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Design of Monitoring System for Banknote Piggy Bank based on Android

Kevin Ardiansah, Chattelin, and Agfa Muhammad Prima

Electrical Engineering National Development University "Veteran" Jakarta
2110314039@mahasiswa.upnvj.ac.id

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ABSTRACT

This research aims to design and build an Android-based banknote monitoring system utilizing Internet of Things (IoT) technology. This system uses TCS3200 color sensor to detect the nominal value of banknotes based on RGB (Red, Green, Blue) values, NodeMCU ESP8266 as the main microcontroller, and 16x2 LCD to display the nominal information. The detected banknote data is sent to the Android application in real-time, allowing users to monitor the balance, view the savings history, and control the opening and closing of the savings box through a solenoid mechanism. System testing showed a 98% success rate in detecting banknotes of various denominations, displaying information on the LCD, and synchronizing data with the Android application. This system is expected to improve children's financial literacy by providing a more interactive, efficient, and safe savings experience.

Keywords: *savings box, nodeMCU ESP8266, TCS3200 Color Sensor*

1. INTRODUCTION

Saving money is the process of allocating a portion of one's funds to be saved, as well as a method of financial management to achieve certain goals. For example, saving money in an ordinary savings box is still considered a popular way to save small amounts of money, especially among children. It also serves as an educational activity for school-age children, encouraging them to set aside their pocket money or pocket money for savings (Chotimatun Chasanah et.al, 2023). This helps them develop discipline in saving, understand the importance of personal financial management, build a saving habit, and plan for their financial future.

In general, an ordinary savings box found at home cannot provide information on the amount of money that has been saved. This causes users, especially children, to often lose interest in saving money. This is because it only functions as a storage place without the ability to show information about the amount of money saved (R. F. Ashari et.al, 2022).

Based on the results of the 2022 Survei Nasional Literasi dan Inklusi Keuangan (SNLIK), Indonesia's financial literacy index stands at 49.68%, an increase from the previous 38.08% in 2019. Despite this increase, the financial literacy of elementary school graduates remains low, reaching only 39.78% (OJK, 2022). This survey highlights the importance of effective approaches to improve children's financial literacy from an early age (S. A. Burairoh et.al, 2024).

The use of a smart savings box as a banknote storage device is designed to detect banknotes inserted through a slot based on the color of the banknote. This savings box is equipped with a secure door and an Android application that monitors the nominal amount of money, savings details, and the date of saving. With this development, users can view the amount of savings and details of the money stored in the Android-based application. Based on these problems, research entitled "Design and Development of a Monitoring System for Banknote Savings Boxes Based on Android" is needed. This is the basis for creating a savings box that can monitor the amount of money saved, with the aim of educating children to save more actively.

2. RESEARCH METHODS

2.1 NodeMCU ESP8266

NodeMCU is an open-source IoT platform described in Figure 1. It consists of hardware in the form of an ESP8266 System on Chip (SoC) from Espressif Systems. NodeMCU can be analogized as an Arduino board connected to an ESP8266. NodeMCU has packaged the ESP8266 onto a board that is integrated with various features like a microcontroller and access capabilities to Wi-Fi and also a communication chip in the form of USB to serial. Thus, in programming, only a USB data cable is needed.

Figure 1. NodeMCU ESP8266

2.2 TCS3200 Color Sensor

The TCS3200 color sensor module in Figure 2 uses the TAOS TCS3200 RGB chip, which is integrated with 4 LEDs. This sensor can detect and measure color intensity. Some applications of this sensor include color reading, color-based object sorting, ambient light sensing and calibration, and others. The TCS3200 chip has several photodetectors, each with a color filter, namely red, green, blue, and clear, which are distributed in each array.

Figure 2. TCS3200 Color Sensor

2.3 LCD 16X2

Liquid Crystal Display (LCD) in Figure 3 is a type of display medium that uses liquid crystals as its main display element. LCDs have been used in various fields, for example, in electronic devices such as televisions, calculators, or computer screens. In a color LCD such as a monitor, there are many light points (pixels) consisting of a single liquid crystal as a light point. Although referred to as a light point, these liquid crystals do not emit light themselves.

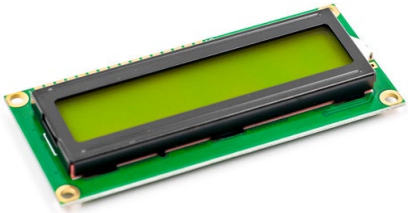

Figure 3. LCD 16X2

2.4 18650 battery

18650 battery in Figure 4 is a rechargeable lithium-ion battery. These batteries have a nominal voltage of 3.6–3.7 volts and capacities ranging from 1500–3600 mAh. 18650 lithium batteries are a popular type of battery and are frequently used in various electronic applications, including mobile devices, laptops, flashlights, vaping devices, solar power devices, portable electronic devices, and many more.

Figure 4. 18650 battery

2.5 LM2596 Stepdown Module

The LM2596 DC step-down module in Figure 5 is a module that functions as a step-down switching converter with a 3A current rating. The main function of this component is to help reduce voltage to a lower voltage. There are several variants of this IC series, namely an adjustable version where the output voltage can be adjusted and a fixed voltage output version where the output voltage is fixed.

Figure 5. LM2596 Stepdown Module

2.6 Solenoid Door Lock

A solenoid door lock in Figure 6 is specifically designed for electronically locking doors. However, in general, a solenoid door lock is an electronic device that works on the principle of electromagnetism. A solenoid lock is basically a latch used to lock and unlock electrically.

Figure 6. Solenoid Door Lock

2.7 Breadboard

A breadboard in Figure 7 is a board used to design a simple electronic circuit. The breadboard will later be used for prototyping or testing without having to solder. Generally, breadboards are made of plastic and have various holes. These holes are pre-arranged to form a pattern based on the internal network pattern. In addition, breadboards that can be found on the market are generally divided into 3 sizes. The first is called a mini breadboard, the second is called a medium breadboard, and the last is called a large breadboard. [1] A mini breadboard has approximately 170 points.

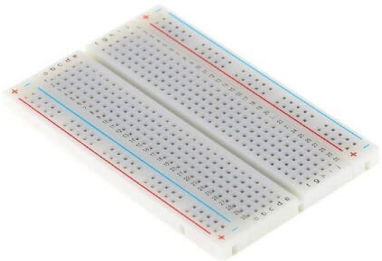

Figure 7. Breadboard

2.8 Relay

The first relay was invented by Joseph Henry in 1835. A relay in Figure 8 is an electrically operated switch and is an electromechanical component that has two main parts: an electromagnet (coil) and a mechanical (switch contacts). The principle used by a relay is electromagnetism, which is used to move the switch contacts so that a small (low power) electric current will conduct a higher voltage electric current.

Figure 8. Relay

2.9 Buzzer

A buzzer in Figure 9 is a part of electronics used to convert electrical energy into vibration or sound. A buzzer has a working principle exactly like a loudspeaker. The working process of a buzzer includes waves on the diaphragm and an electric current flowing through it, which is commonly called an electromagnet. These waves will be pulled outward or inward, depending on the polarity of the magnet and the direction of the current, so random wave movements will occur, causing the air to vibrate and produce sound.

Figure 9. Buzzer

In conducting the research, the author developed stages to achieve the research objectives. The research stages arranged in this research can be seen in the form of a flowchart in Figure 10 below.

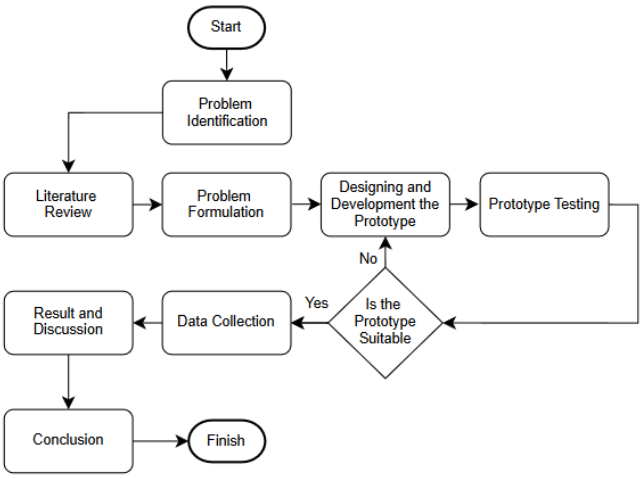

Figure 10. Research and Development (RnD) Method

This research uses the Research and Development (R&D) method to develop an Android-based paper money monitoring system for piggy banks. The initial stage includes problem identification and formulation of system objectives, namely to monitor the amount of paper money accurately and efficiently. A literature study was conducted to gather information about the use of the TCS3200 color sensor, the NodeMCU ESP8266 as the main controller, and data communication through the Android application. Testing was carried out on components such as the TCS3200 sensor to detect the RGB values of banknotes, the buzzer as an indicator, and the 16x2 LCD to display money amount information. Data was collected by observing the system's accuracy in detecting banknote denominations and recording the results in the Android application.

3. RESULTS AND DISCUSSION

3.1 Block Diagram

To facilitate understanding of the design of this device, the researchers created a system block diagram to illustrate the input and output processing of the hardware and software design that the researchers will develop. Figure 11 is the system block diagram.

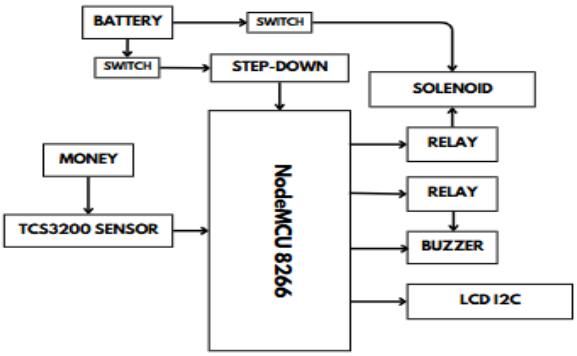

Figure 11. System Block Diagram

3.2 Flowchart

A flowchart or flow diagram is a diagram used to understand the flow of processes that will be executed by a system given by Figure 12.

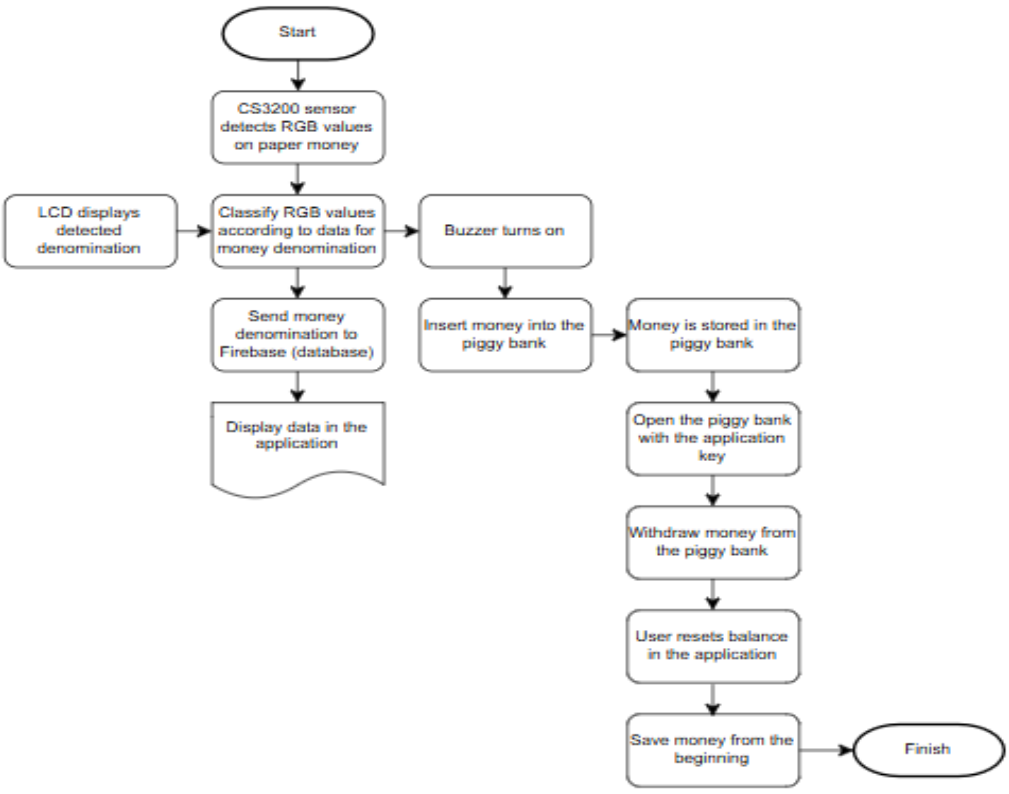

Figure 12. System Flowchart

The TCS3200 sensor detects RGB values on the banknotes. These RGB values are then classified according to predetermined data to determine the banknote denomination. After the denomination is identified, the system displays the banknote value on the LCD.

In addition, the banknote value is sent to Firebase (database), and the data is displayed on the Android application. A buzzer also sounds as an indication that money has been detected, and the user can insert the money into the piggy bank. After the money is inserted, the piggy bank physically stores it.

When users want to withdraw money, they can open the piggy bank using a key available on the Android application. After the piggy bank is opened, users manually take the money from the piggy bank. After that, users reset the balance on the application to clear previous savings data and start the saving process from the beginning. The system returns to its initial state, ready to receive new money.

3.3 Design Scheme

After the system block diagram was created, the next step was to create an overall design of the device to determine how the device would be built according to the desired specifications. The overall design scheme of the device can be seen in the figure below.

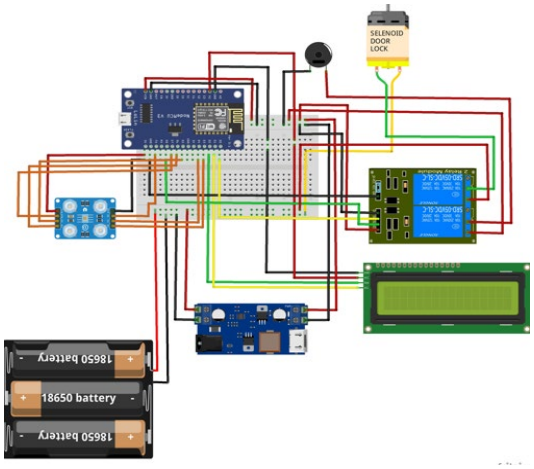

Figure 13. Design Scheme

3.4 Data Collection

A. TCS3200 Color Sensor Data Collection

This data collection is done to obtain the RGB (red, green, blue) value of each money by testing various possibilities and conducting repeated tests to ensure the sensor functions properly and as desired. Table 1 is the result of the tests that have been carried out.

Table 1. TCS3200 Sensor Data Collection

Scenario	Frequency RGB Value			Desired Result	Results	Success Rate
	R	G	B			
Inserting Rp.5000	16-18	28-30	30-32	Detected Rp.5000	Detected Rp.5000 and Rp.100,000	90% Success

Inserting Rp.10,000	13-15	16-18	12-14	Detected Rp.10,000	Detected Rp.10,000	100% Success
Inserting Rp.20,000	15-17	15-17	17-19	Detected Rp.20,000	Detected Rp.20,000	100% Success
Inserting Rp.50,000	17-19	15-17	11-13	Detected Rp.50,000	Detected Rp.50,000	100% Success
Inserting Rp.100,000	11-13	19-21	17-19	Detected IDR 100,000	Detected IDR 100,000	100% Success

B. Tool and Application Testing

This test is carried out to determine the RGB (*red, green, blue*) color value of each money by trying all the possibilities repeatedly. To ensure the sensor works properly and as desired, Tabel 2 is the tests that have been carried out.

Table 2. Overall Testing

No.	Scenario	The Expected Results	Test Results	Status
1	User *logs* into the application by entering email and password	User successfully logs in and enters the main page of the application	User successfully logs in and enters the main page of the application	Successful
2	RGB value of money successfully detected TCS3 200 sensor according to RGB data	LCD displays the amount of money, the amount of money sent and displayed on the application, buzzer	LCD displays money amount, money amount data money sent and Retrieved on	Successful
3	On view lock view contains the status: locked	Door auto- locked piggy bank by solenoid door lock	Door piggy bank auto-locked by solenoid door lock	Successful
4	On view lock contains status: open	Door auto open piggy bank by solenoid door lock	Door piggy bank Auto open by solenoid door lock	Successful

3.5 Design Results

This tool uses the TCS3200 color sensor as a banknote nominal detector, the NodeMCU ESP8266 microcontroller as the main controller, and a 16x2 LCD as an *output* to display the detected banknote nominal information. Figure 4 is the prototype results.

Figure 14. Prototype Results

3.5 App Results

The app in Figure 15 is designed to make it easier for users to manage the banknote piggy bank with various features, such as displaying the amount of balance collected in *real-time*, recording and displaying savings history, resetting the balance to 0 for reuse, and controlling the opening and closing of the piggy bank through a connected solenoid. All these features provide convenience and efficiency in monitoring and managing savings.

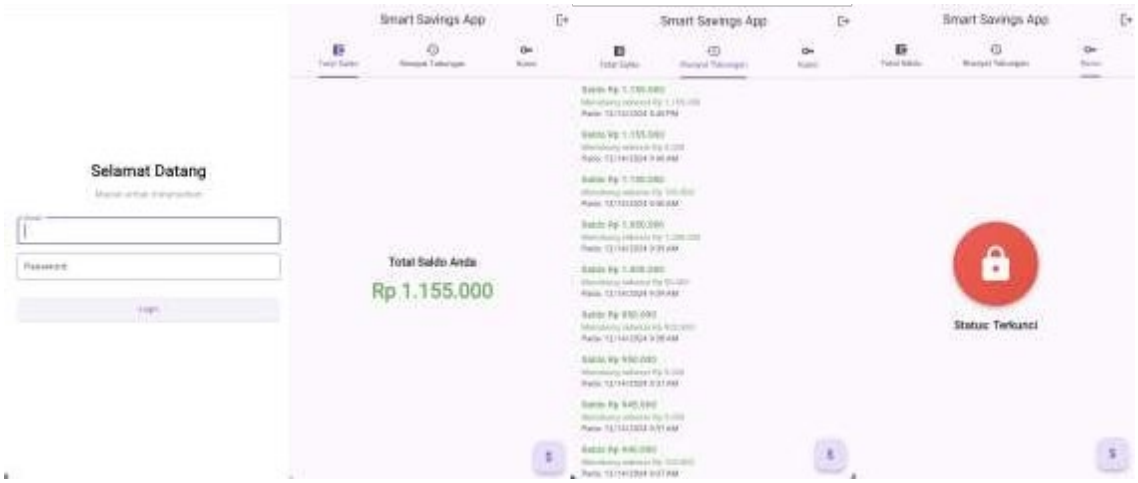

Figure 15. View of the 'Smart Savings' app

4. CONCLUSIONS

After completing the design and manufacture of the system and having tested it, it can be concluded that to design and build an android-based piggy bank monitoring is;

1. An Android-based banknote piggy bank designed with components such as TCS3200, NodeMCU ESP8266, buzzer, solenoid, relay, LCD, and Android application successfully developed as a modern solution to monitor the amount of banknotes collected accurately and efficiently.
2. With the integration of the Android app, users can monitor the total money accumulated in real-time without the need to manually open the piggy bank. Additionally, the ability to control the opening and closing of the piggy bank via the app adds a layer of convenience and security, eliminating the need for physical keys or other manual means.
3. The use of the TCS3200 color sensor enables the system to detect the face value of banknotes based on RGB value readings, with a success rate of 98%.

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