Road-to-10K: Arduino-based Philippine Coin Sorting and Counting Bank

Reginald Geoffrey L. Bayeta IV
De La Salle University
Manila, Philippines
reginald_geoffrey_bayetaiv@dlsu.edu.ph

Matthew Edward S. Toro
De La Salle University
Manila, Philippines
matthew_toro@dlsu.edu.ph

Isaiah Jassen L. Tupal
De La Salle University
Manila, Philippines
isaiah_tupal@dlsu.edu.ph

***Abstract*— This paper presents the design and development of Road-to-10K, an Arduino-based Philippine coin sorting and counting bank. To separate the coin denomination of Php 1, 5, and 10, a paper ramp with holes that matches the sizes of each coin was used, and each hole comes with a TCRT5000 IR line sensor. The coin bank only accepts the New Generation Currency Coin Series instead of old ones as the new coins have varying diameters. The accuracy of sensing test results showed 0% percent error to all test in each denomination accepted by the machine. This study will serve as a guide for a modernized approach on the traditional way of saving money that is simple, but still practical. Furthermore, given that the project uses open-source platforms in the form of Arduino, the device can easily be made and further improved by its users.**

Keywords—Arduino Uno, Coin bank, TCRT5000, IR line sensors, saving

I. Introduction

Nowadays, lots of Filipinos still prefer to save in piggy banks instead of availing the services of financial institutions [1]. According to Ipsos, a multinational market research and consulting firm, the reasons for this include but not limited to Filipinos having no access to disposable funds as they need money in a daily basis, their belief of the unnecessity of having a bank account, and the lack of financial literacy in the Philippines [1]. It can be said that the concept of saving spare coins every day is already part of the Philippine culture. The current practice of having a piggy bank is either by saving all unsorted coins in a single moneybox or having multiple moneyboxes for each denomination. Both said approaches are inefficient as having unsorted coins will cause additional effort for sorting the coins whenever you need to get your extra funds, and having multiple moneyboxes is subject to human error as people are known to be poor at following instructions especially when there exists a better method or user interface in their minds [2].

In this paper, we present Road-to-10K, an Arduino-based Philippine coin sorting and counting bank that lets people save their spare coins and at the same time keeping track of it. The solution provided by this project is to have a single-coin slot as the user input, and it will be processed and sorted inside the machine and will have the coin count and total as the output. It presents a modernized approach on the traditional way of saving money, simple but still practical.

II. Arduino UNO And TCRT5000 IR Sensors

The use of Arduino Uno (Figure 1), an open-source electronics platform is already prevalent in different projects which topic ranges from everyday tools to complex scientific components. Although unlike existing microcontrollers and platforms available for tinkering such as Netmedia's BX-24, MIT's Handyboard, and Parallax' Basic Stamp, Arduino provides an edge than the aforementioned as it is inexpensive, cross-platform, user-friendly, and open-sourced [3]. From this, the device that this paper presents can easily be made and further improved by its users.

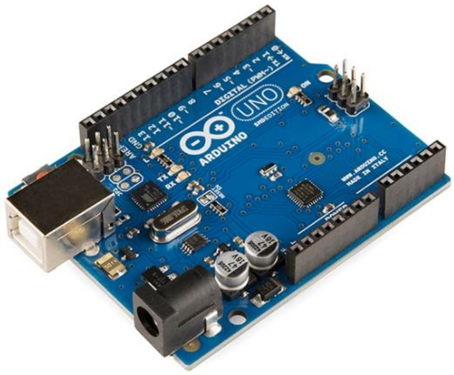

Fig. 1 Arduino Uno

The machine uses the IR line tracking sensors, TCRT5000, to detect the coin that is passing through it (Figure 2). It consists of an infrared LED, phototransistor, voltage comparator, and an adjustable potentiometer. The sensor works by transmitting infrared light from the LED and any light that is reflected on its phototransistor is being registered that change the current flow between its collector and emitter as maintained by the level of light that it gains.

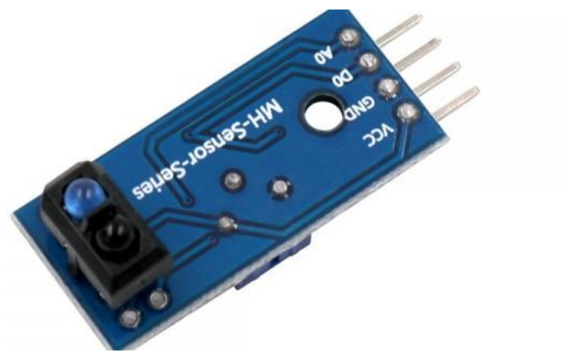

Fig. 2 TCRT5000 IR Line Tracking Sensors

The sensor has 4 pins: VCC, GND, D0 for digital output, and A0 for analog output. The working supply voltage going through the VCC and GND are either 3.3V or 5V. The sensor data is being handled by the D0 and A0 pins. For this project, D0 pin is used as the sensor will only determine if a coin passes through the sensor or not (LOW and HIGH). If not enough infrared light is detected, the output will be always HIGH (idle state), and when an object is detected, the output will be low. Common problems encountered when using this sensor follow that it can be easily affected by other factors such as other light sources, and stability issues. But these pose no problems for the machine as the sensors are free from other light source, and it has a fixed position inside the machine [4].

III. METHODOLOGY

A. *Philippine New Generation Coin Currency*

First, it should be noted the coin bank will only accept new Philippine Peso coins (Php 1,5, and 10) in order to carry out its functions. This is because compared to the old coins, the new generation currency coin series released by the Bangko Sentral ng Pilipinas now differs in diameter with 27.0 mm for the 10-peso coin, 25.0 mm for the 5-peso, and 23.0 mm for the 1-peso coin (Figure 3). In addition, it also said in the guidelines of the BSP that the old coins will be removed from circulation through natural attrition just like what happened in the old paper bills [5].

Fig. 3 New Philippine 10, 1, 5-Peso Coins [5]

B. *Materials Used*

The following materials are used to build the machine:

- Carton papers
- 16x2 LCD with I2C
- TCRT5000 IR sensors
- Breadboard
- Arduino Uno
- Push button
- Glue gun and sticks
- Jumper wires

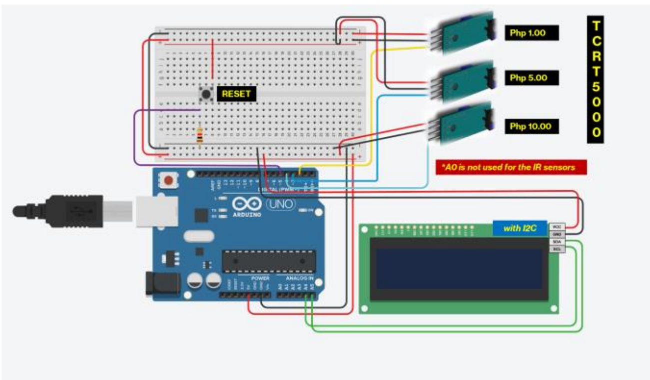

Fig. 4 Equivalent Circuit of the Coin Bank

Figure 4 shows the equivalent circuit diagram of the coin bank. The coin bank is a device that counts the worth of the saved-up coins put inside the bank. When the user puts a coin through the input slot, it goes through a ramp wherein the different sized hole will automatically sort it based on its denomination. Sensors are then placed beside the hole wherein it checks if a coin passes through it (Figure 5). The sensors will then update the microcontroller by incrementing the total value of the coin bank by the denomination of the coin. This will then be displayed on the LCD display. All the components of the device are driven by an Arduino. In case of emergency wherein the user needs to withdraw all funds from the bank, the device also includes a reset button that set all values back to zero. Finally, if the device loses power, the values stored will not reset since it makes use of the EEPROM library of the Arduino to store the count.

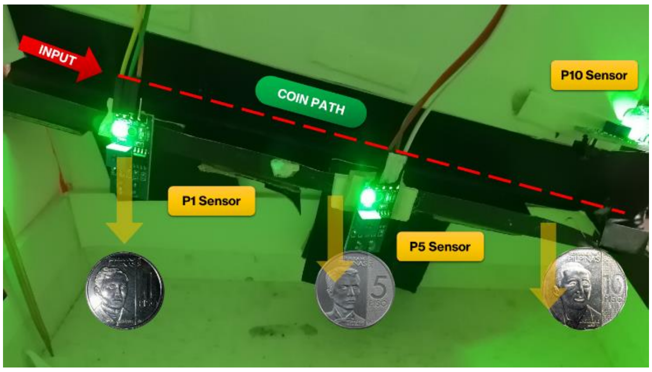

Fig. 5 Ramp Setup and Sensor Placements

C. *Actual Implemented Program Flowchart*

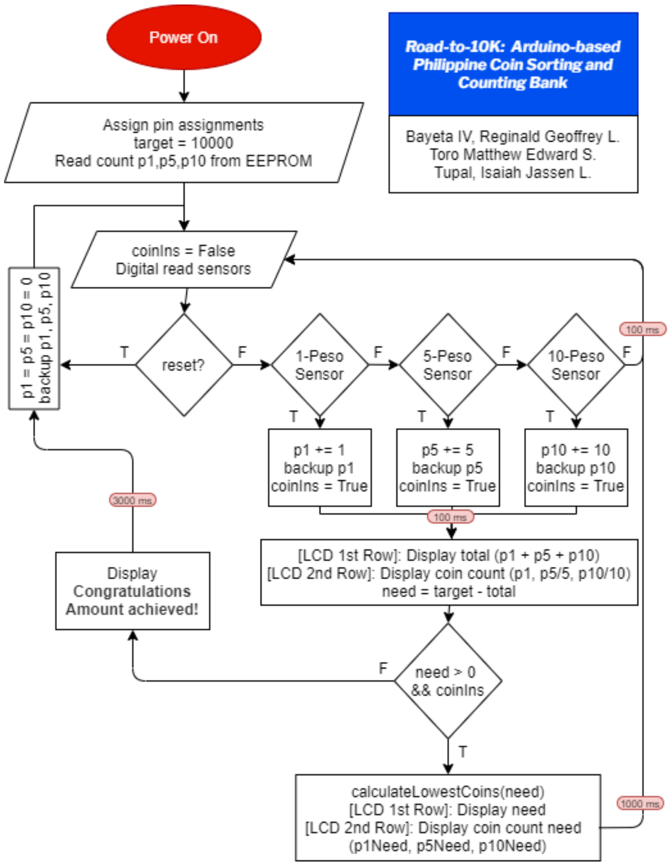

Fig. 6 Program Flowchart of the Coin Bank

Figure 6 shows the implemented program flowchart of the Arduino-based coin bank. The coin program starts when the power is available in the device. The first part of the program is the pin assignments and the declaration of the target amount which is constant at value of 10 000. The next step is to read the values of the count of P1, P5, and P10 from the EEPROM, to continue the progress from the time where the device was turned off. Then comes the declaration that no coins have been inserted yet before the reading of the sensor and button values. If the button reset was pressed, the count of P1, P5, and P10 will reset back to 0. Afterwards, the values of the count will be updated whenever the coin has been detected by its corresponding sensor and triggering the flag that checks that a coin has been inserted. After the read and update, the LCD will now display the current count of each domination, as well as the total amount of all coins. Next, the required amount to reach the target will be calculated. If the target has not been reached and a coin has been inserted, it will display the lowest number of coins needed to reach the said required amount. If otherwise the target amount has been reached, it will display a congratulatory message, resetting the count of P1, P5, and P10 back to 0, and updating the EEPROM values of the said count. Appropriate delay values have been added in the read, update, and display functions to satisfy the functionalities of the system.

D. *Evaluating the Machine*

The machine can be best evaluated by comprehensive inspection of a technician/developer and experience of its target users. Due to the situation at hand (COVID-19 pandemic), only the former can be satisfied. The evaluation of the machine is divided into three parts: design, sensing accuracy, and user experience.

First, the design of the coin bank follows a budget-friendly approach as the developers are still currently students. Additionally, due to the current pandemic, there's difficulty on purchasing materials that can make the overall design better. Aside from the electronic components, all materials used in developing the machine are all recycled materials. Second, the sensing accuracy, which is arguably the most important part of the machine, checks if the machine works as intended. To check the accuracy of the sensors, n number of coins will be inserted into the machine for each denomination. After all trials, the accuracy of the machine will be calculated by using the formula:

$$\%\, Error = \frac{|No.\,of\; Successful\; Trials - Total\; trials|}{Total\; trials}\; x\; 100$$

A good machine must have as low percent error in its functionality test as possible, since having a high percent error is highly undesirable not only for the developers but most importantly for its target users [6]. Lastly, evaluating user experience by getting feedback is vital for the improvement of the machine. These feedbacks can be about the control interface, thoughts on the overall design, suggestions for additional functionalities, and their overall experience in using the machine.

IV. Results and Discussion

A. *Using the Machine*

Fig. 7 Road to 10K Coin Bank

To use the machine, the user must insert a coin into the slot, and then the machine will handle the sorting and updating on its own. As seen in Figure 8, the single slot for the coin of any denomination can be found at the left side of the machine.

Fig. 8 Input Process: Inserting a Coin to the Coin Bank

As stated in the methodology, the machine will only accept new Philippine coins. Currently, the machine does not have any feedback mechanism that can reject wrong coins. Additionally, the user should note that the coins must be free from stains of any sort, as it can be stuck in the ramp, which can also let other problems to occur. After a coin has been successfully inserted, the total amount and coin count are displayed in the LCD as seen in Figure 9.

Fig. 9 Output Process: Displaying Total Amount and Coin Count

B. *Evaluation of the Machine*

Table 1 highlights the result of the accuracy of sensing of the coin bank as seen in the video demonstration that can be accessed in the following link:

https://drive.google.com/file/d/12eAQuPzWbYhIfQMu1kCaHyGw0pMgnmhP/view?usp=sharing

TABLE I. ACCURACY OF SENSING TEST RESULTS

Denomination	Number of Trials	Successful Trials	Percent Error (%)
Php 1	15	15	0.00
Php 5	20	20	0.00
Php 10	10	10	0.00

As seen in the Table 1, the machine has been successful in its functionalities as it achieved 0% percent error in all the tests conducted. However, the number of trials of each denomination differs because of the availability of each coins during the testing phase. From this, the machine has successfully implemented a single coin slot as the input instead of one per each denomination. Issues that could arrive from this however, are inaccurate readings if the user inserted the wrong coin (e.g., old Philippine coins, foreign currency coins) as the machine do not provide a feedback mechanism that can reject such coins. Additionally, as the machine main sorter (ramp) is made from paper, the sensing accuracy could also be affected in the long run as paper and related materials deteriorate with respect to time. Since the coin bank made use of the EEPROM library of the Arduino, the values of the coins are always stored in its memory even if the machine is turned off. Overall, based on the criteria set in the methodology, the functionalities of the coin bank show a very satisfactory performance.

To address the negative effect on the sensing accuracy of the machine due to its paper chassis and ramp, sturdy materials such as wood and any 3D printing materials could be used. The use of wood is more accessible to most users, but the use of 3D printing can bring the best results as its performance can be already simulated during its design phase. However, user should be wary about the materials to be used when it comes to 3D printing, choosing an environment-friendly material is the most desirable choice. Additionally, to solve the issue of feedback mechanism in handling wrong coin inputs that can lead to inaccurate readings, a universal coin slot can be used as the input device as it can accept any programmed coins simultaneously and reject other coins that was not programmed. By using this device, the old Philippine coins can be added as the accepted denominations, until the time where it gets recalled by the Philippine government. This universal coin slot is commonly used in vending machines, karaoke, video game machine, internet cafes, among others.

V. CONCLUSION AND RECOMMENDATION

In this paper, Road-to-10K, an Arduino-based Philippine coin sorting and counting bank was developed. On the basis of making a minimum viable product or a proof-of-concept device, it can be said that the device is considered a success as it can sort and sense the coins that are put inside the coin bank, and it achieved 0% percent error in all sensing accuracy tests. Furthermore, the sensor can reliably transmit the information that a coin has passed through a sorting hole and the device can successfully update the current value of the bank in which this data is shown to the user via the Arduino driven LCD. Aside from the recommendations made to improve the overall performance of the machine, the following are the further recommendations of the authors:

1. Transferring the circuit to a printed circuit board. The use of PCB is more reliable and overall better than using the breadboard to mount the circuit of the machine.
2. Making the target value customizable. To do this, a keypad and a button should be added into the circuit. A customizable target is good for users who uses the product to achieve short term goals such as payment for rent, water and electricity bills, internet, among other things.
3. Machine should turn off when idle. By doing this, it saves the battery life of the machines.

ACKNOWLEDGEMENT

We would like to thank Engr. Mark Lester F. Padilla and Engr. Voltaire B. Dupo for their teachings and guidance in our Microprocessors Lecture (MICPROS) and Microprocessors Laboratory (LBYCPA3) course.

REFERENCES

[1] Adobo Magazine. “Filipinos still saving in piggy banks – MasterCard”, 2014.https://www.adobomagazine.com/philippine-news/filipinos-still-saving-in-piggy-banks-mastercard/

[2] Dunham, S., Lee, E., & Persky, A., “The Psychology of Following Instructions and Its Implications”. American Journal of Pharmaceutical Education, 84 (8), 2020; DOI: 10.5688/ajpe7779

[3] Arduino, “What is Arduino?”. https://www.arduino.cc/en/guide/introduction 2021.

[4] DIY Machines, TCRT5000 Infrared Reflective Sensor – How It Works and Example Circuit with Code. instructables.com, n.d.

[5] Bangko Sentral ng Pilipinas, The Philippine New Generation Currency Coin Series, 2018.

[6] Professional QA. “What is Functional Testing and Types of Functional Testing?”, 2019. https://www.professionalqa.com/functional-testing.