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Paper Currency Sorter with Fingerprint Access Protection for Ethiopian Small and Medium Enterprises (SME)

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Abstract The proposed design and implementation create an automated safe-keeping machine which acts as Paper Currency Sorter with Fingerprint Access Protection for Ethiopian SME's. It will help them lessen their worries every time that the store will be jam-packed with customer. Since it is operated automatically, everything can be done smoothly and will definitely make them worry-free from any thieves because it has a special feature of registering your own fingerprint for access protection. This study will sort out money paper currency according to its color (value). It will also have a safety lock that can only determine the fingerprint of the owner. The study considers banknotes that are currently functional, i.e., 1 Birr, 5 Birr, 10 Birr, 50 Birr and 100 Birr. This design is strictly for sorting money and safekeeping. This design is not a fast paced sorter, and its precision is not perfect when it comes to the last paper bill to be sorted. The device will receive an error if the wrong value of money is sensed at the color sensor.

Keywords: *color sensor, Arduino, paper notes, SME, Ethiopia*

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1. Introduction

Today, money has become an essential part in people's daily life. Money is a non-negotiable, indispensable commodity in every person's life. The possession of money in itself is a resource and the usage of it can help acquire resources. Most of the things we use daily have monetary value, whether directly or indirectly. Money's power is indisputable after the power of self-belief in human life. In Ethiopia, small and medium enterprises (SME) usually use a paper currency counter to put all of the money they have earned and received that is not in order and usually will cost a lot of time to organize. Since currency has great importance in facilitating the management of the economy of countries at large, automatic recognition of currency becomes a great area of interest for researchers and developers [1].

The ability to differentiate colors is essential for human's life as it gives us the awareness about the changes in surrounding through our vision [2]. Moreover, by exploiting the ability of color capture, intelligent machine gains the function to differentiate, sort and organize. The project includes sensors that detect color of the object then sends the information to Arduino Uno which in turn adjusts the servo motor which located just below the ball slider to move it left and right [3].

Colors are light waves that are no different than the electromagnetic waves emitted by cell phones. It is our brain cells that interpret them as real colors [4]. However, there has been a lot of challenges occurred in SME's in sorting paper currency. Usually, SME owners experience during difficult times whenever there are many people gathering around their store to buy anything. The first factor is speed of sorting. This is due to the limitation of response time for a human eye [5]. The eyes will always take some time to see an image and project this to the brain to initiate visual sensation. After the brain has received the image, it will take some time for the brain to determine the colour of the object too [6].

Ethiopia is one the countries in East Africa and it is popular for its diverse cultural destinations. Ethiopian currency is referred to as Birr. 1 Birr is basically separated into 100 cents. The Ethiopian Birr notes are 100, 50, 10, 5 and 1 [7].

The proposed design and implementation create an automated safe-keeping machine which acts as Paper Currency Sorter with Fingerprint Access Protection for Ethiopian SME's. It will help them lessen their worries every time that the store will be jam-packed with customer. Since it is operated automatically, everything can be done smoothly and will definitely make them worry-free from any thieves because it has a special feature of registering your own fingerprint for access protection.

2. Related Works

Zeggeye and Assabie [8] propose hardware and software solutions which take images of an Ethiopian currency from a scanner and camera as an input. It combined characteristic features of currency and local feature descriptors to design a four level classifier. The design has a categorization component, which is responsible to denominate the currency notes into their respective denomination and verification component which is responsible to validate whether the currency is genuine or not. The system is tested using genuine Ethiopian currencies, counterfeit Ethiopian currencies and other countries' currencies. The denomination accuracy for genuine Ethiopian currency, counterfeit currencies and other countries' currencies is found to be 90.42%, 83.3% and 100% respectively. The verification accuracy of our system is 96.13% [8].

Reddy [9] design a Pick and Place Robotic Arm with conveyor belt arrangement in sorting objects based on colour. It is autonomous robot that can identify objects when placed on the conveyor belt based on color sensing and then sort by relocating them to a specific location. It will be using a picking arm which uses a controller motor to pick the particular object from the conveyor belt and place it according to the color sensing. Micro controller (AT89S52) allows dynamic and faster control. Liquid Crystal Display (LCD) makes the system user-friendly. AT89S52 Micro controller is the heart of the circuit as it controls all the functions [9].

Similarly, Dhanoj et.al [10] presents an application to sort colored objects with a robotic arm. A robotic arm which picks different colored cubes and sorts them placing in different cups. The detection of the particular colour is done by a light intensity to frequency converter method. The robotic arm is controlled by a microcontroller based system which controls DC servo motors.

Gaikar et. Al [11] design a Object Sorting using Color Sensor and Arduino. The arduino microcontroller is an intriguing and prestigious venture for techies, who might want to consolidate Electronics, Machine building and programming. The shading Sorting Machines is utilized for sorting mostly RGB hues. It isolates diverse hued questions and characterizes them into individual compartments/glasses. It is electronic task made up of Arduino UNO alongside Arduino UNO BOB, RGB shading sensor, three servo engines and some plastic channels and tube parts [11].

Joy [12] design a robotic arm, which can pick and sort objects of different color. The mechanical structure of the robot was assembled using aluminum brackets which helped to reduce the weight without losing the mechanical strength. The aim of the project was to have a fully functional robotic arm which sorts different colored balls and the target is achieved successfully. In the final run of the project red, yellow and green balls were successfully sorted. The color sensor IC TCS3200 show almost stable response in various sunlight conditions.

In view of the above literature, it is evident that there has been no or limited study on the application of embedded system using microcontroller with a color sensor in sorting Paper Currency.

3. Materials and Methods

3.1. Materials Used in the Research Study

This study will sort out money paper currency according to its color (value). It will also have a safety lock that can only determine the fingerprint of the owner. The study considers banknotes that are currently functional, i.e., 1 Birr, 5 Birr, 10 Birr, 50 Birr and 100 Birr. This design is strictly for sorting money and safekeeping. This design is not a fast paced sorter, and its precision is not perfect when it comes to the last paper bill to be sorted. The device will receive an error if the wrong value of money is sensed at the color sensor.

The Paper Currency Sorter with Fingerprint Access Protection utilize arduino mega micro controller and the accompanying shields, sensors and modules as shown in Table 1.

Table 1. List of Materials

Items	Quantity
Foam Board	2 pcs.
Old Robot Wheel	2 pcs.
Barbecue Stick	6 pcs.
DC Motor	2 pcs.
TCS3200 Color Sensor	1 pc.
Arduino Atmega2560 Microcontroller	1 pc.
Servomotor	3 pcs.
Fingerprint Module	1 pcs.

3.1.1. Arduino Mega 2560

The Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila [13].

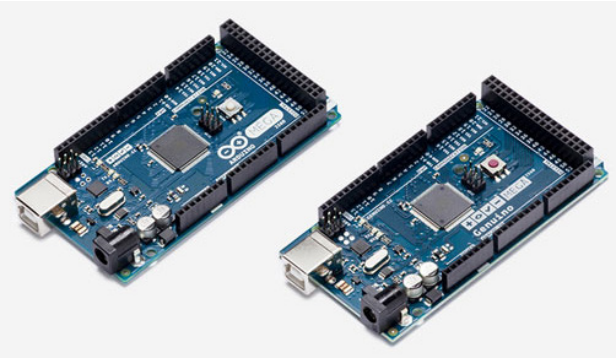

Figure 1. Arduino Mega 2560 Controller

3.1.2. DC Motors

Electrical motors are everywhere around us. Almost all the electro-mechanical movements we see around us are caused either by a AC or a DC motor. Here we will be

exploring DC motors. This is a device that converts DC electrical energy to a mechanical energy. This DC or **direct current motor** works on the principal, when a current carrying conductor is placed in a magnetic field, it experiences a torque and has a tendency to move. This is known as motoring action. If the direction of current in the wire is reversed, the direction of rotation also reverses. When magnetic field and electric field interact they produce a mechanical force, and based on that the working principle of **DC motor** is established [14].

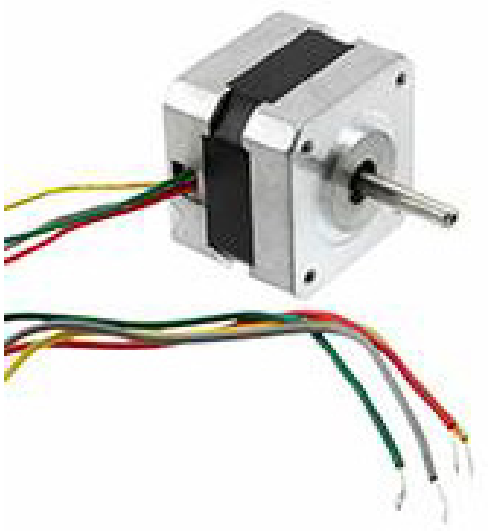

Figure 2. DC Motor

3.1.3. TCS3200 Color Sensor

The TCS3200 programmable color light-to-frequency converter combines configurable silicon photodiodes and a current-to-frequency converter on a single monolithic CMOS integrated circuit. The output is a square wave (50% duty cycle) with frequency directly proportional to light intensity (irradiance). The TCS3200 reads an 8x8 array of photodiodes [15].

Figure 3. Color Sensor

3.1.4. Servo Motor

A servo motor is a rotary or linear actuator that precisely controls the angular or linear position, velocity and acceleration. It has a motor connected to a sensor for position feedback. It receives control signals that would dictate the position of the servo shaft and a power applied to its DC motor to turn the shaft to that position [16].

Figure 4. Servo Motor TowerPro MG-995

3.1.5. Fingerprint Scanner for Arduino

A fingerprint scanner system has two basic jobs -- it needs to get an image of your finger, and it needs to determine whether the pattern of ridges and valleys in this image matches the pattern of ridges and valleys in pre-scanned images.

Only specific characteristics, which are unique to every fingerprint, are filtered and saved as an encrypted biometric key or mathematical representation. No image of a fingerprint is ever saved, only a series of numbers (a binary code), which is used for verification. The algorithm cannot be reconverted to an image, so no one can duplicate your fingerprints. Features Make adding fingerprint detection and verification super simple. Typically used in safes-theres a high powered DSP chip that does the image rendering calculation feature-finding and searching Connect to any microcontroller or system with TTL serial and send packets of data [17].

Figure 5. Fingerprint Scanner

3.2. Methods and Design

Figure 6 shows the flow chart of the whole process of the design. Upon plugging the device on a laptop, the microcontroller will start. The first servomotor will start to function. After inserting the money at the servomotor, the servomotor will now move the paper currency money at the color sensor which is programmed of the microcontroller for the determination of color value. After determining the color value of the paper currency money, the elevator-like storage will move its position on which floor 1st, 2nd, 3rd, 4th and 5th floor which represents the color value that is assigned. Then the second servomotor will move the paper bill money to the storage floor as assigned.

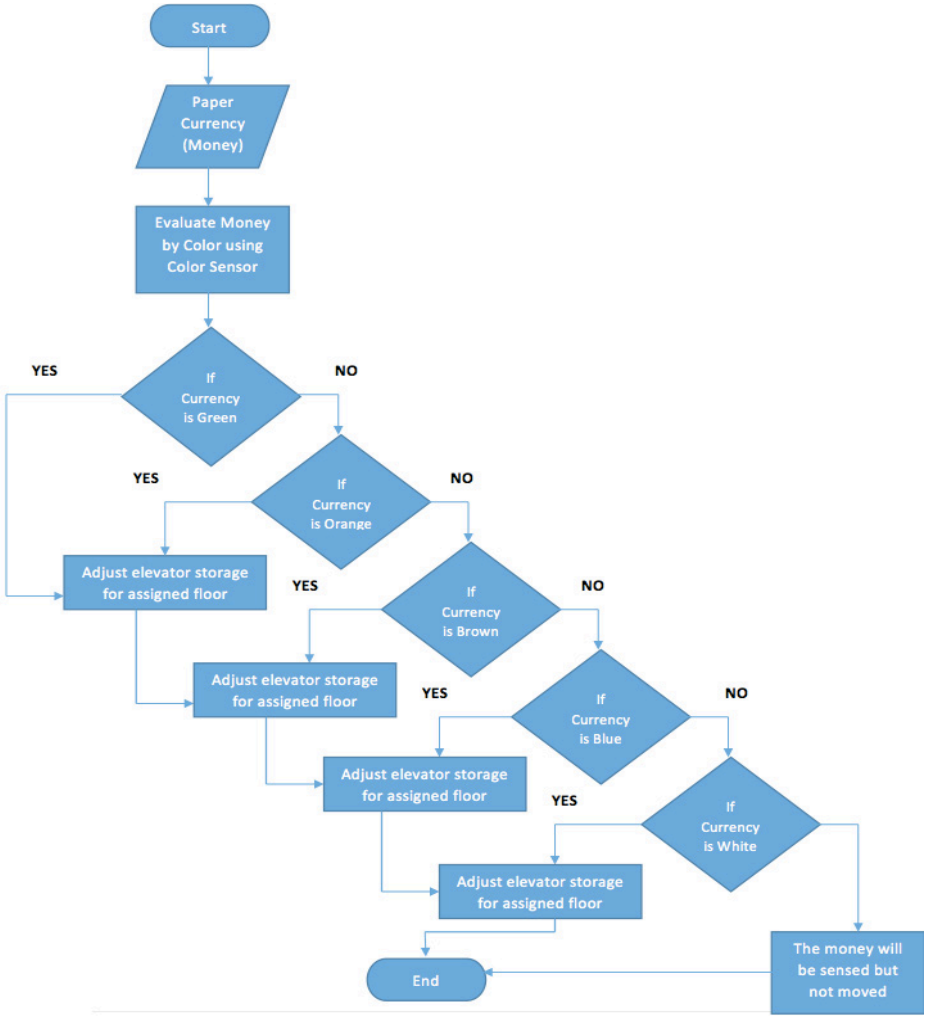

Figure 6. System Flowchart of the Design

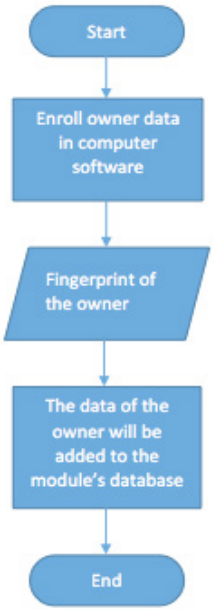

Figure 7. Circuit Diagram of the Luggage Cart

Figure 7 shows the process of how the fingerprint will act when turned on for the first time. As the whole device is turned on, the fingerprint scanner will also turn on. A LED will indicate that the module is on and running. There will be a computer software where the owner's information will be stored. Then the fingerprint of the owner can be added to the module.

3.3. Ethiopian Notes and Color

Table 2 shows the Ethiopian currency in paper notes. 100 birr correspond to color green, 50 birr correspond to color orange, 10 correspond to color brown, 5 birr correspond to color blue and 1 birr correspond to color white respectively.

3.3. Standard Operation

Step 1: Upon turning on the device, the first servomotor will move the money inserted done at a time.

Step 2: The sensor will now then determine if the paper bill inserted whether 100 Birr, 50 Birr, 10 Birr, 5 Birr and 1 birr.

Step 3: After determining the value, the elevator type storage will decide which floor it will stop. First floor for 100 Birr, second floor for the 50 Birr, Third Floor for 10 Birr, Fourth Floor for 5 Birr and Fifth Floor for 1 Birr.

Step 4: After determining which floor it will go to, the DC motor will now move the paper bill to the storage. The finger print access protection is optional.

Step 5: Finally, upon turning on the device for the first time, the finger print of the owner must be recorded or enrolled.

Table 2. Ethiopian Notes and Color

No	Ethiopian Notes Value	Color	Appearance
1	100 Birr	Green	
2	50 Birr	Orange	
3	10 Birr	Brown	
4	5 Birr	Blue	
5	1 Birr	White	

4. Conclusion and Recommendation

4.1. Recommendation

The study utilized the arduino micro controller to assist Ethiopian SME's organizing their earning easy which can save time. It can be further improved by using other materials that will make the process of the paper bill money more precise, which is transferring the money on it a time even though there are a lot of numbers of paper bills inserted at the first servo motor of the device. Another improvement that can be added is the returning of money when the sensor cannot read the color value of the money inserted. Another is to reject the money inserted when the value is not in correct or programmed in the sensor.

References

[1] F. Takeda and S. Omatu (1995). "High-speed paper currency recognition by neural networks", *IEEE Transaction on Neural Networks*, 6(1):73-77.

[2] Khojastehnazhand, M.; Omid, M.; and Tabatabaeefar, A. (2010). Development of a lemon sorting system based on colour and size. *Journal of Plant Science*, 4(4), 122-127.

[3] Avishay, D.; Pavlov, V; and Avramov, I. (2011). Designing and testing acalibrating procedure for combining the coordination systems of a handling robot and a stationed video camera. *Robotics and Computer-Integrated Manufacturing*, 27(3), 514-520.

[4] Dawkins, R. (2006). *Unweaving the Rainbow: Science, Delusion and theAppetite for Wonder* (1st ed.).United Kingdom: Penguin UK, Kensington.

[5] Unay, D.; Gosselin, B.; Kleynen, O.; Leemans, V.; Destain, M.; and Debeir, O. (2011).Automatic grading of Bi-colored apples by multispectral machinevision. *Computers and Electronics in Agriculture*, 75(1), 204-212.

[6] Mehl, P.M.; Chen, Y.R.; Kim, M.S.; and Chan, D.E. (2004). Development of hyperspectral imaging technique for the detection of apple surface defectsand contaminations. *Journal of Food Engineering*, 61(1), 67-81.

[7] https://buzzkenya.com/ethiopian-birr/

[8] Zeggeye, J., and Assabie, Y. (2016). Automatic Recognition and Counterfeit Detection of Ethiopian Paper Currency. International Journal of Image, Graphics and Signal Processing, 8(2), 28-36.

[9] Reddy, D.V.K. (2014). Sorting of Objects Based on Colour By Pick and Place Robotic Arm and With. Conveyor Belt Arrangement. International Journal of Mechanical Engineering and Robotics Research. *Vol 3, Issue 1*.

[10] Dhanoj, M, Reshma K.V.,Sheeba V., and Marymol, P.(2015). Colour Sensor Based Object Sorting Robort Using Embedded System. *Ijarcce*, *4*(4), 619-622.

[11] Gaikar, T. G., Zakobar S.N., Bhandari, R. S., Patil, S.S. (2016). Object Sorting using Color Sensor and Arduino. International Journal on Recent and Innovation Trends in Computing and Communication. Volume: 4 Issue: 4. 483-486.

[12] Joy, A. (2014). Object Sorting Robotic Arm Based on Colour, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering. Vol. 3, Issue 3, pp. 7741-7746.

[13] Arduino (2016).Arduino Mega 2560 Specification. Retrieved from https://www.arduino.cc/en/main/arduinoBoardMega2560. Accessed March 2016.

[14] DC Motor (2017). Retrieved from https://www.electrical4u.com/dc-motor-or-direct-current-motor/. Accessed January 2017.

[15] Color Sensor (2017). Retrieved from http://ams.com/eng/Products/Light-Sensors/Color-Sensors/TCS3200. Accessed January 2017.

[16] Servo Motor (2016). Zigbee Shield for Arduino. Retrieved from https://www.allaboutcircuits.com/projects/servo-motor-control-with-an-arduino/ Accessed July 2016.

[17] How Finger Print Scanner Works? Retrieved from http://www.bioelectronix.com/what_is_biometrics.html http://ultimumvitae.com/Details/B019TPP1UK/KOOKYE-Optical-Fingerprint-Reader-Sensor-Module Accessed January 2017.