# Development of Smart Charity Box Monitoring Robot in Mosque with Internet of Things and Firebase using Raspberry Pi

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***ABSTRACT***

Mosques are the center of the spiritual and communal life of Muslim communities, thus requiring effective financial management. This study aimed to develop a smart donation box robot that utilizes Internet of Things technology to address efficiency and increase transparency in managing donations. The research methodology used a prototyping method consisting of Rapid Planning, Rapid Modeling, Construction, and Evaluation stages, aimed at developing a functional prototype quickly. The results of this study showed that the smart donation box robot detected and counted banknotes with varying degrees of success, achieving a detection success rate of 100% for all tested denominations at an optimal sensor distance of 1 cm. However, the detection rate dropped to 42.86% at 0.5 cm and 28.57% at 1.5 cm, highlighting the significant impact of sensor placement on performance. Coin detection was performed accurately, correctly identifying and sorting denominations without error. This enabled real-time financial monitoring via the Telegram application, significantly increasing transparency for mosque administrators and congregants. The conclusion of this study confirms that IoT technology can substantially improve mosque donation management by automating the collection process and providing real-time transparency. However, further adjustments are needed to optimize the sensitivity and placement of the sensors.



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## 1. INTRODUCTION

Mosques have a very vital role in the lives of Muslims. Mosques can also be a place of worship for Muslims and can have a positive impact on the surrounding community, such as being a center of education and social activities and organizing other community activities. Since the beginning of the development of Islam, the Prophet Muhammad Saw. emphasized that the function and fulfillment of social needs must be considered rather than the aesthetics of the mosque building. Therefore, mosques have enormous potential to improve the welfare of the people and communities around them if managed properly. However, mosques need a lot of funds to carry out community functions optimally. The development of a mosque is usually supported through donations, infaq, alms, waqf, and zakat issued by the surrounding community [1]. These funds can then be used for various mosque purposes such as mosque operations, maintenance and infrastructure development, and supporting various social and educational programs organized by the mosque takmir [2]. Therefore, fund management and collection are very important aspects of the continuity of mosque operations.

Infaq and alms are the main sources of funding for mosques. This can be proven through research conducted by Yuningsih on the Great Pelita Mosque [3]. This reinforces that no matter how small the size of the mosque and the number of worshippers, the biggest income a mosque can receive is through infaq and sadaqah. One of the most widely used methods of collecting infaq and alms is through charity boxes. Charity boxes can be in the form of donation boxes passed independently by the congregation during prayer activities or specifically placed in various strategic corners of the mosque area. Both types of conventional charity boxes can certainly help the congregation give infaq and alms. Based on observations made at 10 mosques around the Syarif Hidayatullah State Islamic University Jakarta campus, it was found that almost all mosques still use conventional charity boxes.

Conventional charity boxes have some fundamental flaws. First, after the funds from the congregation are collected, the mosque taker still has to sort the paper money and coins to get a tally of the income. This takes time and effort and is prone to human error. Second, there is a lack of transparency in managing the collected funds. Lack of access to data on the amount of donations collected can lead to distrust among donors, negatively impacting the amount of donations received. To overcome these problems, the application of modern technology, such as robotics and the Internet of Things (IoT), is a potential solution, especially in the religious field [4]. Coupled with the concept of integration between science and religion, it has become a hot topic that is being discussed by Muslims around the world, including in Indonesia. Robotic technology enables the automation of various processes that were previously done manually [5, 6]. According to Oxford Dictionaries, the Internet of Things or IoT is a network of everyday devices, work equipment, and other objects equipped with computer chips and sensors that can collect and transmit data over the internet [7–9]. From this definition, IoT technology allows devices to connect and communicate with each other via the internet network to provide the ability to exchange data via the internet and be able to conduct real-time monitoring anywhere and anytime as long as it is connected to the internet [10, 11]. One of the implementations of IoT technology is through the use of Raspberry Pi microcontrollers and IoT platforms [12].

Raspberry Pi is a microcontroller that has high computational capabilities [9, 13]. This microcontroller can be integrated with various sensors and communication modules so that it can be used to develop various robotic systems, depending on the sensors and technology used. For the Raspberry Pi microcontroller to be monitored remotely, an IoT platform is needed that can be a bridge between the user and the robotic system via an internet connection. One of the IoT platforms that is freely available and easy to use is the Telegram Bot. Telegram Bot is one of the features in the Telegram application that allows real-time control and monitoring of devices. With Telegram Bot, data collected by sensors can be accessed in real-time, thus enabling transparent and efficient monitoring [14]. This research also uses Firebase technology to store sensor data from Raspberry Pi. Firebase is a cloud platform that provides easily accessible data storage [15]. Using Firebase and Telegram technology, data collected from charity boxes can be stored and accessed in real-time by several mosque congregations simultaneously, increasing transparency and providing donors and mosque managers with access to monitor the number of donations collected.

In conducting a literature search, the author found various studies that developed a money detection and counting system for smart charity boxes. Safiq Rosad et al in 2023 [16] used the RGB method based on Android applications with TCS34725 sensors and NodeMCU ESP8266 to detect the paper money nominal, but this tool has difficulty in detecting money with nominal Rp 1000 and Rp 5000. Ivan et al., 2022 [17] developed an Arduino-based charity box with a TCS color sensor, but this tool cannot count coins and is not integrated with IoT technology. Muhammad Alfaraz et al., 2022 [18] designed a paper money detection tool for the visually impaired using Arduino Uno and TCS 3200 color sensor, but it does not support coin counting and real-time monitoring. Athallah et al. 2021 [19] built an ESP8266-based smart charity box capable of detecting paper money and coins, but not integrated with IoT. Finally, Amal, in 2020 [20] We developed an ESP32-based smart charity box with the working principle of a human-following robot. However, it does not support coin-counting or real-time monitoring. All of these studies show potential but still require further development to meet the needs of a complete and integrated smart charity box.

Although various studies have been conducted to develop smart charity boxes, some shortcomings remain. First, not all of the above research uses IoT technology, which causes the congregation to be unable to monitor the amount of donations to the charity box in real-time from anywhere. Secondly, although some studies successfully detect two types of money, namely coins and paper, the method used is still not practical because it requires two different holes for each type of money. This method is less efficient and makes it difficult for worshippers who want to give alms. The development of an effective smart charity box will inevitably be confronted with a number of challenges. Firstly, it is necessary to determine how the smart charity box will detect and differentiate the amount of money entering the box. The selection of an appropriate sensor and the design of the charity box are key factors in answering this question. Secondly, it is important to identify the most suitable Internet of Things (IoT) platform for developing smart charity boxes. The chosen IoT platform must be easily accessible to the congregation to ensure transparency regarding the mosque's financial income from infaq and alms.

By considering several related literature reviews, novelty factors, and challenges to be faced, this research develops a smart charity box equipped with a monitoring and automation system based on Raspberry Pi and Telegram Bot. This charity box can select coins and paper money that enter through one hole and count the amount of money that enters automatically. The application of IoT technology here uses Firebase to store data on the amount of money sent from the Raspberry Pi, which all congregations can then access via the Telegram bot. The system has several main components, including color and infrared sensors. The TCS 37425 color sensor distinguishes the type of paper money put into the charity box. This sensor can recognize different colors of paper money and classify them [21], making it easier to count and report the amount of donations collected. In addition, the infrared sensor functions to detect coins that are put into the charity box [22]. With this sensor, the system can distinguish between paper money and coins, and record every infaq fund that enters the charity box.

The development of smart charity boxes is expected to overcome various problems conventional charity box systems face. The proposed system offers better transparency by allowing donors and managers to monitor the amount of donations in real-time. In addition, the process of collecting and counting money becomes more efficient and accurate. Smart charity boxes can be a more secure, transparent, and efficient solution for collecting and managing charity funds. Thus, this research aims to make a real contribution to improving fund management in mosques through modern technology.

## 2. RESEARCH METHOD

This research adopts a mixed-methods approach, blending qualitative and quantitative research methodologies to analyze the topic comprehensively. The qualitative aspect involves an exploratory literature review to understand the theoretical frameworks and prior studies related to the subject. Quantitatively, the research employs statistical analysis to measure the effectiveness and user interaction with the smart charity boxes. This hybrid approach thoroughly explores the research question, offering insights from both empirical data and theoretical perspectives. By integrating these methods, the research aims to achieve a balanced view, enhancing the reliability and validity of the results.

### 2.1. Data Collection Methods

The data collection for this research involves two primary methods to gather relevant information. Firstly, a thorough literature study is conducted to identify references pertinent to the research topic. This process involves searching for and accessing various sources online, including e-books, journals, articles, and websites. Once these references are identified, the next step involves carefully selecting the relevant and necessary information for this study's context.

Secondly, the research incorporates direct observation, focusing on the process of receiving infaq and alms in charity boxes currently in use at mosques around the Syarif Hidayatullah State Islamic University Jakarta. This method allows for an up-close examination of the existing practices and aids in understanding the real-world application of the studied concepts. Together, these methods form a comprehensive approach to data collection, ensuring a robust foundation for the research findings.

### 2.2. Development Methods

In developing this tool, the author uses the prototyping method as a framework for implementing the Internet of Things-based smart charity box. According to the Cambridge Dictionary, a Prototype is the first example of something, such as a machine or other industrial product, from which further forms will be developed. According to Pressman [23], the Prototyping Method is a Methodology or paradigm that can help developers and stakeholders to understand better what to build when the requirements are still unclear, and the efficiency of the algorithms used is still in doubt [23]. This prototyping method was chosen because developers need to develop faster, more efficient tools to communicate effectively between developers and users. In accordance with the prototyping paradigm, this method has 5 main steps, shown in Figure 1, each of which contributes to the project's overall success.

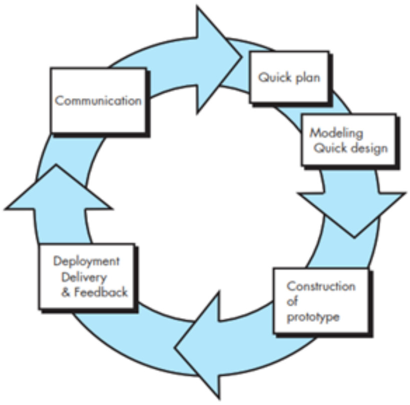


Figure 1. Prototype Method Flow

The development of the smart charity box system was meticulously structured into several key stages, ensuring that the final product effectively met the needs of its users. The process began with the Communication stage, where the authors engaged with several active users, including charity officers and community members. The primary goal of this stage was to ascertain the specific needs of the users in their charitable activities, which would then inform the design of the smart charity box system intended to simplify the donation process. Following these insights, the Quick Planning stage was initiated. At this stage, the authors analyze and formulate the requirements needed to develop the smart charity box based on interviews conducted in the previous stage to determine the general overview of how the smart charity box works, along with the necessary sensors and the appropriate IoT platform. In the Quick Modeling stage, the authors begin designing a simple prototype by creating a block diagram of the smart charity box system, which generally illustrates how the system is connected. Subsequently, the authors start designing the circuit design of the smart charity box system. This will help the authors in the construction process of the smart charity box.

In the construction stage, the authors continued to develop the model by creating the features designed at the Quick Modelling stage. The authors begin to design and build robots that can perform functions following the initial concept. The process starts with designing the schematic design of the smart charity box system and ends with the process of making a smart charity box prototype using Raspberry Pi 3 as the main microcontroller. After that, the construction process continues by configuring Firebase, which will be used to store data sent from the Raspberry Pi 3, and Telegram Bot, which is made to retrieve the data so that the congregation can see the amount of donations in real-time. In the Evaluation stage, testing assessed the prototype's ability to perform predetermined functions, such as sorting paper money and coins, performing real-time counting, and sending data to be displayed on Telegram Bot. Active users were also involved in this testing phase to provide feedback on the designed system prototype to ensure it meets user needs and functions as intended. This comprehensive approach ensures the system is effective and user-friendly, ready for real-world use.

## 3. RESULT AND ANALYSIS

### 3.1. Planning

At this stage, the author collects data using various methods such as observation, literature study, and literature study. Discussions were held with users such as mosque officers and worshippers. The goal is to understand the needs of the system. The requirement gathering stage describes the system requirements, including scope, analysis of hardware and software requirements, and analysis of the proposed system. The scope of the research is a charity box at the mosque, focusing on developing a smart robot that can select incoming coins and paper money and automatically count the amount of money in it. Users such as mosque takers and worshippers can view information on the amount of money in the charity box via the Telegram Bot. Specific hardware is required for the "Smart Charity Box" robot, and the selection of the specifications is very important for the system to function properly. Table 11 shows the hardware used to develop the smart charity box robot.

Table 1. Hardware List

| No. | Component | Quantity | Function |
|---|---|---|---|
| 1 | Raspberry Pi 3 | 1 | Serves as the brain of a smart charity box robot that can process data and manage operations on the robot. |
| 2 | TCS37425 color sensor | 1 | To detect the color of paper money entering the charity box |
| 3 | Infrared Sensor | 2 | To detect coins entering the charity box |

Based on the observations that have been made, the current system can be described by Figure 2.

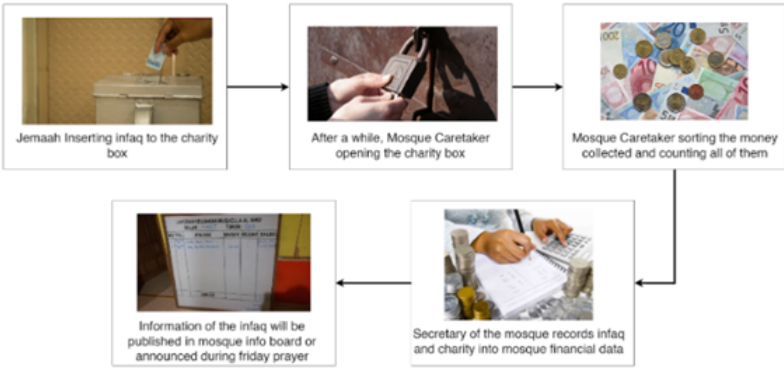


Figure 2. Analysis of the current system

Based on the picture above, the mosque taker must take the contents of the charity box to be counted within a certain period manually, which is prone to human error, and the congregation can only see information on the amount of money in the charity box within a certain period, making it less efficient. In this research, it is concluded that no system allows automatic counting of the contents of charity boxes, which can be seen in real-time. So, this smart charity box robot is designed to help mosque takers calculate the results of donations and mosque congregations to be able to see the results of donations at any time. The proposed system is shown in Figure 3.

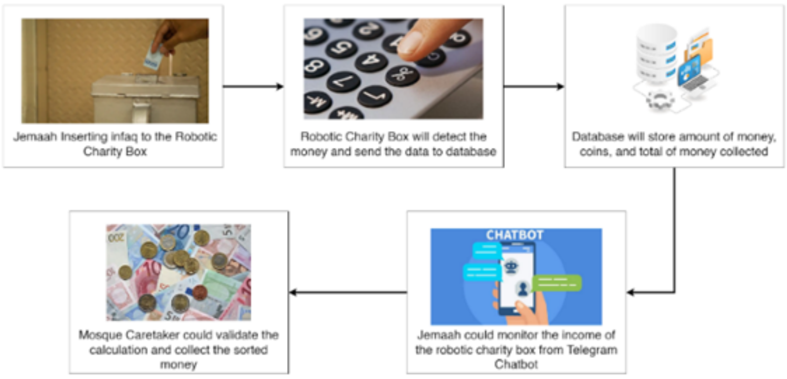


Figure 3. Proposed system

### 3.2. Modeling

At the modeling stage, a scenario for the architectural design of the robot is created, where the hardware components are integrated into a unified system, as shown in Figure 4. This arrangement allows the components to be assembled and programmed at a later stage. All sensors needed in the smart charity box robot, namely the passive infrared sensor and the color sensor, will be connected directly to the Raspberry Pi 3, and the computation process will run on the microcontroller. The computation result will determine how much money goes into the charity box. Then, after the nominal money entered is successfully detected and determined by the system, the Raspberry Pi will update the total fund data stored in Firebase by adding the nominal data that has just been detected. To connect the Raspberry Pi with Firebase, we use the Firebase Admin SDK library, which allows server-side access to Firebase services such as Firestore, Firebase Realtime Database, Firebase Storage, and others. Then, users can monitor the amount of charity box income in real time anytime and anywhere through Telegram Bot. We use BotFather to create a telegram bot that can be customized according to research needs.After creating the robot architecture design, we created a design for the circuit. The circuit design in Figure 5 shows the schematic structure of the Raspberry Pi 3 and all the components used in the smart charity box robot.Each component is connected to the Raspberry Pi 3 as the brain of the smart charity box robot; we summarize the pin configuration between the Raspberry Pi 3 and the other components in Table 2.

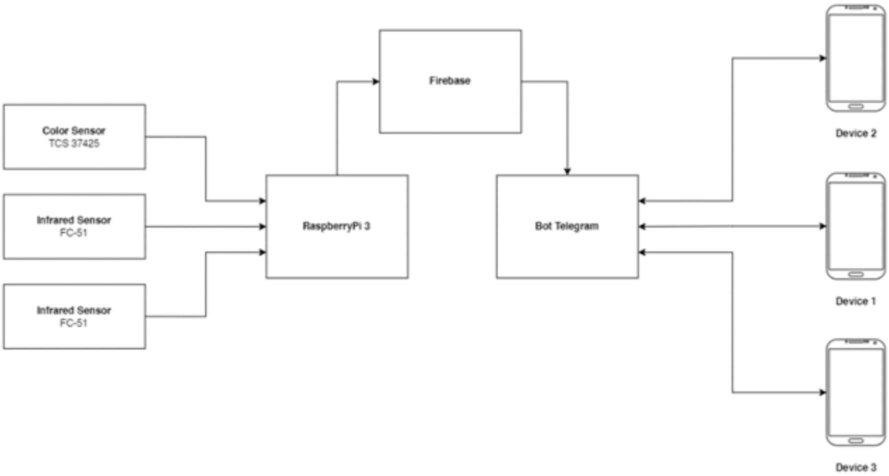


Figure 4. Block diagram of smart charity box system

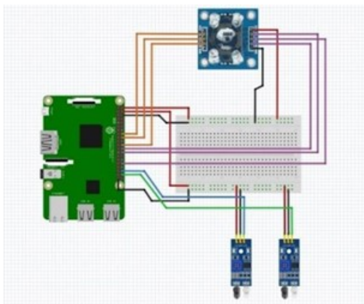

Figure 5. Circuit design of smart charity box system

Table 2. Smart Charity Box System Pinout Configuration

| Component | Component Pin | Pin Raspberry Pi 3 |
|---|---|---|
| RGB Color Sensor TCS 37425 | Vin | 5V |
| | GND | GND |
| | SDA | Pin 2 |
| | SCL | Pin 3 |
| Infrared 1 | VCC | 5V |
| | GND | GND |
| | OUT | Pin 17 |
| Infrared 2 | VCC | 5V |
| | GND | GND |
| | OUT | Pin 27 |

### 3.3. Construction

At the construction stage, the smart charity box robot defined from the block diagram and circuit design will be realized at the smart charity box blueprint design stage. This blueprint allows the reader to know the physical description of the built smart charity box robot. The paper money detection circuit is made, as shown in Figure 6. Between the partition separating coins and paper money, a Raspberry Pi will be placed as the engine for calculating and sending data to Firebase. Then, a color scanner sensor is placed near the hole to insert paper money into the smart charity box robot. When the congregation puts the paper money into the charity box, the color sensor will scan the RGB value on the paper money and send the value to the Raspberry Pi. The Raspberry Pi will match the RGB value received by the sensor with what has been written in the program, and then the nominal value of the money can be determined. After the nominal value of the money is determined, the Raspberry Pi will send the nominal data to Firebase to update the smart charity box robot's total infaq and alms income.

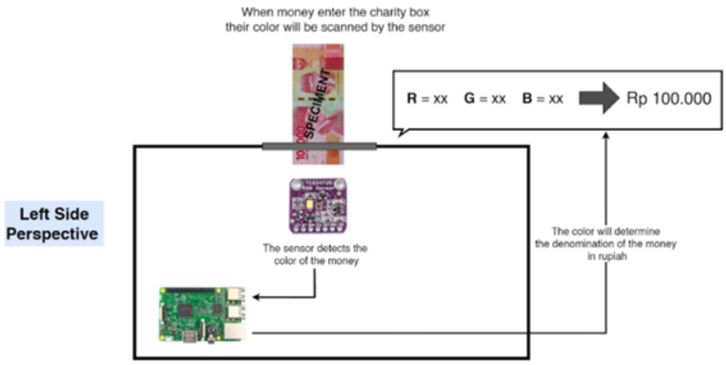


Figure 6. Paper money detector design

For the coin selector, the circuit is made, as shown in Figure 7. In the smart charity box robot, pilgrims can only insert coins nominal Rp 1,000 and Rp 500. When pilgrims insert coins into the slot on the charity box, the coins will move down the rail that has been designed until the coins fall into the special holes that have been measured. The first hole is for coins with a smaller diameter of Rp 1,000, and the second hole is for coins with a larger diameter of Rp 500. When the coins enter the hole, the infrared sensor will detect the coins falling into the hole so that the system can immediately determine the nominal value of the coins. The Raspberry Pi will send the nominal data to Firebase to update the total alms income of the smart charity box robot.

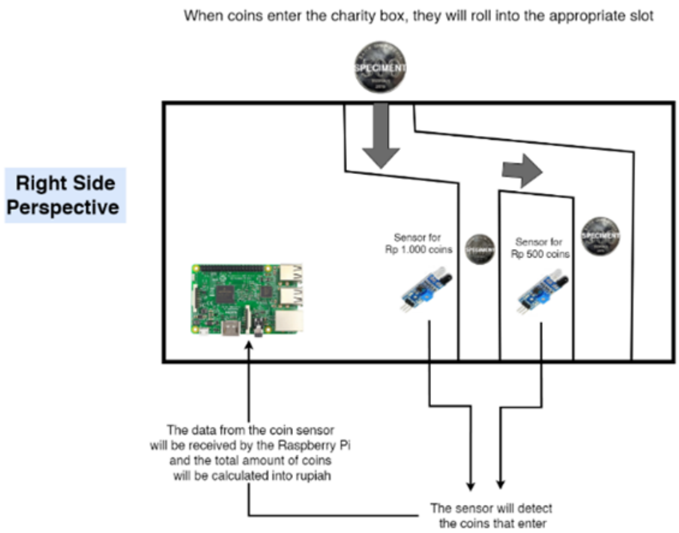


Figure 7. Coin detector design

Figure 8 shows the final design of the charity box. When paper money is inserted, the color sensor will detect the color of the money and add the data to the firebase. As for coins, when the money is inserted, the money will go through a mechanism with two holes; the first hole is made smaller with a diameter of 25mm, which is intended for 1000 coins so that larger coins will not enter through that hole. The second hole is 28mm in diameter and is intended for larger 500 coins. Near the two holes are two different infrared sensors that will detect each passing coin. The power source for the Raspberry Pi is obtained from an electrical outlet inside the mosque.

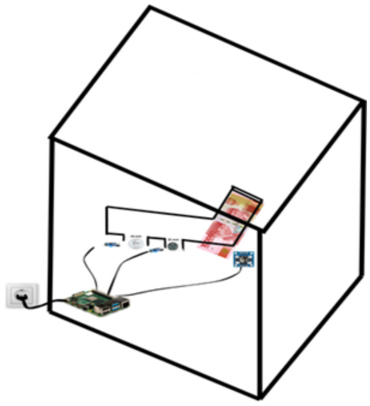

Figure 8. Charity Box Final Design

### 3.4. Evaluation

The last step of the prototype method, evaluation, aims to measure how efficient the robot system being developed is. In this research, several stages of testing were carried out. First, functional testing is carried out to test whether the features made are following their functions with our design. A user acceptance test is also carried out to determine whether the system meets users' requirements. To measure the success rate of the smart charity box robot, a color sensor detection test was conducted to determine the nominal value of money and a money rail test to select the appropriate money. The color sensor was functionally tested with three different distances to measure the optimal distance of the sensor. Details of the tests are shown in Table 3.

Table 3. Functional Testing of The Robot for Paper Money

| No. | Amount | Product Test | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | | 2 | | | 3 | | |
| | | Distance (Cm) | Y | N | Distance (Cm) | Y | N | Distance (Cm) | Y | N |
| 1 |  | 0.5 | √ | - | 1 | √ | - | 1.5 | - | √ |
| 2 |  | | √ | - | | √ | - | | - | √ |
| 3 |  | | √ | - | | √ | - | | √ | - |
| 4 |  | | - | √ | | √ | - | | - | √ |
| 5 |  | | - | √ | | √ | - | | √ | - |
| 6 |  | | - | √ | | √ | - | | - | √ |
| 7 |  | | - | √ | | √ | - | | - | √ |

Based on the results of testing seven consecutive denominations of paper money, ranging from Rp100,000 to Rp1,000, data was obtained on the detection effectiveness of three products with different measurement distances. In the first product test with a measurement distance of 0.5 cm, only 3 paper money were successfully detected, while the other 4 paper money was not detected, resulting in a success rate of 42.86%. In the second product test with a measurement distance of 1 cm, all 7 bills were successfully detected, achieving a success rate of 100%. In the third product test with a measurement distance of 1.5 cm, only 2 notes were successfully detected, and 5 notes were not detected, with a success rate of 28.57%. From these results, it can be concluded that testing the second product with a measurement distance of 1 cm was the best, with a 100% success rate, compared to the first and third products which had lower success rates at both measurement distances tested (42.86% at a distance of 0.5 cm and 28.57% at a distance of 1.5 cm).

Functional testing was also conducted on coin detection as shown in Table 4.

Table 4. Functional Testing of The Robot for Coins

| No. | Amount | Product Test | | | |
|---|---|---|---|---|---|
| | | Y | N | Hole | |
| | | | | 1 | 2 |
| 1 |  | √ | - | √ | - |
| 2 |  | √ | - | - | √ |

Based on the results of testing two denominations of coins, namely Rp1,000 and Rp500 denominations, which were tested consecutively, data on the effectiveness of the coins selector system were obtained. The test was carried out with two money selection holes, with hole 1 reserved for coins of denomination Rp1,000 and hole 2 for coins of denomination Rp500. The results showed that the coins of denomination Rp1,000 successfully entered hole 1 and did not enter hole 2, while the coins of denomination Rp500 successfully entered hole 2 and did not enter hole 1. This test concludes that the coins selection system works well and accurately detects and selects coins according to their denomination. The coins of Rp1,000 and Rp500 were successfully directed to the appropriate holes, indicating that the system in the smart charity box has a high level of accuracy in selecting coins based on their denomination.

In addition to functional testing, researchers also conducted user acceptance tests to validate that the robot is in accordance with the user's needs, the details of which are shown in Table 5. Based on the results of testing five users, data was obtained on the effectiveness of the coins detection system. In this test, each user randomly inserted coins and paper money into the smart charity box for testing. Of the total samples tested, the system detected 5 coins and 16 paper money correctly, indicating a significant success rate. However, one Rp5,000 note, one Rp1,000 note, and 2 Rp500 coins were not detected correctly, representing a 16% failure rate in the testing process. These results show that although the system has a high success rate, improvements are still needed to achieve more optimal accuracy, including using more up-to-date sensors that can read objects with graded colors.

Table 5. User Acceptance Test

| No. | Amount | User Acceptance Test | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | | | | 2 | | | | | 3 | | | | | 4 | | | | | 5 | | | | |
| | | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 | 1 | 2 | 3 | 4 | 5 |
| 1 |  | | | | | | | | | | | √ | | | | | | | | | | | | | | |
| 2 |  | | | | | | | | | | | | | | | | | | | √ | | | | | | |
| 3 |  | | √ | | | | | | | | | | | √ | | | | | | | | | | | | |
| 4 |  | | | | | | | √ | | | | | | | | | | √ | | | | | | | √ | |
| 5 |  | | | √ | | χ | | | | √ | | | √ | | | | | | | | | | | | | |
| 6 |  | | | | | | √ | | √ | | | | | | √ | | √ | | | | | | | | | √ |
| 7 |  | √ | | | | | | | | | | | | | | | | | | | | χ | | | | |
| 8 |  | | | | | | | | | | √ | | | | | | | | √ | | | | | √ | | |
| 9 |  | | | | χ | | | | | | | | | | | √ | | | | | χ | | √ | | | |

Testing was also carried out on the IoT platform used, namely the telegram bot. In the bot created, there are 7 commands that users can send to see the amount of money collected in the charity box. In this test, there are 2 charity boxes and commands to see the number of coins, paper money, and total money in each charity box. There is also a command to see the total money collected from the two charity boxes. After testing, all commands on the smart charity box bot can provide accurate results and match the contents of the charity box shown in Table 6. This test is shown in Figure 9.

Table 6. IoT Test Results

| No. | Amount | Final Test of Smart Charity Box | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | | | | | 2 | | | | |
| | | Y | N | Qty | Count | Interaction on Telegram | Y | N | Qty | Count | Interaction on Telegram |
| 1 |  | - | - | - | | | - | - | - | | |
| 2 |  | - | - | - | | | √ | | 1 | | |
| 3 |  | √ | - | 2 | | | - | - | - | | |
| 4 |  | √ | - | 1 | √ | √ | √ | - | 2 | √ | √ |
| 5 |  | √ | - | 2 | | | √ | - | 3 | | |
| 6 |  | √ | - | 6 | | | √ | - | 3 | | |
| 7 |  | √ | - | 3 | | | √ | - | 7 | | |
| 8 |  | √ | - | 9 | | | √ | - | 5 | | |
| 9 |  | √ | - | 4 | | | √ | - | 20 | | |
| Results | | Rp86.000 | | | | | Rp113.000 | | | | |
| Final Result | | Rp199.000 | | | | | | | | | |

The user acceptance test results indicate that out of 25 trials conducted, there were 4 failures, meaning the failure rate of the smart charity box is 16%. Additionally, the failure rate of the smart charity box in detecting the difference between banknotes and coins is 1:1. This issue might occur due to the similarity in color between the Rp 1000 and Rp 5000 paper money, which sometimes causes the sensor to misinterpret the denomination of the paper money. Furthermore, the Rp 500 coin often gets stuck in the Rp 1000 coin slot, causing the system to fail to detect the inserted coin.

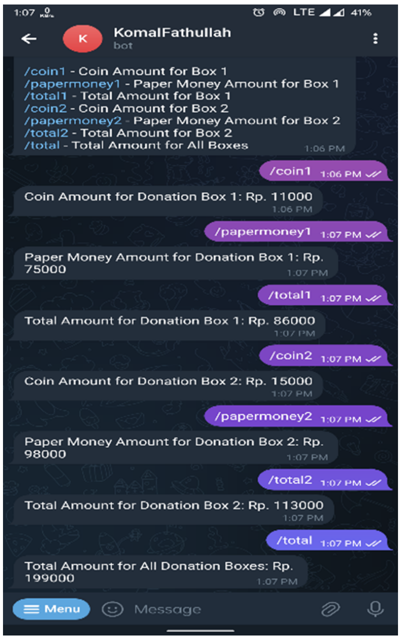


Figure 9. Telegram Bot Monitoring View

The view displayed in Figure 9 shows the Telegram Bot interface used in our smart charity box system, providing congregants with real-time monitoring capabilities. This interface lets users access detailed information about donations collected in the charity box directly on their smartphones. Through simple Telegram commands, users can request and receive updates about the amount of coins, paper money, and total funds collected, enhancing transparency and engagement. Integrating Firebase for data storage, this IoT-based system marks a significant enhancement over traditional methods by allowing congregants to actively participate in and verify the transparency of the donation management process.

## 4. CONCLUSION

The Smart Charity Box Robot developed in this research successfully automates the detection and recognition of currency denominations while providing real-time transparency for mosque donations. The system accurately identifies and sorts coins and banknotes using an RGB color sensor and infrared sensors. Data is processed by the Raspberry Pi and stored in Firebase, allowing users to monitor donations through a Telegram bot. The color sensor test found that the optimal distance for the sensor was 1 cm, where all paper money denominations were successfully detected with a 100% success rate. This test shows that adjusting the sensor distance is very important and directly impacts the effectiveness of paper money detection. Meanwhile, at distances of 0.5 cm and 1.5 cm, the sensor showed lower success rates of 42.86% and 28.57%, respectively. These results indicate that the sensor's sensitivity decreases at distances closer or farther than 1 cm. For the coins selection test, the system worked very effectively and accurately. The system successfully differentiated and directed the coins of Rp1,000 and Rp500 denominations to the appropriate holes without failure, demonstrating high accuracy and consistency in the operation of the selection system.

In addition, a user acceptance test was conducted to validate that the system meets the needs and expectations of the users. The test involved 5 users who randomly inserted coins and paper money. The results showed that the system successfully detected 16 paper money and 5 coins correctly. Still, there were several failures in detection, including one Rp5,000 note, one Rp1,000 note, and two Rp500 coins that were not detected correctly, resulting in a failure percentage of 16% in the testing process. In the IoT test, all commands from the Telegram bot successfully provided accurate information on the amount of money collected in the charity box, with the total money collected reaching Rp199,000. This shows that the smart charity box robot can work well. However, although the performance of this smart charity box is proven to be effective in detecting incoming infaq funds, the proposed system still has limitations. First, the paper money to be donated into the smart charity box can only be inserted and folded a maximum of 2 times with the white paper money not scanned by the color detection sensor. Secondly, the only coins that can be detected are coins with a nominal value of Rp 1,000 and Rp 500. Suppose a congregation inserts coins with a value lower than Rp 500. In that case, the coins will likely enter the hole of the Rp 1,000 coins, and the system will think that the congregation's money donated infaq of Rp 1,000 and will greatly affect the results of the calculation of the total infaq funds distributed. Third, this smart charity box robot system is intended for charity boxes that are not running because it requires a continuous source of electricity and a good internet connection to perform its functions optimally.

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## 6. DECLARATIONS

AUTHOR CONTIBUTION

The first author is responsible for designing the system architecture and overseeing the implementation. They also coordinated the technical development of the project. The second author provided supervision and offered guidance during the research process. They reviewed the methodology and ensured alignment with the research objectives. The third author contributed by giving advice on system optimization and the integration of components, ensuring the research outcomes were achieved.

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COMPETING INTEREST

The authors declare no competing interests in relation to this research. They affirm that no financial, personal, or professional conflicts influenced the outcomes or conclusions of the study. All stages of the research, from design to implementation, were conducted impartially and transparently. No external parties were involved in influencing the research direction or results. The authors remain committed to upholding the integrity and objectivity of their work.

## REFERENCES


[1] N. Marhayati, "The Dynamic of Infaq and Sadaqah: According to the Social Facilitation Theory," in *Proceedings of the Proceedings of the 1st International Conference on Religion and Mental Health, ICRMH 2019, 18 - 19 September 2019, Jakarta, Indonesia*. Jakarta, Indonesia: EAI, 2020, pp. 1–11, https://doi.org/10.4108/eai.18-9-2019.2293319. [Online]. Available: http://eudl.eu/doi/10.4108/eai.18-9-2019.2293319

[2] A. K. M. Julendra, N. H. Sholihah, and A. N. Zaida, "Determinan Praktik Pengembangan Infaq Sedekah Masjid di Indonesia (Studi Knowledge, Attitude and Practice)," *Asyafina Journal: Jurnal Akademi Pesantren*, vol. 1, no. 2, pp. 27–52, Jun. 2022, https://doi.org/10.2896/asyafina.v1i2.17. [Online]. Available: https://jurnal.asyafina.com/index.php/pesantren/article/view/17

[3] I. Yuningsih, A. M. Kamaruddin, and A. T. Pramono, "The Role of Takmir in Mosque Fund Management on Increasing Trust Community for Zakah, Infaq and Alms (Study on the Great Mosque of Pelita Samarinda)," *AFEBI Islamic Finance and Economic Review*, vol. 5, no. 02, p. 133, Jun. 2020, https://doi.org/10.47312/aifer.v5i02.450. [Online]. Available: https://journal.afebi.org/index.php/aifer/article/view/450

[4] L. K. Wardhani, N. Anggraini, N. Hakiem, M. T. Rosyadi, and A. Rois, "IoT-based Integrated System Portable Prayer Mat and DailyWorship Monitoring System," *MATRIK : Jurnal Manajemen, Teknik Informatika dan Rekayasa Komputer*, vol. 22, no. 3, pp. 639–650, Jul. 2023, https://doi.org/10.30812/matrik.v22i3.3058. [Online]. Available: https://journal.universitasbumigora.ac.id/index.php/matrik/article/view/3058

[5] D. O. Aghimien, C. O. Aigbavboa, A. E. Oke, and W. D. Thwala, "Mapping Out Research Focus for Robotics and Automation Research in Construction-Related Studies: A Bibliometric Approach," *Journal of Engineering, Design and Technology*, vol. 18, no. 5, pp. 1063–1079, Dec. 2019, https://doi.org/10.1108/JEDT-09-2019-0237. [Online]. Available: https://www.emerald.com/insight/content/doi/10.1108/JEDT-09-2019-0237/full/html

[6] P. Hofmann, C. Samp, and N. Urbach, "Robotic Process Automation," *Electronic Markets*, vol. 30, no. 1, pp. 99–106, Mar. 2020, https://doi.org/10.1007/s12525-019-00365-8. [Online]. Available: http://link.springer.com/10.1007/s12525-019-00365-8

[7] A. A. Laghari, K. Wu, R. A. Laghari, M. Ali, and A. A. Khan, "Retraction Note: A Review and State of Art of Internet of Things (IoT)," *Archives of Computational Methods in Engineering*, vol. 30, no. 8, pp. 5105–5105, Nov. 2023, https://doi.org/10.1007/s11831-023-09985-y. [Online]. Available: https://link.springer.com/10.1007/s11831-023-09985-y

[8] W. Kassab and K. A. Darabkh, "A–Z survey of Internet of Things: Architectures, protocols, applications, recent advances, future directions and recommendations," *Journal of Network and Computer Applications*, vol. 163, no. 11, pp. 1395–1413, Aug. 2020, https://doi.org/10.1016/j.jnca.2020.102663. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S1084804520301375

[9] L. K. Wardhani, C. B. Anggraini, N. Anggraini, N. Hakiem, I. M. Shofi, and T. Rosyadi, "Medicine Box Reminder for Patients with Chronic Disease with IoT-Based Database Monitoring," in *2021 9th International Conference on Cyber and IT Service Management (CITSM)*. Bengkulu, Indonesia: IEEE, Sep. 2021, pp. 1–7, https://doi.org/10.1109/CITSM52892.2021.9589015. [Online]. Available: https://ieeexplore.ieee.org/document/9589015/

[10] R. A. Radouan Ait Mouha, "Internet of Things (IoT)," *Journal of Data Analysis and Information Processing*, vol. 9, no. 2, pp. 77–101, 2021, https://doi.org/10.4236/jdaip.2021.92006. [Online]. Available: https://www.scirp.org/journal/doi.aspx?doi=10.4236/jdaip.2021.92006

[11] W. R. Pratama, B. Yulianti, and A. Sugiharto, "Prototipe Smart Parking Modular Berbasis Internet of Things," *Jurnal Teknologi Industri*, vol. 11, no. 2, pp. 434–443, Aug. 2022, https://doi.org/10.35968/jti.v11i2.954. [Online]. Available: https://journal.universitassuryadarma.ac.id/index.php/jti/article/view/954

[12] K. M. Hosny, A. Magdi, A. Salah, O. El-Komy, and N. A. Lashin, "Internet of Things Applications Using Raspberry-Pi: A Survey," *International Journal of Electrical and Computer Engineering (IJECE)*, vol. 13, no. 1, p. 902, Feb. 2023, https://doi.org/10.11591/ijece.v13i1.pp902-910. [Online]. Available: https://ijece.iaescore.com/index.php/IJECE/article/view/27879

[13] S. E. Mathe, A. C. Pamarthy, H. K. Kondaveeti, and S. Vappangi, "A Review on Raspberry Pi and its Robotic Applications," in *2022 2nd International Conference on Artificial Intelligence and Signal Processing (AISP)*. Vijayawada, India: IEEE, Feb. 2022, pp. 1–6, https://doi.org/10.1109/AISP53593.2022.9760590. [Online]. Available: https://ieeexplore.ieee.org/document/9760590/

[14] S. H. Al Furuqi, M. Abu Hafsin, and H. Haryono, "IoT-Based Remote Light Control System Using Bot Telegram Application (Case Study of SMP Al Washliyah Cirebon)," *Jurnal Teknik Informatika (Jutif)*, vol. 3, no. 6, pp. 1475–1482, Dec. 2022, https://doi.org/10.20884/1.jutif.2022.3.6.313. [Online]. Available: http://jutif.if.unsoed.ac.id/index.php/jurnal/article/view/313

[15] J. Mehariya, C. Gupta, N. Pai, S. Koul, and P. Gadakh, "Counting Students using OpenCV and Integration with Firebase for Classroom Allocation," in *2020 International Conference on Electronics and Sustainable Communication Systems (ICESC)*. Coimbatore, India: IEEE, Jul. 2020, pp. 624–629, https://doi.org/10.1109/ICESC48915.2020.9155825. [Online]. Available: https://ieeexplore.ieee.org/document/9155825/

[16] S. Rosad, M. R. A. Kamali, and H. Nuraini, "Deteksi Nilai Nominal Uang Kertas Menggunakan Metode RGB Pada Sistem Keuangan Masjid Berbasis Aplikasi Android," *Proceedings of the National Conference on Electrical Engineering, Informatics, Industrial Technology, and Creative Media*, vol. 3, no. 1, pp. 765–777, 2023, https://doi.org/10.26858/jmtik.v3i3.15172. [Online]. Available: https://conferences.ittelkom-pwt.ac.id/index.php/centive/article/view/130

[17] I. A. Syahruli, J. Prayudha, and M. Ramadhan, "Rancang Bangun Kotak Amal Penghitung Uang Otomatis Dengan Sensor TCS (Sensor Warna) Menggunakan Metode Counter," *Jurnal Sistem Komputer Triguna Dharma (JURSIK TGD)*, vol. 1, no. 5, pp. 168–178, Sep. 2022, https://doi.org/10.53513/jursik.v1i5.5692. [Online]. Available: http://ojs.trigunadharma.ac.id/index.php/jskom/article/view/5692

[18] M. Alfaraz and I. R. Jasril, "Rancang Bangun Alat Deteksi Nominal Uang Kertas Penyandang Tuna Netra Berbasis Arduino Uno," *Voteteknika (Vocational Teknik Elektronika dan Informatika)*, vol. 10, no. 1, pp. 28–37, Jun. 2022, https://doi.org/10.24036/voteteknika.v10i1.116455. [Online]. Available: http://ejournal.unp.ac.id/index.php/voteknika/article/view/116455

[19] D. A. Ramadhan, G. Firmansyah, and S. O. B. Agustien, "Kotak Amal Pintar Berbasis Internet of Things Dengan Metode Penghitungan Uang Secara Otomatis," *Jurnal Nasional Aplikasi Mekatronika, Otomasi dan Robot Industri (AMORI)*, vol. 2, no. 2, pp. 52–57, Jul. 2021.

[20] N. I. Qalbi, C. W. Purnama, N. I. Dwi, A. B. Kaswar, and J. M. Parenreng, "Rancang Bangun Kotak Amal Cerdas sebagai Solusi Ketidak Efisienan Pendistribusi Kotak Amal di Masjid," *Jurnal Media Elektrik*, vol. 17, no. 2, pp. 25–32, Jun. 2020, https://doi.org/10.59562/metrik.v17i2.14034. [Online]. Available: https://ojs.unm.ac.id/mediaelektrik/article/view/14034

[21] B. T. Syahputra, "Arduino-Based Anti-Theft System in Mosque Charity Box," *Brilliance: Research of Artificial Intelligence*, vol. 2, no. 3, pp. 81–85, Jun. 2022, https://doi.org/10.47709/brilliance.v2i3.1548. [Online]. Available: https://jurnal.itscience.org/index.php/brilliance/article/view/1548

[22] M. Javaid, A. Haleem, S. Rab, R. Pratap Singh, and R. Suman, "Sensors for daily life: A review," *Sensors International*, vol. 2, p. 100121, 2021, https://doi.org/10.1016/j.sintl.2021.100121. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S2666351121000425

[23] L. Kent, C. Snider, J. Gopsill, and B. Hicks, "Mixed reality in design prototyping: A systematic review," *Design Studies*, vol. 77, pp. 1–12, Nov. 2021, https://doi.org/10.1016/j.destud.2021.101046. [Online]. Available: https://linkinghub.elsevier.com/retrieve/pii/S0142694X21000570

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