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Smart Safe Using Face Detection Method ESP32 CAM

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ABSTRACT: Currently crime cases are undeniable, one of the cases of crime or crime that often occurs in our lives is theft, the role of technology has an important role in the security system, one of which is the security system in the Safe. The author got the idea to design a "Smart Safe With Face Detection Method Use ESP32 CAM" which uses ESP32 CAM which functions to recognize or detect the face of the safe owner, the safe is also equipped with a keypad as an alternative to open the safe and alarm when forcibly disturbed by others. This smart safe technology is expected to help users in safeguarding assets and valuables stored in a safe, so there is no more worry over theft.

KEYWORDS: *ESP32 CAM, security*

1. INTRODUCTION

1.1 Background

Nowadays, crime rates are increasing all around us, it cannot be denied that crime can come at any time and anywhere. One of the current crime cases is theft. According to the Central Statistics Agency, in 2021 there were 23,308 cases of theft in Indonesia. Sometimes people use various methods to secure their valuables so that they are far from being stolen. One way to store valuable goods and assets is a safe. A safe is a storage box that is used to store valuable items or assets so that they are not stolen (Prasetyo et al., 2021).

Current technological advances encourage every human being to be able to overcome the problems that exist in life, one of which is the security system. (Saleilei et al., 2023). One system that can help develop security technology is the use of microcontrollers. The use of microcontrollers in safe security systems can help develop previously existing technology.

With this in mind, the author got the idea to design a smart safe, which can be opened by facial pattern recognition so that the safe can only be opened by the owner of the registered face. Therefore, to be able to recognize facial patterns, a face detector is needed in the form of a camera module, namely the ESP32 CAM, which can capture facial patterns that have been registered via the IoT system. After the face pattern is registered, the ESP32 CAM can function as a security system to open the safe using the face pattern, but the safe is also provided with another alternative, namely by using a keypad so that the safe can also be opened using a number code, the safe will be equipped with an alarm system that will sound if the mc38 or door sensor detects a forced opening of the safe door.

1.2 Formulation of the problem

From the above background the problem can be formulated as follows:

How to design and test a Smart Safe Using ESP32 CAM face detection Method?

How to reduce cases of theft of assets and valuables?

1.3 Scope of problem

The limitations of the problem in this research are as follows:

The Smart Safe working system uses the ESP32 CAM face detection method only detects the face of the safe owner and has another alternative, namely the keypad.

The control used in the Smart Safe uses the ESP32 CAM and Arduino nano face detection method.

1.4 Research purposes

The aims of this research are:

Able to design and test a security system in the form of a Smart Safe Using the ESP32 CAM facial detection method. So it becomes a safe that is able to secure valuable items and assets and provide warnings when theft occurs.

Able to reduce cases of theft and loss of assets and valuables.

2 THEORETICAL BASIS

Table 1.Tool

No	NameTool	Specification
1	Soldering	Dekko 40Watt
2	Soldering Tin	Paragon 0.8mm
3	Tin Suction	Dekko
4	Cutting pliers	Tekiro
5	Screwdriver Set	Tekiro
6	Cellphone	iPhone 6s

2.1 Material

Safe

A safe is a cupboard made of iron, which can be steel or other metals, which can be used to store money or valuables (kbbi.kemdikbud.go.id, n.d.). In general, safes are shaped like blocks/cubes or cylinders. Safe working systems usually consist of two types, some are analog and some are digital. (Ali et al., 2021). An example of a safe is in figure 2.1

Figure 1. Safe (spartacom.co.id, 2020)

ESP32 CAM

The ESP32 was first introduced by a company based in Shanghai, namely the Espressif System company, this ESP32 is the successor to the ESP 8266 microcontroller, this ESP32 has its own advantages, namely that it already has Wi-Fi as well as Bluetooth, making it easier and more practical to create an IoT circuit (Munafi et al. , n.d.). In this research, the ESP32 CAM is used, which is an ESP32 that is equipped with a camera, this module is an open source module. The physical form of the ESP32 CAM can be seen in Figure 2.

Figure 2. ESP32 CAM (Yulita et al., n.d.)

Table 2. ESP32 CAM Specifications

(Munafi et al., n.d.)

Module	*ESP32 CAM*
RAM	520KB SRAM + 4M PSRAM
SPI Flash	32Mbit
Wi-Fi	802.11 b/g/n
IO pins	9
Antenna	*Onboard PCB antenna 2dBi*
Security	WPA/WPA2/WPA2-Enterprise/WPS
Voltage	5Volts

Arduino Nano

The Arduino Nano is a microcontroller based on the Atmega328 P chip which is quite small compared to the Arduino Uno, even though it is smaller, the functions of the Arduino Nano and Arduino Uno are not much different, the difference being that the Arduino Nano does not have a DC power jack. Arduino nano is based on the ATmega328 microcontroller for Arduino nano 3.x and Atmega168 for Arduino nano 2.x. Arduino nano is not equipped with a power supply, but Arduino nano can use a power supply from the miniUSB port. Figure 2.4 shows the layout of the Arduino nano board along with the pins on the board (Iksal1, 2018).

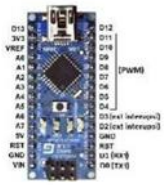

Figure 3. Arduino Nano Board Pin Configuration (Iksal, 2018)

Table 3. Arduino Nano Specifications

Microcontroller	Atmega168 / Atmega328
Input Voltage	7-12 Volts
Operating Voltage	5 Volts
Input Voltage(minimum)	6 Volts – 20 Volts
Digital I/O Pins	14 (6pin is used as PWM output)
Analog Input Pins	8
DC current per I/O pin	40 mA
*Flash*Memory	16 KB for Atmega168 and 32KB for Atmega328
SRAM	1KB for ATmega168 And 2KB ForAtmega328
EEPROM	512 Bytes (Atmega168) and 1KB (Atmega328)

MC 38

The MC38 sensor or Magnetic Switch MC38 is a door open/close detection module that works according to electromagnetic principles. When normal, the sensor and magnet are not close together, and the switch is in a Normally Open (NO) condition. When active, the sensor and magnet are close to each other or the door is closed and the switch is closed or Closed Circuit (NC) with a resistance value of approximately 4Ω. as in Figure 2.5 which shows the physical form of MC38 (Siswanto et al., 2018).

Figure 4. Magnetic Switch

MC38(eprints.utdi.ac.id)

Table 4. MC38 Specifications

(Siswanto et al., 2018)

Rated Voltage	200 Volts DC
Rated Current	100mA
Operating Distance	15mm-25mm
Resistance	±4Ω
Dimensions	28x15x0.9cm

Solenoid

The door lock solenoid is a solenoid that has a special function to lock the door electronically. Door lock solenoids have 2 types of working systems, namely NC and NO. The difference between the two working systems is that when voltage is applied, the solenoid will close or extend. And the way the NO solenoid works is the opposite of the NC solenoid (Ali et al., 2021), the physical form of the solenoid can be seen from the following figure 5.

Figure 5. Door lock solenoid

Keypads

*Keypads*is an interface between electronic devices and humans, known as HMI (Human Machine Interface). The 4x4 keypad is an example of a keypad used for communication between humans and a microcontroller. The 4x4 keypad matrix has a simple arrangement in the use of microcontroller ports. This keypad configuration with a matrix arrangement aims to save microcontroller ports. (John C, et al 2018).

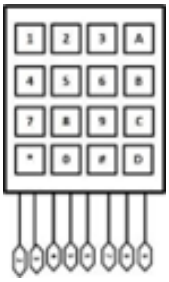

Figure 6. Keypad Matrix

Power Bank

*Power bank*is a device that can charge smartphones, gadgets or other electronic equipment that has limited power and is far from a power source. The definition of Powerbank can also be defined as power storage or can also be called a backup battery, using a powerbank is very practical, you don't need to remove the cellphone battery or electronic device battery, just plug the cable into the charger hole of the electronic device (Aminardi & Falani, 2017).

***OLED*128 X 64**

*OLED*which stands for (Organic Light-Emitting Diode) is a device that is quite important in electroluminescence technology. OLED is a screen that already has a panel. The panels used by OLED LCDs are panels that contain organic elements that can emit light when electricity flows. OLED screens provide power consumption, so that the black level on the screen is deeper and deeper (Ismail et al., 2022). To better understand the OLED LCD specifications, you can see table 5.

Table 5. OLED LCD Specifications

Type	Graphic
Display format	128 X 64
Work Cycle	1/64
Power supply	+3V
Interface	6800,8080, serial and *I2C*

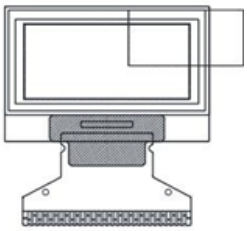

Figure 7. The shape of an LCD

OLED (www.vishay.com, 2016)

Battery

Lithium batteries or Lithium-Ion Batteries are a type of battery that has a secondary current that can be recharged. Currently, lithium batteries are needed as electrical energy for electronic equipment that requires recharging such as smartphones, MP3s and other electronic equipment. Lithium batteries currently have a light weight but the power they produce is quite high and can be used many times because they can be recharged. (Prime, 2021).

Figure 8. Image of 18650 Battery

(www.sandielektronik.com, 2018)

3. METHODOLOGY

The methodology in this research uses experimental empirical research methods, this method is carried out by

carrying out a design and testing the tool in real time, so that data is obtained from the tool that was designed directly.

A. Tool Block Diagram

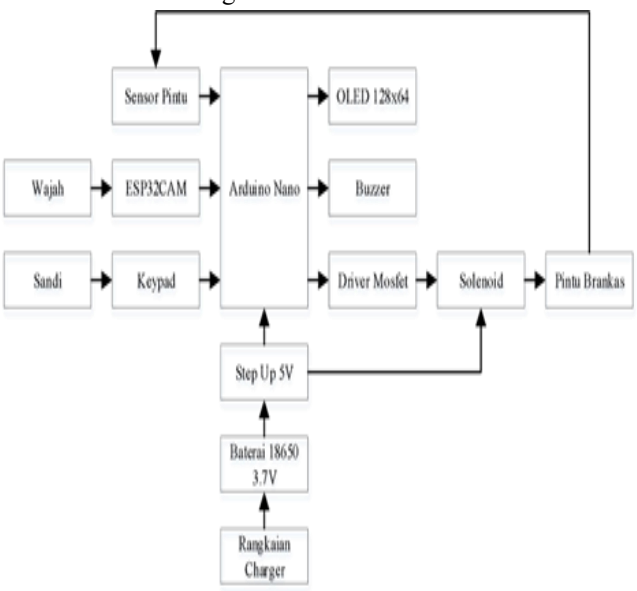

Figure 9. Tool Block Diagram

The function of each part in the blog diagram is

1. Arduino Nano as a Microcontroller to process input from door sensors, ESP32 CAM, Keypad
2. *ESP32 CAM*As a camera and recorder of the safe owner's facial pattern so that the safe can be opened automatically without physical touch
3. *Keypads*as an alternative to entering a code so that the safe door can be opened using a number code.
4. The Door Sensor/Mc38 is a magnetic sensor which functions to detect forced opening of a door or forced break-in of a safe door.
5. OLED 128X64 functions as an output that can display numbers and writing.
6. The buzzer functions to make a sound or alarm.
7. *Mosfet Driver*functions to control the voltage entering the selenoif.
8. The doorlock solenoid functions to lock or open the safe door automatically after being energized by the MOSFET.
9. *Step up*5V functions to increase the voltage of the 18650 battery which is supplied from the charger circuit
10. The 18650 3.7V battery functions to supply voltage
11. Charger Circuit

B. Tool Work Flow Chart

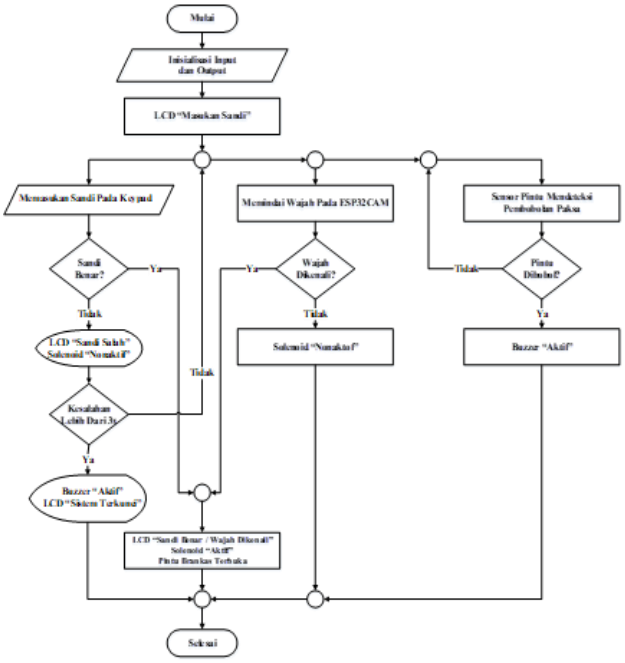

Figure 10. Tool Work Flow Chart

When the device is running it starts with input and output initialization, input consists of facial recognition or a code on the keypad. If the input used scans the face, the ESP32 CAM will detect the face of the safe user. If the face is detected, the selenoid will open the safe automatically, but if there are 3 errors in face recognition or the face is not registered with the ESP32 CAM, the buzzer will make a sound and the LCD will produce output. writing.

"System Locked". Alternative input when opening the safe also uses a numeric code by pressing the code numbers on the keypad. If the code/password is correct then the solenoid will open the safe door. However, if the code/password entered is wrong then the user is given 3 chances to enter the code, if the error is more than 3x then the buzzer will sound and the LCD will output the words "System Locked". If the door sensor detects a break-in, the buzzer will function as a warning alarm and will make a sound, and the work process is complete.

4. RESULTS AND DISCUSSION

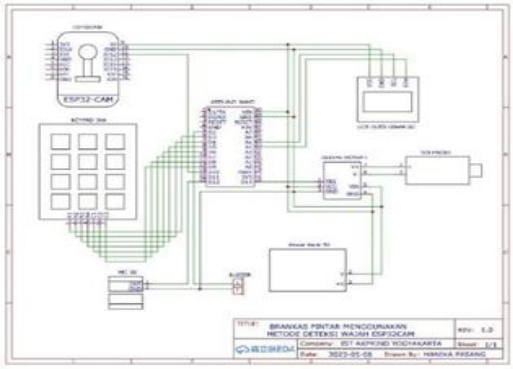

Figure 11. Schematic design of the circuit

The analysis that will be carried out is to test the system so that it can work as expected. There are two things that will be tested and analyzed in this research, namely camera testing and testing the number code on the keypad.

1. Tool Design Results

Figure 12. Inside view

Figure 13. External view

2. Facial Pattern Registration Results

The results of facial pattern registration are obtained after activating Face Detection and Face Recognition at the IP addresshttp://172.20.10.2and then enroll the face and get 3 samples, so that the face can be recognized by the ESP32 CAM camera.

Figure 14. Face Registration Results

3. Camera Response

Figure 15. Hanika Pasang, as safe user

Figure 16. is not a safe user

4. Keypad Reading Results

The result of reading the Keypad is a 6 digit numeric code which is input into the program which is then compiled. The numeric code from the input then becomes the password to open the safe, S

Figure 17. Number code test results

5. Camera Distance from Face

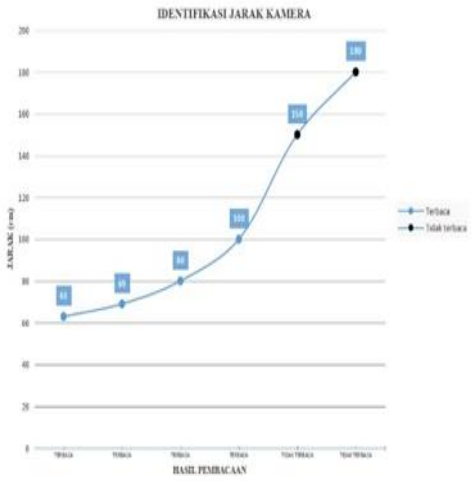

Figure 18. Camera Distance Graph

The camera distance was measured by taking 6 distance samples, so that the results that were read were, at a distance of 63 cm to 1m the camera could identify the user's face, so that the user could open the safe at a distance of 1 meter or less than 1 meter, and above a distance of 1 meter the camera was no longer able to open the safe. identify the user's face so that there is no response from the safe.

6. The tilt of the face position with the camera

Table 2.6 Slope

No	*Users*	Slope	Results Reading
1.	HanikaInstall	0 degrees	Read
		15 degrees	Read
		30 degrees	Read
		45 degrees	Read
		60 degrees	No Read
		75 degrees	No read

Measuring the distance between the user and the camera shows that the face can be identified by the camera at a distance of 90 degrees to 45 degrees because at this distance the user's face can be completely detected and at a slope of 30 degrees downwards the camera is no longer able to identify the user's face, and at a distance of 90 degrees is the greatest distance of illumination.

Table 7. Distance between camera and face

No	User	Distance	Results Reading
1.	Hanika Pasang	63cm	Read
		69cm	Read
		80cm	Read
		1m	Read
		1,5m	Can not be read
		1,8 m	Can not be read

Figure 19. Slope Graph

Measuring the distance between the user and the camera shows that the face can be identified by the camera at a distance of 90 degrees to 45 degrees because at this distance the user's face can be completely detected and at a slope of 30 degrees downwards the camera is no longer able to identify the user's face, and at a distance of 90 degrees is the greatest distance of illumination.

7. Lighting Test Results

This lighting test aims to find out how much lux light is needed in the room to be able to identify the user's face.

Table 8. Time Taking Data

Position	Time TakingData	Level Lighting(Lux)	Information
Akprind Installation Lab	12.07	68 Lux	Read
	13.28	73 Lux	Read
	14.00	58 Lux	Read
Room	08.47	62 Lux	Read
	9.45	274 Lux	Read
	11.48	72 Lux	Read
	13.59	75 Lux	Read
	16.18	15 Lux	Can not be read
	22.00	10 Lux	Can not be read

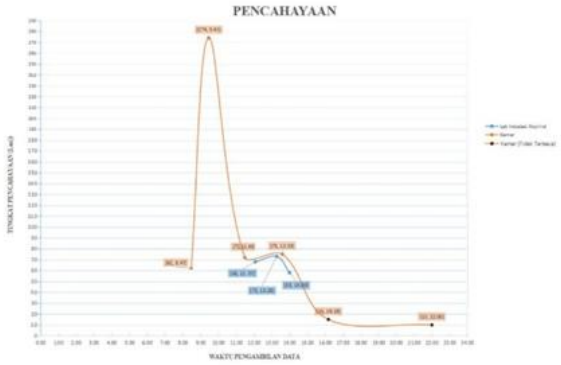

Figure 20 Room lighting lux graph

the results of lighting measurements are very influential on the face identification process carried out by the user to open the safe. The room light lux needed by the camera to be able to identify faces is above 15 lux, below 15 lux as in the red graph indicates that the camera cannot identify the user's face so it requires light above 16 lux so the camera can work.

5. CONCLUSIONS AND RECOMMENDATIONS

1. Conclusion

From the research "Smart Safe Using the ESP32 CAM Face Detection Method" which has been carried out, the following conclusions are drawn:

1. ESP32 CAM is a camera module used to detect or identify faces so it plays an important role in the creation of this research
2. Operation of the tool is done by opening the IP address of the ESP32 CAM then turning on the start stream on the website then pointing your face at the camera which is placed right in front of the safe door after which the camera will detect the face.
3. The distance required for the camera to identify faces is less than or equal to 1 meter. More than one meter the camera cannot identify faces.
4. The user's position can be detected if the entire face is visible. The position is at a tilt of 90 degrees to 45 degrees. Less than that, the camera cannot identify the face
5. The light needed in the room to detect faces must be above 15 lux, light below 15 lux cannot be identified or detected by the camera

2. Suggestion

For further research, there are several things that can be done in developing this research, including:

1. The face detection process in this research can only detect if the IP Address is opened, if the IP Address is not open then the face detection process cannot be carried out, therefore to develop it you can add a micro SD to the ESP32 CAM.

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