RASPBERRY PI 3 BASED AUTOMATIC DOOR LOCK SECURITY SYSTEM WITH CAMERA AND SMARTPHONE INTEGRATION

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***Abstract**:* Theft cases are the most prevalent crime in Indonesia, with various variations in each case. One type of theft that often occurs in residential areas is breaking into houses, which can happen due to weak traditional security systems. To address this issue, an adaptive and technology-based home security system is required. Advancements in technology have driven innovation in enhancing home security systems, one of which is the "Automatic Door Lock Security System Based on Raspberry PI3 with Camera and Smartphone Integration." This research aims to develop a security system that allows users to monitor the status of their front door in real-time and control it at any time using a smartphone in a practical and efficient manner. This device uses an application tailored to user needs on a smartphone, with input from a SW420 vibration sensor for security detection, a push button for the doorbell, and a webcam to display the door's status in real time. The Raspberry Pi 3 serves as the microcontroller, with output via a buzzer as an alarm and an MG996R servo motor for opening and locking the door. The research process began with modifying the door handle according to requirements and testing the app's connection with the microcontroller, testing the SW420 vibration sensor's readings, testing the webcam, and testing the MG996R servo motor to operate the door lock and handle. Based on the research results, the app can control the device in real-time at a distance of 1m to 15m. The system is designed such that when the SW420 sensor detects vibrations deemed hazardous, the Raspberry Pi 3 sends a danger notification to the user via smartphone and also triggers a buzzer on the active door as a danger signal. The user can then monitor the area around the door and open or lock the door via smartphone.
Keywords: Raspberry Pi 3, SW420 Vibration Sensor, Security System, MG996R Servo, Smartphone.

A. Introduction

Home security is a very important aspect in maintaining the safety and valuable assets of residents. With the increasing crime rate in Indonesia, especially in cases of burglary in vacant homes, a reliable and efficient home security system is greatly needed. Based on Indonesian police data showing an increase in burglary cases every year, especially in densely populated urban areas [1]. To address this issue, technology-based security systems have emerged as a highly relevant solution to develop.

Current technological advancements have enabled the creation of smart security systems that can be controlled and accessed in real-time. The Raspberry Pi 3 has been widely adopted as a microcontroller for developing smart security systems due to its low power consumption yet robust processing capabilities. By integrating the Raspberry Pi, a camera, and a connection to a smartphone, this system can be accessed in real time and provide immediate notifications to users when suspicious activity is detected.

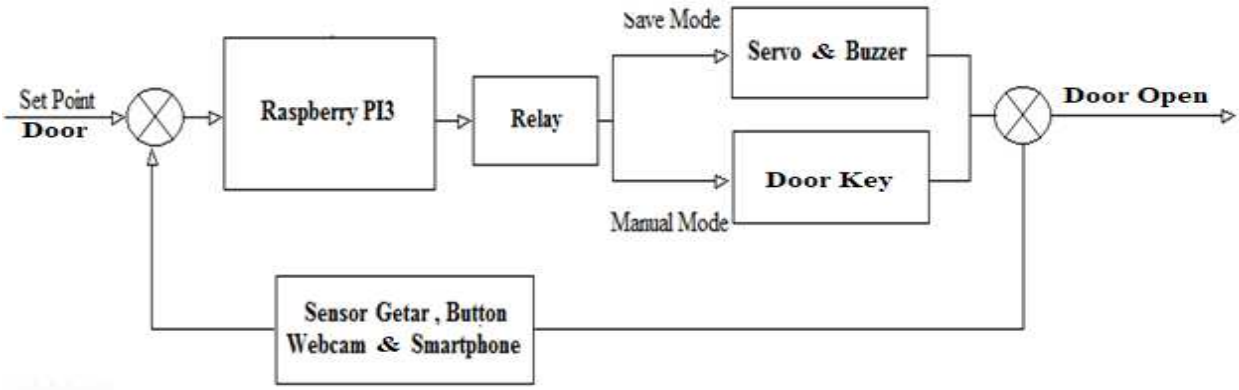
A Raspberry Pi-based home security system has been studied in previous research, but there are limitations in terms of data transmission efficiency, accuracy, and response to emergency conditions. For example, research conducted by Ahmad et al. (2020) demonstrated the successful integration of Raspberry Pi, cameras, and motion sensors to detect movement, but this study did not include a real-time notification system [3]. Meanwhile, a study was also conducted by Putra and Santoso (2021), who successfully developed a system for sending images to Telegram, but did not use a camera for efficient visual identification [4]. This study aims to improve both approaches by creating a security system using a Raspberry Pi 3 integrated with a vibration sensor to detect movement and a camera to provide real-time notifications on a smartphone.

The "Raspberry Pi 3 Based Automatic Door Lock Security System With Camera And Smartphone Integration" door lock system has two modes for controlling the door: save mode for controlling the door via a smartphone app and manual mode for controlling the door manually using a traditional key. Users can also monitor the door status remotely in real time via their smartphone. It is hoped that this system will serve as an effective solution to enhance home security, thereby providing a sense of safety and comfort to the general public.

B. Research Method

System Design

Before creating a circuit and system, a block diagram must first be created to ensure that the circuit is designed according to specifications. The following is a block diagram of the overall system.



Picture 1. Overall Block Diagram

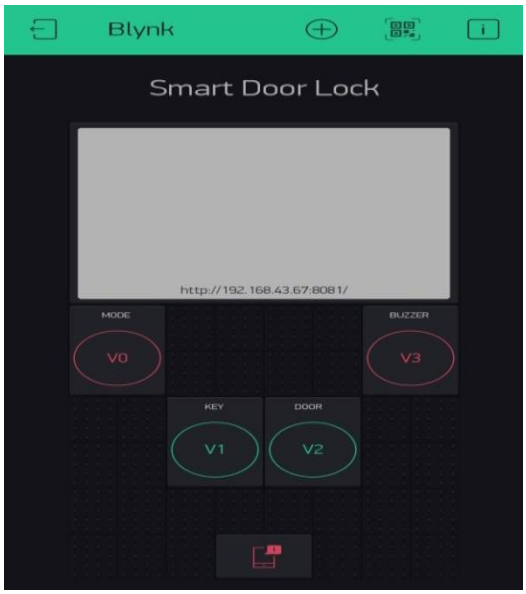
Based on the image above, the functions of each block diagram are:

1. **Webcamera**
   The webcamera functions to record the surroundings of the door.
2. **Vibration Sensor**
   In this designed system, the vibration sensor functions as a detector of vibrations that occur on the door lock when it is locked.
3. **Smartphone**
   Access the application used to control the door and monitor door security.
4. **Push Button**
   The push button functions as a doorbell, activating alerts on the device and in the app when there are visitors.
5. **Raspberry Pi**
   The Raspberry Pi functions as the overall system controller and main processor used to process data received from the vibration sensor and Android device so that the system can synchronize.
6. **Relay**
   The relay is used to switch between save mode and manual mode, as well as to turn the buzzer on and off when the door is locked and unlocked.
7. **Servo Motor**
   The servo motor functions as the door lock actuator when controlled via the app as a replacement for the key and door handle actuator to open the door.
8. **Buzzer**
   The buzzer functions as a danger warning alarm in the form of sound; the buzzer is the output of data read by the vibration sensor.

System Working Principle

The working principle of this door lock system is that the device is controlled using a smartphone with a specially designed application tailored to the device's requirements. To control the door lock, there are two mode options: save mode and manual mode. In save mode, the entire door security system is active, meaning the door lock can only be controlled via the smartphone app using two MG996R servos installed on the door handle as the door lock and handle actuators. Servo 1 acts as the door lock actuator to lock and unlock the door when commanded by the app, while servo 2 acts as the door handle actuator when commanded to open the door. The vibration sensor will activate to detect forced opening attempts when the door is locked. If dangerous movement is detected, the buzzer installed on the door will sound, and the device will send a real-time danger notification to the app, allowing users to monitor the door's status directly from their smartphone based on camera recordings. Additionally, in manual mode, all security systems except the camera and push button will be deactivated, so the door lock can only be controlled manually using a key like a standard door lock. However, users can still monitor the door's status through the app.

This door lock system is controlled using a smartphone app, which was created using Blynk with the following design:



Picture 2. Virtual Pin Application Menu

Based on Figure 2, we can see the design of the application buttons used to control the door, where each menu has its own function and uses a virtual pin to connect to the Raspberry Pi. The following is an explanation :

1. **Monitoring Screen**

The monitoring screen displays live streaming video from the webcam on the application. The screen is connected to the Raspberry Pi's IP address, which is http://192.168.43.67:8081/.

2.Menu Mode

The mode menu is used to give commands to change the door control mode, where the mode menu uses virtual pin 0 (V0) and is connected to a relay.

3.Menu Key

The menu key is used to control the door lock to lock and unlock the door. The menu key uses virtual pin 1 (V1) on the application and is connected to servo 1 on the circuit.

4.Menu Door

The door menu is used to control the door handle, to move the door handle when given a command to open the door. The door menu uses virtual pin 2 (V2) on the application and is connected to servo 2 on the circuit.

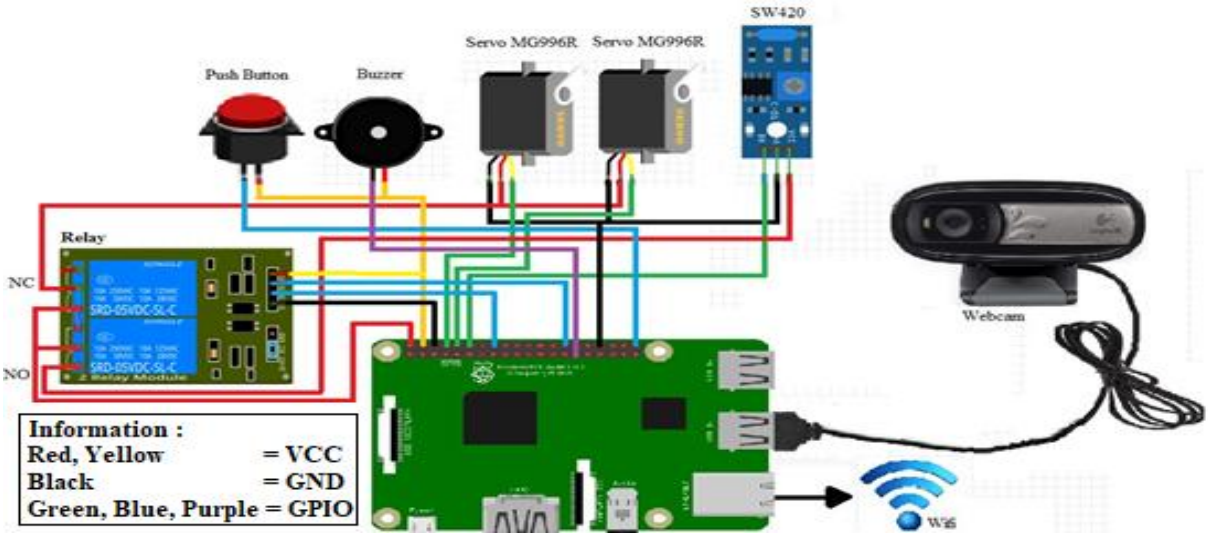
5.Menu Buzzer

The buzzer menu is used to control the buzzer, to turn the buzzer on and off from the application. The buzzer menu uses virtual pin 3 (V3) on the application and is connected to the buzzer on the circuit.

6.Notification

Notifications serve to alert users to the status of the door on the app, whether the app is open or closed on the smartphone.

Overall System Configuration



Picture 3. Overall System Configuaration

Figure 3 above shows an overview of the entire door lock security system, where each component used is connected to the Raspberry Pi using different pins, as shown in the table below:

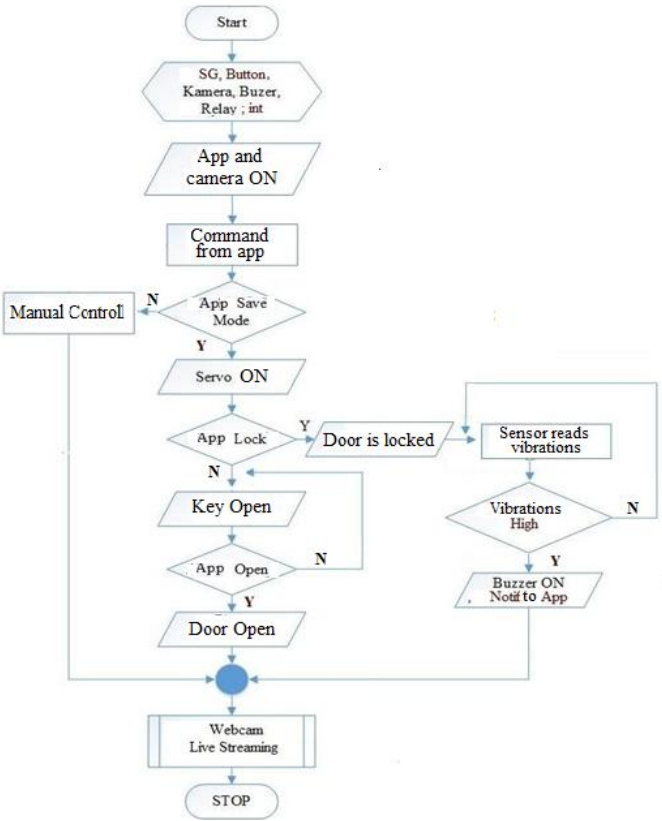
Table 1. The Relationship Between Raspberry PI3 and Components

Name	Pin Module	Pin Raspberry		Name	Pin Module	Pin Raspberry
Sensor SW 420	D0	GPIO 24		**Servo MG996R 2**	Pulse	GPIO 17
	VCC	Pin 5V Raspberry			VCC	Pin 5V Raspberry
	GND	Raspberry GND			GND	Raspberry GND
Push Button	**Pin 1**	**Raspberry GND**		**Relay**	IN	GPIO 20
	Pin 2	GPIO 20			VCC	Pin 5V Raspberry
Buzzer	Pin 1	Raspberry GND			GND	Raspberry GND
	Pin 2	GPIO 21		**Webcam**	Webcam USB	Raspberry Port USB
Servo MG996R 1	Pulse	GPIO 4				
	VCC	Pin 5V Raspberry				
	GND	Raspberry GND				

Table 2. System Design Conditions

Name	Conditions	Data	Descriptions
Sensor SW 420	ON	1	Door Condition Not Safe
	OFF	0	Door Condition Safe
Buzzer	ON	1	Door Condition Not Safe
	OFF	0	Door Condition Safe
Servo MG996R 1	LOCK	Move 90º Clockwise	Locked Door
	UNLOCK	Move 90º counterclockwise	Open key
Servo MG996R 2	OPEN	135º Counterclockwise and back to the starting point	Handle Opens and closes again
Webcam	ON	-	Live Streaming Actif
	OFF	-	Live Streaming Off

In the creation of this security system device, we can see how the application initialization, vibration sensor, camera, relay, and buzzer work based on the flowchart shown below :



Picture 4. Flowchart System

C. Hasil dan Pembahasan

Based on the tests conducted on each component used, the input voltage for all components can be determined, where the power supply provides an input voltage of 5Vdc to the vibration sensor circuit, relay, servo 1, and servo 2. After testing with a multimeter, the measured input voltage for the vibration sensor was found to be 4.8Vdc, the relay had an input voltage of 4.74 Vdc, and servo 1 and servo 2 had an input voltage of 4.68Vdc.

Next, testing was conducted on the overall security system conditions, as shown in Table 3 below.:

Table 3. Overall System Condition

Aplication			Servo 1	Servo 2	Vibration Sensor		Buzzer		Webcam
					Resistance		Condition		
					> 5KOhm	<5Kohm	High	Low	
Save Mode	Door	Open	OFF	ON	0	0	0	0	ON
		OFF	OFF	OFF	0	0	0	0	
	Key	Lock	ON	OFF	1	0	1	0	
		Unlock	ON	OFF	0	0	0	0	
	Buzzer	ON	OFF	OFF	0	0	1	0	
		OFF	OFF	OFF	0	0	0	0	
	Notification		NO Notification		Notifications On Smartphone	NO Notification	Notifications On Smartphone	NO Notification	
Manual Mode	OFF		OFF	OFF	OFF		OFF		ON

Based on Table 3 above, the overall condition of this door lock security system can be determined. The door lock control has two modes that are configured via the application. The first mode is Save Mode, where the Key, Door, Buzzer, and Notification menus can be used. The Key button is used to control Servo 1, the Door menu is used to control Servo 2, the Buzzer menu is used to control the buzzer, and the notification is active when the buzzer is in the high state. The yellow color indicates a condition that may not occur during testing in Save Mode. The second mode is manual mode, which disables the door's security system. In this mode, the key, door, buzzer, and notification menus are disabled, so the door can only be opened using a traditional door key like a regular door. However, the webcam remains active, recording the area around the door in both save mode and manual mode, allowing users to monitor the door's status in real-time under any conditions..

To determine the effectiveness of the device/system, direct testing was conducted by placing the device on the door lock and testing it. The results of the testing of the entire system can be seen in the table below:

Table 4. Overall Circuit Test Results

Aplication			PWM Servo 1	PWM Servo 2	Vibration Sensor		Buzzer		Web cam	Information
					Resistance		Condition			
					>5KOhm	<5KOhm	High	Low		
Save Mode	Door	Open	-	5 %	-	-		-	ON	Suitable
		OFF	-	12.5 %	-	-	-	-		
	Key	Lock	7.5%	-	1	0	1	0		
		Unlock	12.5%	-	-	-	-	-		
	Buzzer	ON	-	-	1	0	1	0		
		OFF	-	-	0	0	0	0		
	Notification		NO Notification		Notifications On Smartphone	NO Notification	Notifications On Smartphone	NO Notifration		
Manual Mode	OFF		OFF	OFF	OFF		OFF		ON	Suitable

Table 5. Results of observation and testing of the entire circuit

Data Input	Expected Results	Observation and Testing Results
Data from the module.	Both the input and output schemes of the system work well for controlling and securing door locks.	Both the input and output schemes of the system work well for controlling and securing door locks.

Based on Table 5, it can be seen that this door lock security system works well in controlling door locks and door security systems..

Table 6. Application range test results

Distance (m)	Condition	Descriptions
1 m	The app connects to the device	The smartphone is connected to Wi-Fi and the app can control the device in real time.
5 m	The app connects to the device	The smartphone is connected to Wi-Fi and the app can control the device in real time.

10 m	The app connects to the device	The smartphone is connected to Wi-Fi and the app can control the device in real time.
15 m	The app connects to the device	The smartphone is connected to Wi-Fi and the app can control the device, but sometimes there is a delay.
20 m	The app connects to the device	The smartphone is connected to Wi-Fi and the app can control the device, but sometimes there is a delay.

Based on Table 6 above, it can be seen that the application connects well within a range of 1 m – 14 m, while at a distance of 15 m – 20 m, the application sometimes experiences delays in responding to commands from the application due to reduced network speed.

D. Closing

Conclusion

After conducting tests and collecting data directly from the device, the following conclusions can be drawn:

1. Tests on the application's range in controlling the device after connecting to Wi-Fi showed that the application can connect well to the device and give commands in real time within a range of 1m to 14m.
2. Testing on the SW420 vibration sensor shows that the resistance value setting affects the sensor's reading, where a lower resistance value makes the sensor more sensitive to vibrations, and a higher resistance value makes the sensor less sensitive. The resistance value range for the vibration sensor is 1 kOhm to 5 kOhm.
3. The servo angle setting on the Raspberry Pi is calculated using the formula: DutyCycle = 1/18 x (DesiredAngle) + 2.5%.
   Based on the above formula, the results for an angle of 180º are written as 12.5% in the program, an angle of 90º is written as 7.5% in the program, and an angle of 45º is written as 5% in the program..

Advice

1. In order to create a tool that works well for application in society, development is needed in terms of both benefits and overall system performance. Here are some suggestions from the author's research:
2. In order for the tool to remain accessible from a greater distance, it is recommended to use additional modules such as sim800 or to create a web server.
3. For live video streaming in the application, it is recommended that the results of the webcam recording be stored in memory or on a web server in future research. This is so that users can access videos that have already been recorded.
4. To produce better recordings, it is recommended that better cameras or higher-end webcams be used in future research.

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