

DESIGN AND IMPLEMENTATION  
OF AN AUTOMATIC COIN SORTING  
AND COUNTING MACHINE

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## ABSTRACT

In this modern year, we can see that many automatic devices like drinking machine, washing machine, arcade game machine, massage chair and other coin operated machine using the automatic coin device to act as the coin counter and sorter. But, most of the coin counting machine in Malaysia is incapable to differentiate between the old and new Malaysian Coins accurately. The systems of the machine that are available in the market are not good enough because sometimes it makes mistake when detect the value of coin and cause the error calculation in the result. In this project, a coin operated machine which can differentiate old and new Malaysia coin accurately and automatically is implemented. An automatic coin counting and sorting machine prototype is developed by using ARDUINO as the main controller. This work included design the simple display panel to show total quantity of each coin and total amount of coin value as the Crystal Display (LCD) has been implemented to display the result. The coin acceptor has been used as it acts as coin selector to determines the denomination of coin and forbid any invalid or unwanted coins. The coin sorting system is designed by using servo motor and the stepper motor to hold and distributes coin to the corresponding slot. Through the project, this integrated design has high performance for coin counting and sorting in terms of user-friendly, accuracy, and attractiveness.

## ABSTRAK

Pada tahun moden ini, kita dapat melihat bahawa banyak peranti automatik seperti mesin minum, mencuci, permainan arked, kerusiurut dan lain-lain duit syiling mesin dikendalikan dengan menggunakan peranti syiling automatik untuk bertindak sebagai kaunter duit syiling dan tukang pilih. Tetapi, kebanyakan duit syiling mesin pengiraan di Malaysia tidak berupaya untuk membezakan antara syiling Malaysia lama dan baru dengan tepat. Sistem mesin yang terdapat di pasaran tidak cukup baik kerana kadang-kadang ia membuat kesilapan apabila mengesan nilai duit syiling dan menyebabkan pengiraan ralat dalam keputusan. Dalam projek ini, duit syiling yang dikendalikan mesin yang boleh membezakan lama dan baru Malaysia syiling tepat dan automatically.is dilaksanakan. Satu pengiraan syiling automatik dan menyusun mesin prototaip dibangunkan dengan menggunakan Arduino sebagai pengawal utama. Kerjakerja ini termasuk mereka bentuk panel paparan mudah untuk menunjukkan jumlah kuantiti setiap syiling dan jumlah nilai duit syiling sebagai LCD telah dilaksanakan untuk mendapat keputusan seperti. Para penerima syiling telah digunakan kerana ia bertindak sebagai pemilih syiling untuk menentukan nama pengenalan syiling dan melarang mana-mana syiling tidak sah atau tidak dikehendaki. Sistem menyusun syiling direka dengan menggunakan motor servo dan motor pelangkah untuk memegang dan mengedarkan syiling untuk slot yang sama. Melalui projek ini, reka bentuk bersepadu ini mempunyai prestasi yang tinggi untuk mengira duit syiling dan pengasingan dari segi mesra pengguna, ketepatan, dan daya tarikan.

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**LIST OF SYMBOLS**

$x$	position at time $t$
$v_0$	velocity at time = 0
$x_0$	position at time = 0
$a$	acceleration
$e_A$	back emfs induced in the A phase windings
$e_B$	back emfs induced in the B phase windings
$i_A$	A phase winding currents.
$I_B$	B phase winding currents.
$v_A$	A phase winding voltages.
$v_B$	B phase winding voltages.
$K_m$	Motor torque constant.
$N_r$	Number of teeth on each of the two rotor poles
$R$	Winding resistance.
$L$	Winding inductance.
$R_m$	Magnetizing resistance.
$B$	Rotational damping.
$J$	Inertia.
$\omega$	Rotor speed.
$\Theta$	Rotor angle.
$T_d$	Detent torque amplitude.

**LIST OF ABBREVIATIONS**

LCD	Liquid Crystal Display
Emf	Electromagnetic Fields

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 PROJECT BACKGROUND**

The creation of the coin counting and sorting machine is exist for the purpose to help people record down the quantity and total value of coin and divide the coin to corresponding slot automatically. The concept of the coin counter is mostly based on the detection of the dimension, weight, edge of credit pulses by using sensor. The coin sorting tray is designed to sort different type of coins based on the size of coin in different denomination (Richard E. McCarty, Jr., 2001). For the old design of the device, it is just a simple mechanical construction that only has the basic function of counting and sorting the coin and it has many limitations such as the limit of quantity of coins and fails to identify different coins accurately (Joseph J. Geib, Steven S. Kuhlin, 2001). Nowadays, the high technology has shown the improvement to the counting and sorting machine as the modern device becomes more advanced to running the counting and sorting process. Now, the device has the characteristic of simplicity, convenience and high efficiency as the counting and sorting machine can be computerize and it brings speed and accuracy to us. The coin counting and sorting system can be found in various device like vending machine, washing machine, drinking machine, message chair to help the machine handle the work of coin counting and sorting.

#### **1.2 PROBLEM STATEMENT**

Many of the coin operated machine in market is incapable to detect between the old and new Malaysia coin with high accuracy and this resulting coin value loose.

### **1.3 PROJECT OBJECTIVE**

- a) Implement a coin operated machine which can differentiate 10, 20 and 50 cent of old and new Malaysia coin accurately and automatically.
- b) Implement the coin counting and sorting system to the machine by using microcontroller ARDUINO as the operating platform.

### **1.4 PROJECT SCOPE**

The microcontroller ARDUINO is used as the processing unit to operate the automatic coin counting and sorting system of the machine. This project including the design of the simple display panel to show total quantity of each coin and total amount of coin value as the LCD has been implemented to display the result. The coin acceptor has been used as it acts as coin selector to determines the denomination of coin and forbid any invalid or unwanted coins. The coin sorting system is designed by using servo motor and the stepper motor to hold and distributes coin to the corresponding slot.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This chapter including the development of the coin operated machine from its early invention until latest modern today. This chapter has also discussed about the concept and theories of the coin operated machine to do the coin counting and sorting process. Analyzing and understanding from the literature review is important because it act as the guidance for the project.

#### **2.2 EARLY INVENTION**

In the early invention, the mechanical device of the coin machine is capable to do the counting and wrapping all kinds of coin – gold, silver, nickel, and copper in USA. It consists of a counting-board, a separate counting tube for each denomination and size of coin, and separate brass tubes for attacking and wrapping (Jens H. Molbak, 1888).

The process of operation is simple. A handful of coins of any denomination are placed in a counting-tube of the right size. The tube is then run rapidly over the grooved tracks of the counting-board, where they are deposited. Each track holds only ten coins. When the coins are all placed on the track, the board is slightly tilted, thus throwing the coins into the spaces between the tracks. One end of the board is then raised, and the coins quickly run down the aisles into the stacking-tube to the end of the tray. This tube contains a paper wrapper, which can easily be closed when the tube is opened. Formerly coin counting was a job for an expert, but this machine equals in speed and

accuracy the best of the old-time money-handlers known to banking fame (Jens H. Molbak, 1888)..

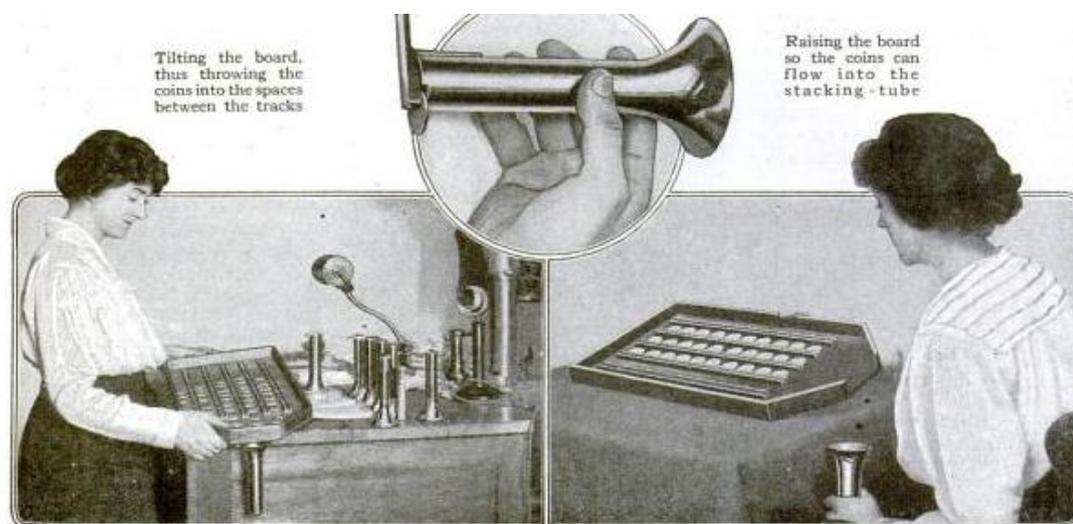


Figure 2.1: The early invention of the coin counting and wrapping machine

Source: Jens H. Molbak 1888

### 2.3 SENSOR IN COIN DISCRIMINATORS

Coin discriminators or commonly known as coin selector usually can be found in a coin-operated machine like vending machine, washing machine, drinking machine, or slot machine. The function of the coin selector is to determine the denomination of coin as well as to forbid any fake or invalid coin. The operation time to detect each coin is very fast as possible the consumer will not realize the delay between each insertion of the coin during the operation (Edward H. Bell, 2004).

In the structure of coin discriminators, it generally contains the structure and component like sensor for detect coin, coin entrance, avril, coin tubes and electronic circuit. For the mode of operation, the coin is insert to the coin slot and through coin path then passes through the sensor which is located at along the coin path to measure the coin's physical properties. The properties of coin like dimensions, weight, elasticity,

conductivity, and dropping time is measured based on the sensor used in the coin discriminator. Generally there are 4 sensors commonly used, which are electromagnetic sensor, magnetic sensor, acoustic sensor, and optical sensor (Edward H. Bell, 2004).

The most commonly sensor that can be found in the conventional coin discriminator is the Electromagnetic sensor. This sensor is usually are the inductive sensor or Hall Effect sensor. The permanent magnet is normally placed on the side of the coin path and the location of the magnetic sensor is directly opposite to the permanent magnet. A constant magnetic flux and magnetic field strength is generating across the coin path. When the coin passes and goes through the path, the coin will vary the magnetic flux density so that the initially form of the magnetic flux density in the space has been changed, and this resulting specified change of the magnetic sensor and instantly induced the electromotive force (emf). The induced emf's magnitude is influenced based on the metallurgical property like thickness and diameter of the coin. To detect the peak value of induced emf, the magnetic sensor is connected with an electronic sensor. Since different types of coin will produce specific peak voltage, it can be used to verify the validity of coin denomination (Earl Hovey C, 2001).

Besides that, there are other types of operation of magnetic sensor in coin discriminator that implement the coin discrimination based on magnetic property with the oscillator circuit. Inductors and capacitors are usually used to build the oscillator circuit for this configuration of the magnetic sensor. When the coin does not exist, the oscillator circuit is at the predetermined frequency according to the value of components and configuration. The change in oscillating is occurring and the result will be changed when the coin is detected based on the material and thickness of the coin (Earl Hovey C, 2001).

Secondly, the optical sensor is also widely used as the sensor to detect the coin in the coin discriminator. The secant segment of a coin at a predetermined level is measured by using this sensor. This sensor consists of the component of light emitting diode and light receiving phototransistor. This sensor is used to determine the diameter of the coin which the duration or delay between coin entering and leaving the barriers is stored (Earl Hovey C, 2001). If we assumed that the acceleration inside the path is

uniformly acceleration, the optical barriers consist of light emitting and light receiving placed at the same height need to be measured. Based on the equation 2.1, the time can measure based on the period when coin come enter the optical barrier and leave the optical barrier.

$$x = \frac{1}{2} at^2 + v_0t + x_0 \quad (2.1)$$

The third type of the sensor been used in the coin discriminator is acoustic sensor which consist of a microphone to gain the acoustic signal when the token or coin is hit to the anvil. The last type of the sensor that is commonly used is impact sensor that is used to measures the vibration or acceleration of coin when the impact is come on. This sensor is normally built by the piezoelectric materials and it is configured as accelerometers pressure sensors. The acoustic sensor and impact sensor is not practically because it is difficult to obtain the signal and then convert correctly to show the correct result (Earl Hovey C, 2001)..

## 2.4 COIN DETECTION AND RECOGNITION

The various techniques can be used to recognize and detect the coins of different denomination. The technique such as Circular Hough Transform, Artificial neural networks, heuristics approach has been used for the recognition of coin. The parameters such as size, weight, material have been used as the parameter to analyze and recognize the denomination of coin (Richard A. Mazur, G.Watts, Donald E. Raterman, Robert J. Crawford, 2001).

The steps of coin recognition to detect and recognize the coin is described. First, start the process and make the data capturing or also the data acquisition. Next, initialized the image segmentation process after the image is captured. The cropping of image is done after the coin image is been segmented. The feature of coin image for example texture and edge detection is been extracted. The calculation of the threshold value of grey scale image is obtained from the segmentation (Richard A. Mazur, G.Watts, Donald E. Raterman, Robert J. Crawford, (2001).

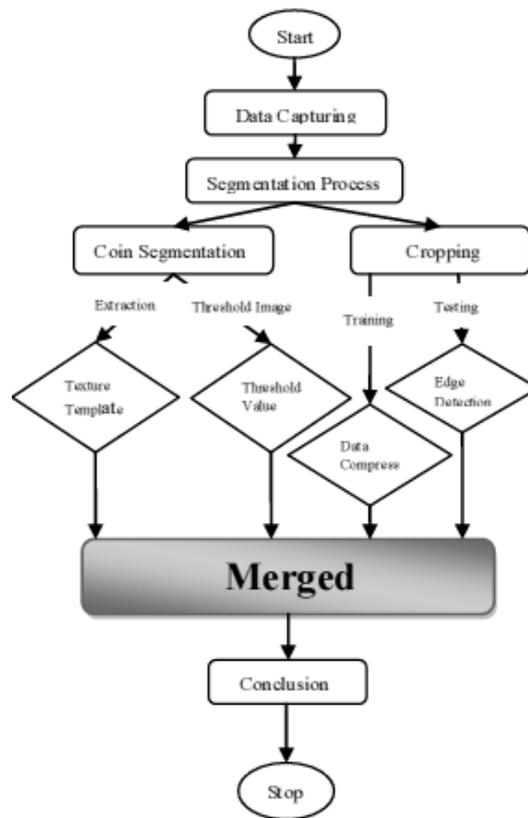


Figure 2.2: Flow Chart to represent the Recognition

Source: Richard A. Mazur, G.Watts, Donald E. Raterman, Robert J. Crawford 2001

## 2.5 COIN COUNTING PROGRAMMING

Various programming language can be used for the coin counting system. Below are the common languages that be used for the coin counting system:

- C
- C++
- Java
- Scratch
- Ruby
- Python

Besides counting the amount and quantity of the coin, the coin counting programming system can be view, print and save all counting results to the computer. A complete database can be built as the coin counting resulted can be saved. The example of the feature of using coin counting system are: upload coin counting results to computer, store counting results on computer, printing the counting results, have an overview of counting history(transaction history) and etc (Douglas A. Martin, 2012).

## **2.6 COIN OPERATED MECHANIC DESIGN**

### **2.6.1 HIGH SPEED COIN SORTER WITH REDUCED SIZE**

The invention of this coin sorter has the objective to provide a coin sorting system with operate at high speed and high accuracy in a size-reduced machine.

The coin sorter is including a rotatable disc which has a resilient top surface and also a stationary sorting head with the lower surface is positioned parallel to the upper surface of the disc. The sorting head from the lower surface create a numbers of coin exit doors for the purpose to sort and discharge different type and value of coins.. For the purpose to achieve one of the aims which is high number of coins in a small and size-reduced area, the coins are queued in a short gauging of length about 2 inches. So that, this short gauging region resulting the smaller diameter of the sorting head (Joseph J. Geib, Scott D. Casanova, Bogdan Kowalczyk, Glenn C. Gray, Steven S. Kuhlin, 2000).

The coin sorter is including a unitary base member. This unitary base member is recess in which the sorting head is inserted as it is automatically align with the rotatable disc. The unitary base member includes a number of integral coin chutes which each of the chutes will receives a particular coins exit doors and the coins are guided for each denomination (Joseph J. Geib, Scott D. Casanova, Bogdan Kowalczyk, Glenn C. Gray, Steven S. Kuhlin, 2000).

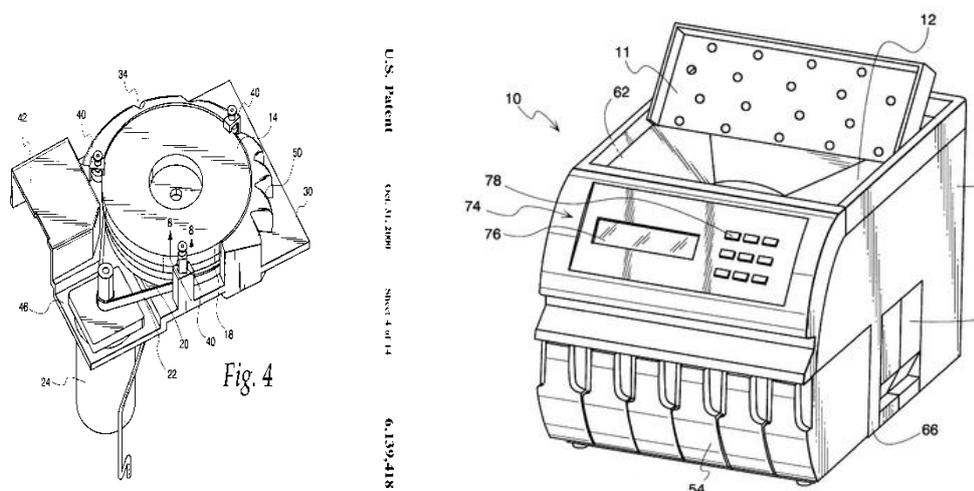


Figure 2.3: The design of the high speed coin sorter with reduced size.

Source: Joseph J. Geib, Scott D. Casanova, Bogdan Kowalczyk, Glenn C. Gray, Steven S. Kuhlin 2000

## 2.6.2 SENSOR-BASED COIN COUNTING MACHINE

The sensor-based coin counting machine is created with the capability of accepts a number of coins, count the coins and also displays the value and result to the end user.

The coin counting machine is consists of a coin discriminator sensor, a coin hopper with a container for receive numbers of coins, and a feed for accept the coins in the container to the coin discriminator sensor, and a controller for calculate the total value of the coins which is responsive from the coin discriminator sensor (Bruce R. Korman, August Golds, 2001).

The controller is controlling the container so that the coins have been extracted from the container by the feed. The feed is construct and build with a moveable backplate biased toward the container. The circular disc rotatably is also mounted to the moveable backplate, and the controller can dispense the coin by moving the backplate away from the container (Bruce R. Korman, August Golds, 2001).

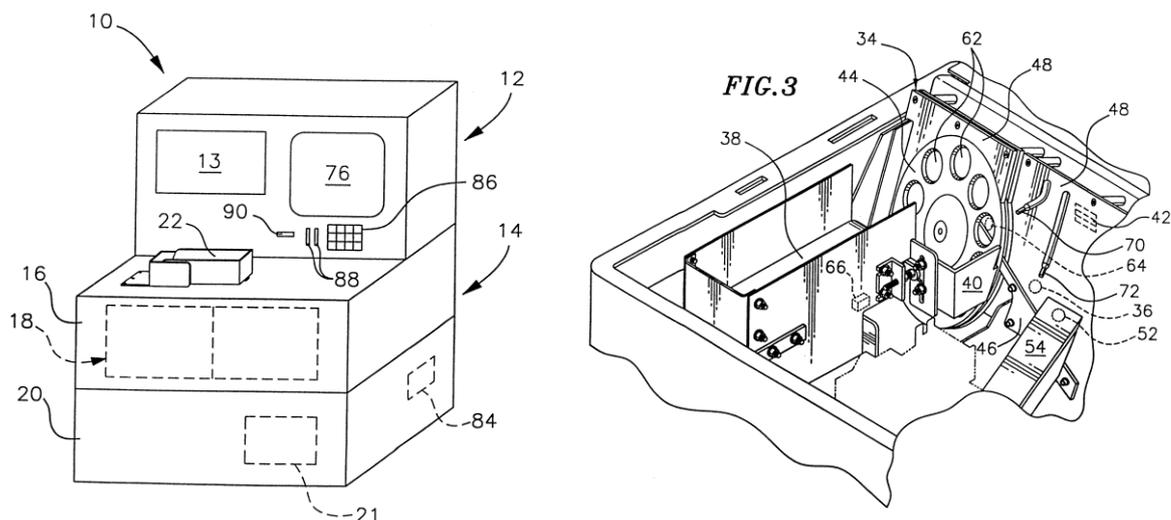


Figure 2.4: The design of the sensor-based coin counting machine.

Source: Bruce R. Korman, August Golds 2001

## 2.7 COMPARISON OF NEW AND OLD MALAYSIA COIN

As the target to be count and sort, the information about the Malaysian coin has been review as well. Malaysia 2nd series coins are introduced on 4 September 1989 as the Malaysian coins have the tradition and character design/theme. This series of coins are also known as "Cultural Artifact Series". The coin denominations issued at that time are 1, 5, 10, 20, 50 cent and 1 ringgit. The 1 cent and 1 ringgit is withdrawn from circulation from year 2005. On 25 July 2011, the Bank Negara Malaysia released Malaysia 3rd series coins. The coin denominations issued are 5, 10, 20, and 50 cent. We can still use Malaysia 2<sup>nd</sup> old coins when the 3<sup>rd</sup> series new coins start circulating (Malaysia Coin, 2011).

The 2nd series and 3rd series Malaysian Coins have different based on the size, diameter, thickness, weight, and material. Due to the different of 2 series of Malaysia coin, the coin have different denomination so that the parameter of the coin must be list down and been identify. This is because the coin recognition or detection are using the

parameter such as material or diameter to determine the value of coin. Table below are the detail show that the different between 2 series of coin (Malaysia Coin, 2011).

Table 2.1: Comparison between 2rd and 3rd series Malaysian Coin

Old Coin vs New Coin	Weight		Material		Diameter	
	Old Coin	New Coin	Old Coin	New Coin	Old Coin	New Coin
5 cent	1.41	1.72	Composite of Copper and Nickel	Steel	16.25	17.78
10 cent	2.82	2.98			19.40	18.80
20 cent	5.66	4.18		Brass	23.59	20.60
50 cent	9.33	5.66		Nickel Brass Clad Copper	27.76	26.65

Source: Malaysia Coin 2011

## CHAPTER 3

### METHODOLOGY

#### 3.1 INTRODUCTION

This chapter is involved about the discussion to build the project which consists of hardware design and software design to complete the coin counter and sorter. The detail of each part will be discussed along with the figure related.

#### 3.2 PROJECT FLOWCHART

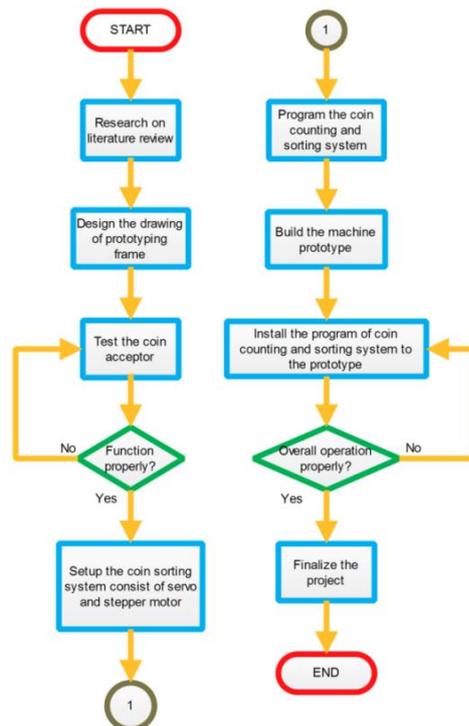


Figure 3.1: Project Flowchart

Figure 3.1 shows that the overall flowchart to complete the project from the beginning to the end. First, start the project by revise literature review of related article, journal and scholar through online or the books in library. After that, the fundamental and the basic concept of the project will be known and understand. The concept to programming the counting system and the mechanism of build the sorting system should be clear. Next, the counting system will be designed as the coin acceptor is the device to count the coin value and it is interface to the computer through ARDUINO. The design of the counting system will be detail explained in the part below. Then, the sorting mechanism is being designed to allow 6 different coins to sort and store in the box respectively. The design of the sorting system will be detail explained in the part below. Next, both hardware and software is combine and assembly and the overall test to the machine is making to ensure that the machine is performing well. Finally, the data and result through the project is obtained to analysis the overall performance.

### 3.3 BLOCK DIAGRAM

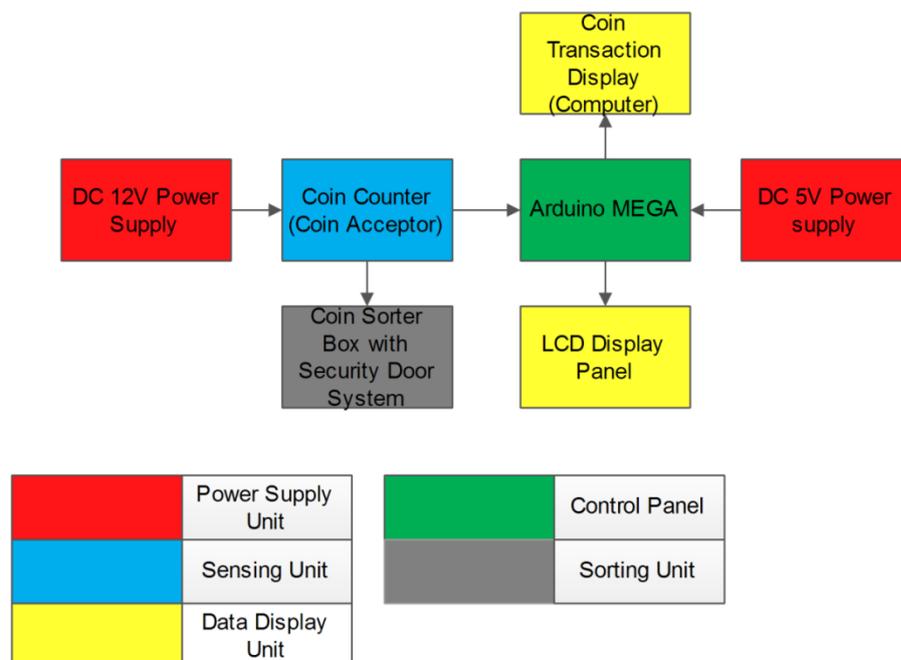


Figure 3.2: Block Diagram of the Coin Counting and Sorting Machine