4%) and Muhammad Rizal Fachri, MT (97 .1%). So the average percentages are added up with a result of 96.9% which shows the category is very valid. Therefore, it can be concluded that the automatic home door security *prototype is feasible* to use.

Conclusion

Based on the results of research that has been carried out on the security design of automatic door locks with notifications based on RFID (Radio Frequency Identification) IoT-based PIR sensors, several conclusions can be drawn as follows:

1. Successfully designed a house door security device that uses IoT-based RFID. The working system of this house door security device is controlled using *NodeMCU* ESP8266 as *a microcontroller* from a device equipped with PIR and RFID RC522 sensors, *door lock solenoid*, *buzzer* as a registered sound and *relay* as well as Also control using the *Blynk* Touch Sensor application to open or close the door from the desired distance.
2. Successfully produced a *prototype device* that is suitable for use by the public because based on tests carried out by three media experts who understand automatic home door security devices and obtained a percentage result of 96.9%, the system can read RFID cards to open doors and can also be accessed using the *Blynk application* and the system also sends notifications to Email.
3. The aim of designing this security system is to provide convenience for homeowners when leaving the housing empty. This is important to prevent the possibility of burglary or theft.

References

[1]   A. full moon. *IoT-Based Home Security System Design.* Informatics Engineering Study Program, Faculty of Engineering and Computers, Putera Batam University. 2022.

[2]   F . H. A. Mubarok, M. Subali. *National Seminar on Information and Communication Technology STI&K (SeNTIK) Volume 4 Number 1,* 23 September 2020.

[3]   Suhendi, H., & Sofyan, I. Home Security System Using Rfid, PIR Sensor, and GSM Module Based on Atmega328 Microcontroller. *Journal of Innovation Research and Knowledge*, *2* (7), 2989-3000. 2022.

[4]   Simarangkir, MSH, & Suryanto, A. Automatic Door Lock Prototype Using RFID (Radio Frequency Identification) Based on Arduino Uno Microcontroller. *Astra Polytechnic Technologic*, *11* (1). 2020.

[5]   Ningrum, NK, & Basyir, A. System Design Automatic Room Door Security Using Internet of Things (IoT) Based RFID. *MATRICS Scientific Journal*, *24* (1), 21-27. 2022.

[6]   Sugiyono. *Quantitative Qualitative Research Methods and R&D.* Alfabeta, p.297, 2013.