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Security System For Motorcycle Using Raspberry Pi and Fingerprint With Mobile-Based Finite State Machine (FSM) Method

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ABSTRACT

Data from the BPS (Central Statistical Agency) show that private car theft in Indonesia is on the rise year after year, especially for two-wheeled vehicles or motorcycles. According to the BPS Crime Statistics Report, there were around 35,000 motor vehicle theft events in Indonesia in 2017 and 38,000 instances in 2018. People's concerns regarding the security of these two-wheeled vehicles are growing as a result. This study presents a fingerprint- and Raspberry Pi-based motorcycle security system. Bikes may be monitored, and their ignitions can be controlled remotely using a mobile-based Finite State Machine (FSM) technique. The Neo 6 GPS module will send longitude and latitude in real time to the Android smartphone application, which generates a map or location point so that it will send notifications if there is movement on the motorcycle. The voltage sensor connected to the Raspberry Pi circuit can detect the motor voltage. A system that uses the FSM (Finite State Machine) approach to identify changes in location data from designated parking lots and deliver messages to a push bullet is the study's output. Controlling the motorcycle ignition, which may remotely switch off the motorcycle when one is taken, is another way to provide early notice.

1. INTRODUCTION

Motorized vehicles have developed into an important component of everyday people's lives. Two-wheeled vehicles are one type of motorized vehicle that can be classified according to the needs of the community. The level of theft of private vehicles, especially two-wheeled vehicles or motorbikes, tends to increase in proportion to the number of people who use motorized vehicles. The Crime Statistics Report from BPS shows that there were around 35,000 incidents of motor vehicle theft in Indonesia in 2017, and this number increased to 38,000 cases in 2018. According to a study published by https://www.motorplus-online.com/, the perpetrator's method demonstrates that the perpetrator usually commits this act by tampering with the vehicle's ignition using a T key. This method is considered efficient because most motorcycle owners do not install a safety lock. In addition to the lock that the manufacturer produces as standard equipment. Thieves may still steal two-wheeled vehicles even when they are fitted with extra security measures such as padlocks, alarms, and other similar devices, although owners of motorcycle vehicles often install additional security features on their cars, such as padlocks. Theft cases involving two-wheeled vehicles may be more easily resolved if the community is able to make use of the technology that has evolved and put it to good use. The installation of double locks that need fingerprints as well as a tracking system that makes use of GPS are two examples of the kinds of technologies that may be put to use in order to combat this instance of theft.

Design of a motorcycle security system with fingerprints and telephone call notifications based on the atmega 328 [1] and Design of a Motorcycle Position Tracking Control System [2] are two pieces of research that are relevant to the author's discussion. However, according to the two studies that are part of the review of the relevant literature, this discussion has some flaws. Namely, there is no first-generation security system for motorized vehicles in the form of an authentication user system based on fingerprint scanning, and there are no notifications sent out when a two-wheeled vehicle moves from its initial location to a new one. Educational Game for Introductory to West Kalimantan Culture and Tourism Using the Android-Based Finite State Machine Technique" [3] is a related study on the topic of state machines. Nevertheless, in this research, the state machine was used in a game, but in this study, the authors will utilize it in the creation of a security system based on an embedded system. Given the lack of previous research, the authors try to develop a motorcycle security system using Raspberry Pi and fingerprints with a mobile-based state machine method by combining GPS technology with fingerprints as a double-key security measure and fingerprints as a type of secondary identification. Pushbullet as a notification receiver when the motorbike moves from the parking location, as well as an application on a smartphone to make it easier for users to monitor the location and turn off the motorcycle engine when a theft occurs. This system can help reduce cases of theft and provide convenience for motorbike owners when they are in a parking location.

2. RELATED WORK

In this study, a review of the literature has been done on a number of earlier studies that have commonalities in their approaches to problem-solving and their choice of tools. There are certain studies that are thought to be directly related to the research that will be covered in this study. In the paper "Design and Construct a Motorbike Security System with Fingerprints and Atmega 328-Based Phone Call Alerts," [1] summarized the results of much prior research. High rates of crime against motor vehicles and theft are issues that arise. Thieves may readily steal a vehicle not only in isolated areas but also in dense crowds. The ZFM60 V1.2 fingerprint sensor is used in this system for access control, and the SIM800L V2.0 module is added to provide call notification. This system uses the ATmega 328 minimal system. [4], on the other hand, also investigated the development of a motorbike position tracking control system. The vehicle security system uses a fingerprint sensor in place of a key to start and stop the car. As a consequence, it can identify fingerprints and provide vehicle information through SMS, GPS, and websites. There is a need for technology to stop future car theft since there is an issue with motorcycles not having security systems. This system's components include the SIM800L-based motorcycle GPS tracker, GPS Neo 6M, and Arduino Nano. In addition to the two capabilities mentioned above, the GPS controller may also remotely turn on the engine and horn by sending an SMS. The GPS tracker is aware of the coordinates, speed, and altitude of the device mounted on the motorcycle. Remote alarm control can compensate for the Ublox Neo 6M GPS's coordinate point accuracy being 2–3 meters off from the real spot. According to the findings of this investigation, the location of the motorcycle may be ascertained simply by sending an SMS. When a motorcycle ignition is damaged, early warning may also function to activate an alarm and send SMS messages. The horn and engine start may be operated remotely. An SMS typically takes 5 seconds to transmit, and the speed of SMS delivery has an impact on the local network. The next system was created by [5], utilizing SIM900 and GPS to track the location of a vehicle. When the security system is triggered by the car owner, it immediately shuts off and locks the door at a distance of 100 meters from the original coordinate point. In different research, [6] developed a motorcycle security system using SMS media as a relay controller, which would then turn off and reconnect the power to the CDI of the motorcycle. [7] is the next inventor, and he created a motorbike starting system that uses an Arduino Uno-based application to make it simpler for customers to warm up the motorcycle engine and prevent engine damage. The ATMega328 microcontroller, which serves as a controller and sends instructions to the relay so that it is active in high- or low-logic circumstances, is used in the creation of this instrument. The Bluetooth HC5 is an additional component that serves as a conduit between the motorcycle and the telephone.

3. METHODOLOGY

To acquire information, an analytical method is used; this method utilizes an interpretative stance [8],[9]. The bulk of these case studies give a comparative overview of the applicable technology. Using systematic literature analysis, software analysis, hardware analysis, block diagram design principles, and circuit systematics, the research technique gathers contextual information [9]. As a consequence, the authors chose to undertake a systematic literature study in order to construct an overview of the pertinent concerns.

3.1 Analysis Software

According to the flowchart in Figure 1, the working concept of this tool is that the system is activated by turning on the contacts on the motorbike [10], [11], [12] . The circuit system will get voltage from the motorcycle battery. Then the fingerprint will scan the finger inputted on the module and then send data in the form of a registered ID to the Raspberry pi. The registered ID is stored in the module fingerprint directory according to the ID that was input when registering. Raspberry pi processes fingerprint sensor data and controls the output using the FSM (Finite State Machine) method. If the ID is detected, the Buzzer will be ON and emit a beep so that the Relay module is ON connecting the Ignition to the motorcycle, and if the ID is not detected, the Buzzer is OFF so that the Relay is OFF [13], [14], if there is a change in parking location or theft, the GPS module will detect the location based on the coordinates then The smartphone receives a notification in the form of a movement and displays Google Maps to see the location of the motorcycle.

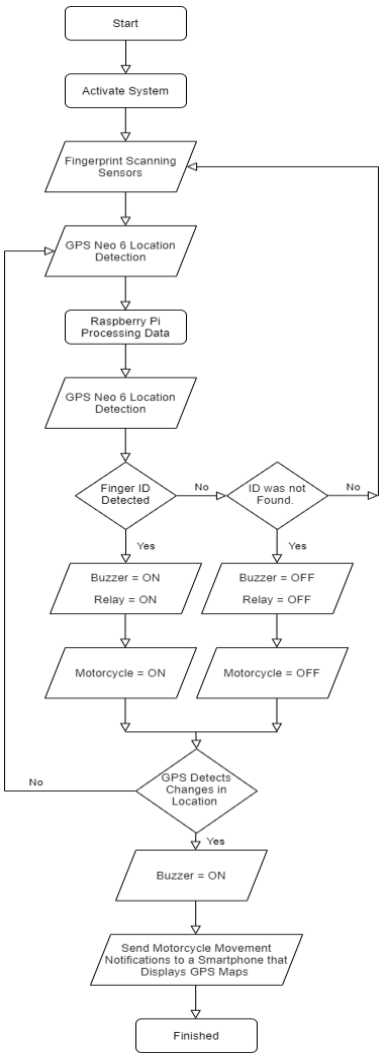


Figure 1. Flowchart design

3.2 Analysis Hardware

Several hardware components are needed to design a motorcycle security system using the Raspberry Pi and fingerprints using the Mobile-Based Finite State Machine (FSM) Method.

TABLE 1. HARDWARE

No	Component	Function
1	Raspberry Pi	The system's primary control
2	Fingerprint FP10 A	Fingerprint Identification
3	Sensor Neo GPS	Data from a GPS Receiver is Read (Latitude and Longitude)
4	Converter 12V-5V DC	Converting Direct Current (DC) Electricity
5	Relay Modul	Connectors and Circuit Breakers
6	Buzzer 5 V	As a Sound Output (beep).
7	Motorcycle Battery 12 V	Supply Current Power to The Dashboard Panel.

3.3 Block Diagram Design Concept

The block diagram below shows how the Raspberry Pi microcontroller is utilized to regulate every aspect of the system's functioning [15], [16]. The design of the motorcycle that will be used to test the tool is created in this phase, which also facilitates the completion of the next processes. The fundamental principle of study design is shown in Figure 2.

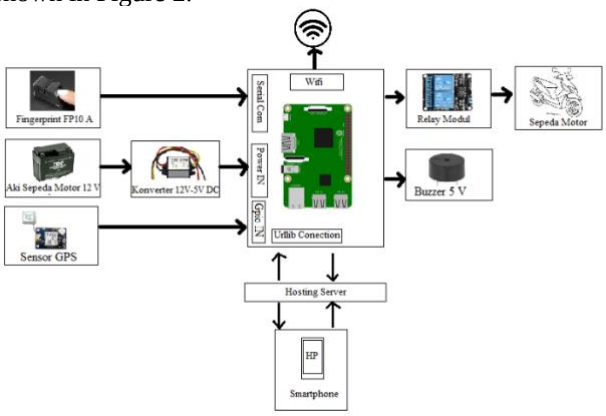


Figure 2. Flowchart design

The Fingerprint Sensor Module detects or recognizes fingerprints by scanning, then transmits the ID number or processed data to the Raspberry Pi through a serial Rx/Tx connection. The Neo 6 GPS sensor detects and interprets the position using earth coordinates. The DC 12V to DC 5V converter will convert the voltage of the 12V DC motorcycle battery to 5V DC, which the Raspberry Pi can accept. 12V motorcycle batteries as a power source and system circuit for a motorcycle relay module to connect and disengage bicycle ignition depending on commands from the Raspberry Pi's GPIO output pin. The 5V buzzer will emit a beeping sound (an alert) when the finger ID is discovered during fingerprint scanning. In addition, the system will deliver android smartphone alerts through the server.

3.4 Circuit Systematic

A number of tools are developed using the Raspberry Pi 3 microcontroller to construct a motorcycle security system. Circuit illustration in Figure 3.

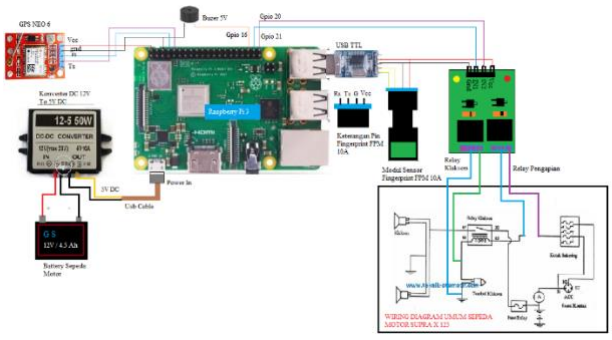


Figure 3. Illustrates circuit

4. RESULT AND DISCUSSION

Black-box testing was used in this investigation. Black-box testing is mostly concerned with functional

requirements. Black-box testing allows for the creation of input scenarios that satisfy all program functional requirements in full. Without a particular output, it is impossible to determine if a system is true or false. The output generated may be used to evaluate the program's accuracy and its capacity to satisfy user demands. To check if the input data and output of this system have functioned as predicted, the black box test is utilized.

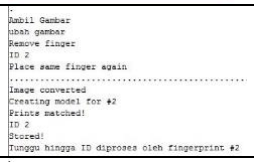
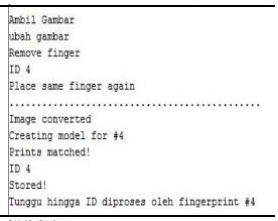
Some tests conducted include testing of finger ID lists, registered finger detection testing, relay module testing, Neo 6 GPS sensor testing, movement notification testing, FSM process testing, and evaluation of test results.

4.1 Testing of Finger ID Lists

This test is carried out by setting the COM port that is connected to the computer, then inputting "no ID" as desired as the address of the finger image template taken from the scanning process. From the results of the test, when the finger was successfully scanned and stored in the fingerprint directory, a notification of the list of successes appeared.

The test results of the finger ID list in fingerprint with several finger inputs can be seen in the table 2 below.

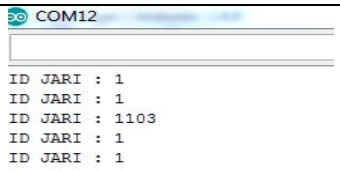
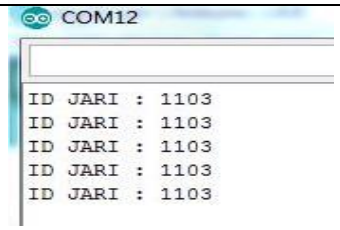
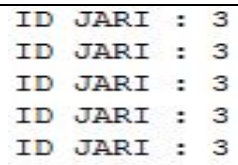
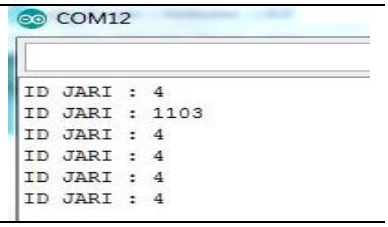
TABLE 2. TESTING OF FINGER ID LISTS

No ID Input	Fingerprint Registration	Status of Testing	Testing
1	Thumb	Successfully registered	
2	Forefinger	Successfully registered	
3	Ring Finger	Successfully registered	
4	Little Finger	Successfully registered	
5	Right Rhumb	Successfully registered	

4.2 Registered Finger Detection Testing

After the finger template registration on the fingerprint and storage into the directory based on the input ID, it is time to test the finger that is registered and not registered. The results of this test can be seen in Table 3 below.

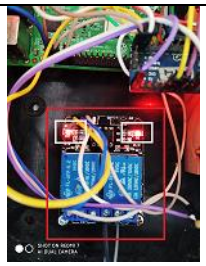
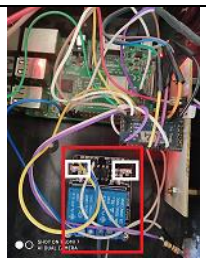
TABLE 3. REGISTERED FINGER DETECTION TESTING

No	Fingerprint Registration	Status of Testing	Testing
1	Right Thumb	Fingerprints can detect the right thumb and produce an ID of 1.	
2	Right Index Finger	Fingerprints can detect the right index finger that is not registered to produce 1103 code, which is not registered.	
3	Ring Finger	Fingerprints can detect the ring finger and produce an ID of 3.	
4	Little Finger	Fingerprints can detect the little finger and produce an ID of 4.	

4.3 Relay Module Testing

Testing is carried out by providing HIGH or LOW logic as an output to control the relay. According to the test results, when the IN relay pin is HIGH, the red indicator light turns on, and when the IN pin is LOW, the indicator light turns off. When set to HIGH, the relay acts as an electronic switch, connecting the current source to the output circuit. Vice versa, when the condition is low, the relay disconnects the load from the voltage source. The following are the results of the relay test that has been carried out (see table 4).

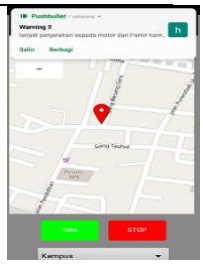
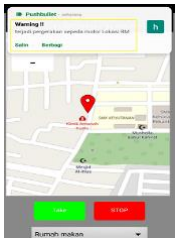
TABLE 4. RELAY MODULE TESTING

No	Condition of Relays 1	Condition of Relays 2	Testing	Status of Testing
1	High	High		IN 1 and IN 2 on the relay module are given HIGH logic so that the relay functions as a link to the circuit to the voltage source.
2	Low	Low		The relay module's IN 1 and IN 2 are set to LOW logic, allowing the relay to function as a circuit breaker from a voltage source.
3	High	Low		IN 1 = HIGH and IN 2 = LOW are marked with a red indicator light that lights up on channel 1 and goes out on channel 2, where channel 1 is connected and channel 2 disconnects the current.

4.4 NEO 6 GPS Sensor Testing

This test is carried out by activating the NEO 6 GPS module, opening the monitoring application on the smartphone, and testing the activity points. The test results from activity points read by GPS can be seen in Table 5 below.

TABLE 5. NEO 6 GPS TESTING

No	State	Event	Action
1	A motorcycle is parked on campus.	There was a movement of motorcycles from the campus parking lot.	Notification: There was a movement from the campus location.
				
2	Parked Motorcycle at The Restaurant. 	Motorcycles were being moved from the restaurant parking lot. 	Notification: There has been a movement from the restaurant's location. 

4.5 *Movement Notification Testing*

Testing is carried out by parking the motorcycle and then taking a location to mark the starting point. Then proceed with taking the motorbike out of the parking location and calculating the distance of movement from the initial location to the location where the notification appears in the form of a warning that the motorbike is moving from the parking location. To calculate the distance to move a location using a speedometer on a motorcycle, where the system sends notifications or activates a buzzer at a distance of > 50 M to 60 M, the following is a picture of the results of the tests that have been carried out.

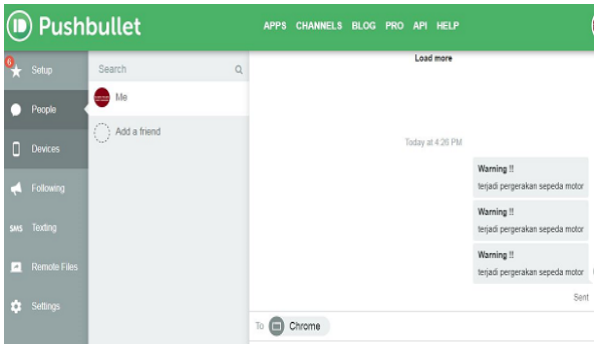


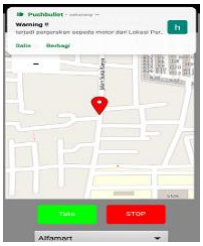
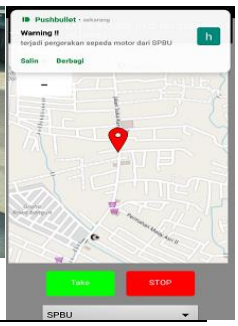
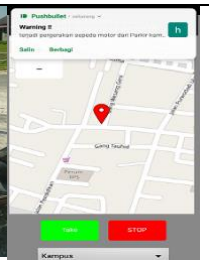
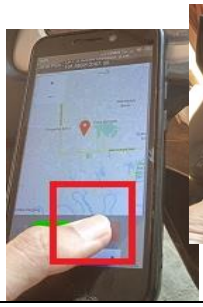
Figure 4. Nofitication testing

Figure 5. Movement Distance Testing

4.6 *FSM process testing*

The results of testing the FSM (Finite State Machine) process on this tool to detect changes in the location data from the marked parking and then turn off the motorcycle from afar can be seen in Table 6 under this section.

TABLE 6. FSM PROCESS TESTING

No	State	Event	Action
1	The motorcycle was left parked in Alfamart.	There was a motorcycle movement from the parking lot.	Notification: "There was a motorcycle movement from Alfamart parking."
			
2	Motorcycle parked at the gas station.	From the gas station, there was a motorcycle movement.	Notification: "There was a movement from the gas station parking lot."
			
3	A motorcycle is parked on campus.	There was a movement of motorcycles from the campus parking lot.	Notification: There was a movement from the campus location.
4	Using a fingerprint scanner, activate the ignition of a motorcycle.	Fingerprint detects fingerprints and determines whether or not they are registered.	The start of an active motorcycle is signaled by a series of indicator lights that send data on latitude and longitude to a smartphone.
			
			
5	Turn off the motorcycle remotely.	By pressing the "Stop" button on the application	ignorant of a dead motorcycle
			

4.7 Evaluation of Test Results

After all of the testing has been completed, an evaluation is required. The findings of the overall test evaluation are presented in Table 7.

TABLE 7. EVALUATION OF TEST RESULTS

No	Evaluation	Result	Status of Testing	
			Succeed	Failed
1	The Neo 6 GPS Sensor Detects Earth Coordinates During Testing	GPS Neo 6 can detect the coordinates of the earth to produce latitude and longitude.	✓	
2	Fingerprint Module FPM10A does finger scanning for input ID.	Fingerprint sensors are capable of detecting fingers and retrieving a template image stored in the specified ID.	✓	

3	Fingerprints are used to identify individuals.	Fingerprints can identify a registered or unregistered finger.	✓
4	Raspberry Pi processes the Neo 6 GPS sensor data coordinates on Earth and sends them to the application.	Raspberry Pi can process sensor data and send it to the web server, where it is then received by an Android smartphone.	✓
5	The application displays a location map, and the user inputs the parking location point.	Applications can display locations on Google Maps through the conversion of coordinate points and store data input points for parking locations.	✓
6	The application is expected to be able to control the ignition of motorcycles and kill the ignition of a motorcycle.	Applications can control the ignition of a motorcycle remotely.	✓
7	The FSM method processes the location of the habit as input data, determines the status of the condition, and takes action in the form of notifications and monitoring.	The FSM method can be used to process input and output data, which is divided into 3 components, namely Events: 5 points of habitual location Condition: a. Motor moves or moves from the parking location b. There was a motorcycle theft. Action: Notification, deciding ignition, and monitoring the location	✓

5. CONCLUSIONS

This paper presents a motorcycle security system using a Raspberry Pi and fingerprints using a mobile-based finite state machine (FSM) method that can control ignition and monitor motorbikes remotely. The voltage sensor connected to the Raspberry Pi circuit can detect motor voltage, and the installed Neo 6 GPS module will send Longitude and Latitude in real time to the Android smartphone application, which generates a map or location point and sends notifications if the motorcycle moves. The results of this study are in the form of a system that applies the FSM (Finite State Machine) process to detect changes in location data from marked parking lots so that it will send notifications to a push bullet. In addition, an early warning can be done by controlling the motorcycle ignition, which can turn off the motorcycle remotely when a motorcycle is stolen. The authors propose adding a camera hardware interface to identify motorcycle users (motorcycle thieves) for future work, with the goal of connecting the system to emergency numbers such as police call center numbers. So that when the motorcycle is stolen, the system can send location information and photos of the thief. We believe that with more hardware support system designs, this research will provide a more accurate security monitoring system.

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