Design Smart Locker Doors Using Quality Function Deployment Based on ATMega 2560 Microcontroller

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ABSTRACT

Smart Locker system to provide more security for the house that is a place to live to avoid losses and negative impacts of criminal case actions with incrimination. This study designed door security with a door bar control system that can be done from outside the house using Android and a keypad so that the bar behind the door automatically closes and opens according to the password code command entered by the user or homeowner. Consumer desires home security systems using the QFD (Quality Function Deployment) method. The QFD method will conclude that a better door security product design is needed, with home security system updates as needed. Consumers need thirteen dimensions with three priorities with the highest value, namely securing the door of the house with a shape that matches the door with a rating of 4.55, Securing the door of the house with an alarm system with a rating of 4.50, Securing the door of the house is easy to use for the owner. The intelligent locker design is based on ATMega 2560 Microcontroller, which functions to program other components so that they can work according to the data that has been inputted.

Keywords: Smart Locker, Quality Function Deployment, ATMega 2560 Microcontroller

INTRODUCTION

Home is an immediate need that must be met by every human being today [1]. But how is it possible if a house that is said to be the safest and most comfortable place to live in becomes an object targeted by criminals such as theft cases with incrimination to take valuables in the house where their target object [2]. Therefore, every human being must be more selective to provide more security for the home that is a place to live to avoid losses and negative impacts of the actions of criminal cases with incrimination [3].

Some tools commonly used in home door security systems are RFID, PIR (Passive Infra Red), alarms, passwords, and other home door security [4]. However, it only detects perpetrators who enter the detection area of the tool, as well as detecting identity recognition such as ID cards, fingerprints, and others [5]. The device is still ineffective in stopping the perpetrators of theft from entering the house, just as the perpetrators can still access the house. Home security tools described above generally have pretty good security specifications, but the price and maintenance are relatively expensive. It is a factor that consumers cannot use these tools because the price is not affordable by consumers [6].

This study designed door security with a door bar control system that can be done from outside the house using an android and keypad so that the bar behind the door automatically closes and opens according to the password code command entered by the user or homeowner [7]. In addition, the advantage of this tool is that when the door is broken into forcibly, the magnetic field or battery touches the positive pole (+) and negative pole (-), producing sounds and sounds issued by the buzzer as an alarm [8]. The only drawback of this study is that the door security design is still a prototype, so it is necessary to develop it for further research [9].

An environmental security system will be sound if every house in the neighborhood has a good security system [10]. This will minimize the space for crime in the area so that every crime that arises can be detected early [11]. For this reason, a home security system is needed that can make burglars unable to enter the targeted house and can provide signs or simple information where the information provides a sign that the owner's house is being joined by unknown people so that thieves cannot access the homes of their victims [12].

The desire of consumers for home security systems using the QFD (Quality Function Deployment) method [13]. The QFD method will produce a conclusion where a better door security product design is needed with home security system updates to consumer needs, which are expected to reduce cases of decomposition with weight in the community [14].

METHOD

Identify the Problem

Identification of the problem found that the current home security system is still incomplete and does not provide a comfortable security system when leaving or occupying the house [15][16].

Problem Statement

The main point of this research is how to design a home door security product that consumers need according to their wishes using a QFD method [16][17].

Setting Research Goals

The design objectives of this study are to find out the technical response by the designer's ability based on VOC (voice of customer), to find out the priority of the technical application, to determine the exemplary technical aspects in designing home door security products, find out the results of concept testing carried out on product concepts that have been developed using the QFD method [17].

Data Collection

1. Open questionnaire

   Research respondents wanted home door security products with alarm features, easy to use, can be used inside or outside the home, have a password, have access via Android (cellphone), door access only belongs to the house, have a simple design, affordable price, quality, automatic system, not easy to break, long-term durability, door security design by the door of the house [18].

2. Product Design

The design of home door security products includes product descriptions, namely door security products, easy to use and sensors that can avoid cases of home theft with incrimination. The voice of the customer is then used to create a House Of Quality (HOQ) matrix that helps in knowing the attributes and determining the selected choices[21].

Data Processing
1. Identify Consumer Needs
    Design of home door security for users of home door security products using the House of Quality (HOQ) - Quality Function Deployment (QFD) method[22].
2. Tool Design
    Tool design is a process of connecting tool components, such as Arduino, with other hardware components where the hardware components that have been linked are expected to be able to manage program information designed by the objectives of this study [18].

RESULTS
Recapitulation of Consumer Needs
   A summary recapitulation of consumer needs obtained from the results of the interpretation of consumer needs is shown in Table 1.

Table 1. Interpretation of Consumer Needs

Dimension	Consumer Compliance	Importance Rating
Features	Home door security has an alarm system	4.50
Features	Home door security is easy to use for owners	4.33
Features	Home door security can be used inside or outside the house	3.90
Features	The door of the house is accessed through a password.	3.93
Features	Home door security is accessed via cellphone	4.15
Features	Homeowners only have access to the security system.	4.30
Price	Low price	4.10
Reliability	Home door security must be of good quality	4.05
Reliability	Securing the door of the house with an automatic system	4.20
Durability	Securing the door of the house is not easy for thieves	4.15
Durability	Long-term home door safety durability	4.30
Aesthetic	Simple door security	4.05
Aesthetic	Securing the door of the house with a shape that matches the door	4.55

Hubungan Antara Customer Requirement dan Technical Requirement
   The following is the relationship between requirements and technical requirements made in the form of a HOQ shown in Table 2.

Table 2. The Relationship Between Requirements and Technical Requirements

Customer Requirements	Importance Rating	additional Product Features	Product Design	Product Safety	Quality of Raw Materials	Types of Raw Materials
Alarm Features	4,50	●	○	●		●
Easy to Use	4,33		●			
It can be used inside or outside the home	3,90		●	●		
Password Features	3,93	●	●	●		●
HP Features	4,15	●	●	●		●
Accessible to Homeowners Only	4,30		●	●		
Simple	4,10		●	○		
Priced	4,05	●	●		●	
Quality	4,20			○	●	
Automated System	4,15	●	●	○		
It is not easy to break into	4,30	○	●	●	●	
Long-Term Resilience	4,05		○		●	
Design According to the shape of the door	4,55		●			

Competitive Customer Evaluations (CCE)

The value of competitive customer evaluations is obtained from the calculation of consumer perception questionnaires and expert staff who understand different home door security products. Home door security products will be competitors from standard house lock products (Competitor 1) and door trellis products (Competitor 2). Data is obtained by calculating the mean value of each item asked. The complete results can be seen in Table 3.

Table 3. Customer Competitive Evaluations

Customer Requirements	Importance Rating	Customer Competitive Evaluations (CCE)				
		1	2	3	4	5
Alarm Features	4,50	▲	▇			●
Easy to Use	4,33				▇ ▲ ●	●
It can be used inside or outside the home	3,90				▇ ▲ ●	
Password Features	3,93	▇ ▲		●		
HP Features	4,15	▇ ▲				
Accessible to Homeowners Only	4,30		▇ ▲ ●		●	

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Requirement	Value	Left	Center	Right
Simple	4,10			■ ▲ ●
Priced	4,05		●	■ ▲
Quality	4,20		■	● ▲
Automated System	4,15	■ ▲		●
Not Easy to break into	4,30	■	▲	●
Long-Term Resilience	4,05			■ ▲ ●
Design According to the shape of the door	4,55			■ ▲ ●

The position of the product to be developed against competing products can be seen in Table 3, obtained from the HOQ, with symbols (●) representing products being designed, signs (▲) representing standard door lock products, and symbols (■) representing trellis products.

3D Product Implementation Design

Making Design Drawings The implementation of home door security design products is made using SketchUp software, shown in Figure 1 and Figure 2
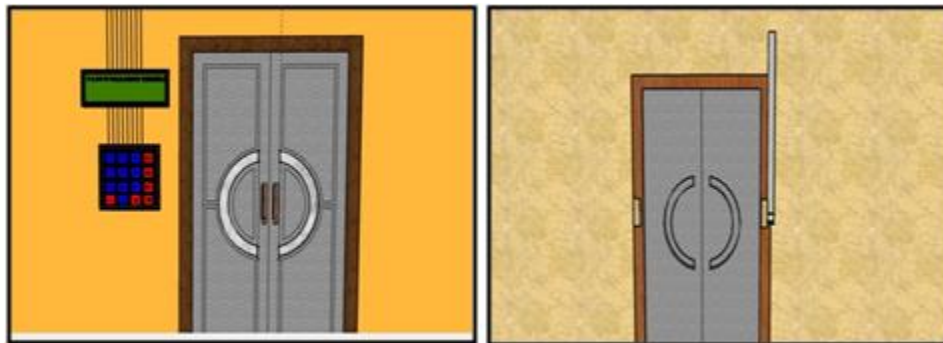

Figure 1 Front and Rear View of The House Door Security System In Open Condition
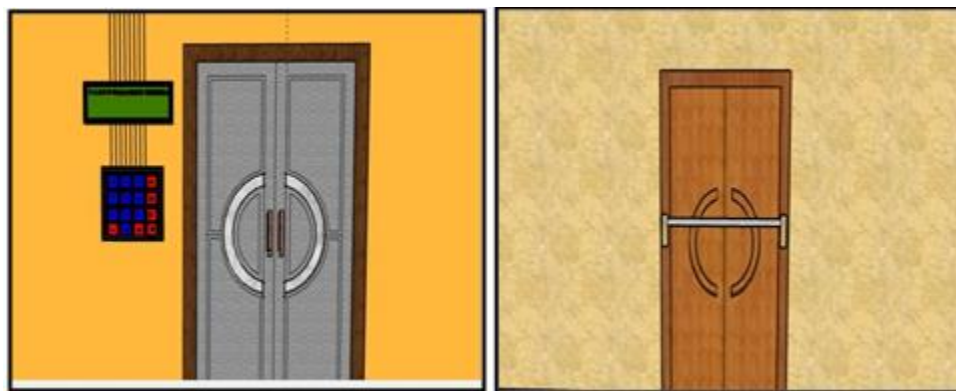

Figure 2. Front and Rear View of The House Door Security System In Closed Condition

Tool Design

The components of tools and materials used as needed in designing a home security system can be seen in Figure 3.
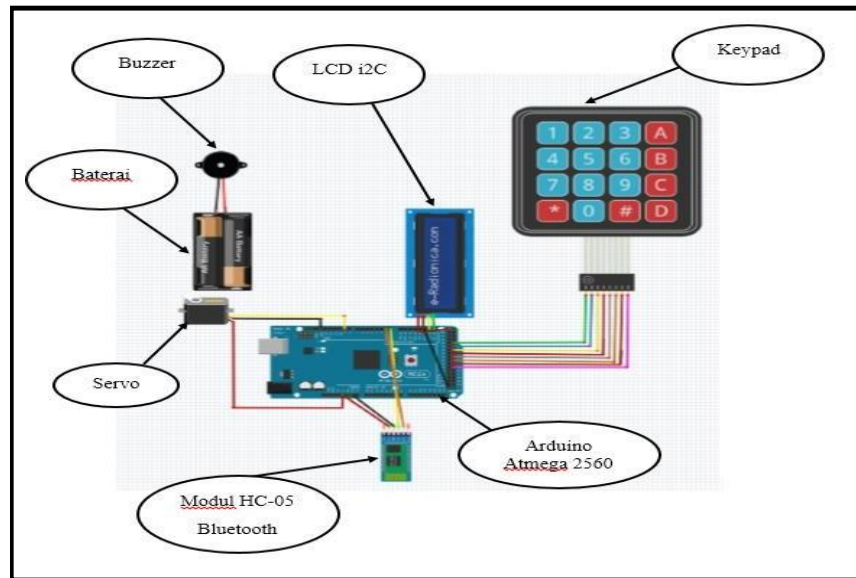

Figure 3. The Components of Tools and Materials

Arduino ATMega 2560: System from ATMega 2560 Microcontroller that functions to program other components to work according to the data that has been inputted.

HC-05 Module : Bluetooth is a wireless communication module via Bluetooth (Mobile) interface on the microcontroller.

Keypad : The keypad functions as an access to open and closes the security bar behind the door. If the password entered is correct, the door bar will move automatically to open and close the door bar. If the password is wrong, there is no action to secure the door.

Servo : Servo functions as a door security drive in the form of servo door bars controlled by two systems: the keypad and Bluetooth.

Battery : The battery is a current-voltage source that turns on the buzzer.

Buzzers : Buzzers function as a danger booster when the house door is pushed forcibly.

LCD : LCD functions to display a value of command results from passwords or Bluetooth.

Tool Testing

The results of the i2c LCD test were obtained where there were several displays, including the initial collection when the Arduino process was run, the show when entering the right and wrong password, the HC-05 input display connected via Android, and the display when securing the door of the house in the open and closed position. Here is a collection of the i2C LCD test results shown in Figure 4.

Figure 4. The Results of The Initial Display of LCD I2c When Securing The Door of The House Are Carried Out
(*Display in Indonesian)

HC-05 Test Results

From the HC-05 test, the results were obtained when using the serial Bluetooth application on the HP application to move the home door security system. If the user presses the open door button, the result "1" will appear in the application. Bluetooth serial on the HP application means securing the door open. However, if the user presses the closed door button, the result "0" will appear in the Bluetooth serial application, which means the door security is completed. The display on the Bluetooth serial application on the cellphone while running home door security. The following is a display of i2C LCD test results, as shown in Figure 5.
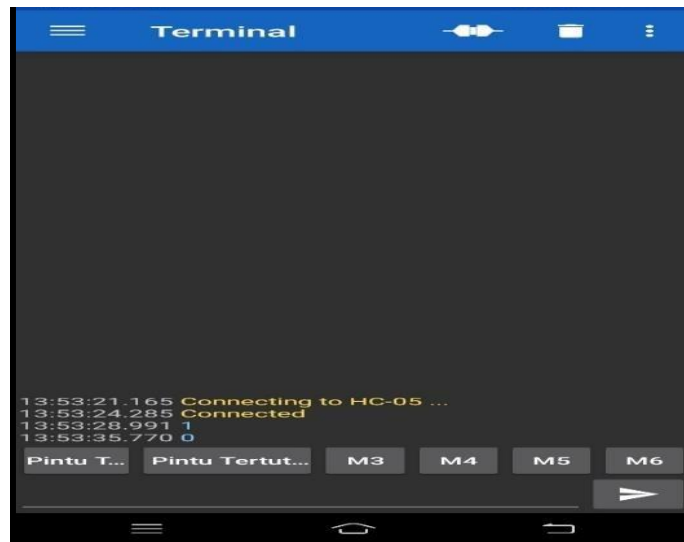

Figure 5. Display of Bluetooth Connection When the Door Security of The House Is Carried Out

Keypad Test Results

Keypad testing obtained results when inputting passwords, and test results can be seen on the i2C LCD. If the password is successfully inputted, the result (*) will come out on the i2C LCD on the keypad. This test also shows that if the input password is correct, it will look like the display on the i2C LCD is "correct." The "wrong" i2C LCD will appear if the input password is incorrect. The following is a display of i2C LCD test results, as seen in Figure 6.

Figure 6. i2C LCD at the time of Password Input
(*Display in Indonesian)

Servo Motor Test Results

From servo motor testing, results are obtained if, when inputting the password and Bluetooth correctly, the servo motor will rotate the bars attached to the engine to close and open the door. If during the process of inputting the wrong password and Bluetooth, the servo motor will not move at all. The following is a display of i2C LCD test results, as shown in Figure 6.

Figure 6. Test Results of Servo Motor When House Door Command Is Closed

Buzzers Test Results

From the buzzers test, the results are obtained that when the door security bar is closed, and there is an excessive push, the battery current in the door comes into contact with the wind of the buzzers on the side of the bar. So, it causes an emergency sound. The following displays the i2C LCD test results, as shown in Figure 7.

Figure 7. Buzzers Test Results

DISCUSSION

Customer needs are obtained from the voice of consumers in fulfilling desires in designing security for the house door that will be made. As for the results of consumer desires in research on the design of house door security, including having an alarm feature, easy-to-use safety, security that can be used outside and inside the house, a password feature, an Android feature, security can only be accessed by homeowners, house door security with a simple design, secure the door at affordable prices, secure the door with quality, secure the door with an automatic system, protect the door from thieves, protect the door with long-term durability, design the security of the gate by the shape of the door design. These consumer desires are the same as the results of [23] research concerning the Design and Development of Automatic Doors Using RFID. The results of this study are prototypes of automatic doors using RFID that can operate correctly. The ability of the RFID sensor to detect ID between the Card and the Reader is a maximum distance of 5cm. The power of the Reader to see ID cards is 2 to 3 seconds, starting when the ID card is attached to the Reader. The Selenoid system on this automatic door will work if the ID and password are correct, and the servo will move the door.

In [24] research, the consumer's desire for door security is designed to be based on IoT. This tool works because the Arduino Uno sends an output signal to the LCD and relay. The relay, which receives a command signal from Arduino Uno, acts as a switch so that the condition of the relay can be ON or OFF, then the selenoid looks. The door will work when the relay is ON, and the lock will be active when the look door selenoid works. This study resulted in a working door lock system with a password, and this is the same as [25] research designing an Arduino-based automatic door lock system using a password. This system uses an Arduino microcontroller as a controller for every given input. The user enters the password that has been prepared via the keyboard that has been installed. The entered password will appear on the LCD and then be processed in the microcontroller. The door will open and lock again automatically after the door is open for 5 seconds. Based on the tests that have been carried out, this tool can function properly according to the design that was made and provide convenience for the user in using it.

CONCLUSION

The specifications of consumer or customer needs in choosing home door security products based on the results of QFD (Quality Function Deployment) are as follows: Security has an alarm feature, Home door security is easy to use for owners, Home door security can be used inside and outside the house, Home door security has a password access feature, Home door security has a cellphone access feature, Home door security can only be accessed by homeowners, home door security with simple design, house door security at affordable prices, quality home door security, home door security with an automatic system, home door security is not easily broken, home door security with long-term durability, Securing the door of the house with a shape according to the door design, Products designed based on the results of QFD has been tested for implementation and the product successfully works according to what is expected.

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