DESIGN AND CONSTRUCTION OF A CURRENCY COUNTING MACHINE

WITH FAKE NOTE DETECTION

BY

ARINBOLA AKINWANDE TEMILOLUWA

EEE/13/1100

A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL/ELECTRONICS ENGINEERING, FEDERAL UNIVERSITY OYE-EKITI

IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING DEGREE

(B.ENG ELECTRICAL AND ELECTRONICS ENGINEERING)

FEBRUARY, 2019

UNIVERSITY LIBRARY
FEDERAL UNIVERSITY
OYE - EKITI
(FUOYE)

DEDICATION.

This project is dedicated to God Almighty who has been faithful thus far in my academic journey and to my parents Mr. and Mrs. Arinbola for their love, guidance and support.

DECLARATION OF ORIGINALITY.

This project is all my own work and has not been copied in part or in whole from any other source except where duly acknowledged. As such, all use of previously published work (from books, journals, magazines, internet, etc.) has been acknowledged within the main report to an entry in the References list.

I agree that an electronic copy or hardcopy of this report may be stored and used for the purposes of plagiarism prevention and detection.

I understand that cheating and plagiarism constitute a breach of University Regulations and will be dealt with accordingly.

Copyright

The copyright of this project and report belongs to Federal University, Oye-Ekiti.

Signed: [signature] Date: 4TH MARCH, 2019.

Office Stamp

CERTIFICATION

This is to certify that this project was carried out by ARINBOLA AKINWANDE TEMILOLUWA with matric number EEE/13/1100 of the Electrical and Electronics Engineering department, Federal University Oye-Ekiti, Nigeria.

DR. ENGR. OLAITAN AKINSANMI ______________________

(PROJECT SUPERVISOR) SIGN & DATE

ENGR. G.K. IJEMARU ______________________

(DEPARTMENTAL PROJECT COORDINATOR) SIGN & DATE

DR. ENGR. J.Y ORICHA ______________________

(H.O.D ELECTRICAL AND ELECTRONICS) SIGN & DATE

EXTERNAL SUPERVISOR ______________________

SIGN & DATE

ABSTRACT

The project presents a currency counting machine with fake note detection. Over the past few years, there has been a large amount of counterfeit money in circulation, usually manufactured by illegal counterfeit rings with the aid of great technological advances. This money is usually spent in public places like a market, buses, etc. This money keeps moving in circulation until it gets to the bank where they notice that the currency is fake and the money is then confiscated, leaving the owner of the money at a loss. This is where the machine comes in as it is difficult for humans to identify a counterfeit by mere visual inspection.

This study tends to evaluate the technique employed in the counting process and the detection of fake notes by the currency counting machine. The machine uses an Atmega 8 microcontroller which is the central unit of the project through which other components are connected. The machine also utilizes three sensors: the ultraviolet sensor, which checks for UV fluorescence on the money; the magnetic sensor, which checks for magnetic inks in the currency; and the infrared sensor which checks the thickness and also checks the infrared properties of the currencies. Other components include resistors, transistors, diac and triac, LED, etc. The microcontroller is programmed using the C+ programming language, and the project makes use of an a.c source. The result shows that the machine was able to count successfully the genuine notes, and makes a loud sound when it detects a fake note.

Table of Contents

ACKNOWLEDGEMENTS.

A special thanks to my project supervisor, Engr. G.K Ijemaru for overseeing and coordinating the project. His constructive scrutiny and criticisms were really helpful throughout the course of the project.

I am also thankful to all the lecturers in the Department of Electrical and Electronics Engineering from the H.O. D (Dr. J.Y Oricha), to Prof. Y.A Adediran, Engr. Obikoya, Engr. H.U Ezea, Engr. Ofusori, Engr. A.K Babarinde, Engr. Olusuyi, Engr. Sanni and Mr. Omoleye that impacted skills and knowledge in me. I will forever be grateful and may God bless you all.

I would also like to say a big thank you to my siblings *Tolulope* and *Temitope* for their support for me ever since I started the project.

A sincere thanks also goes to my school parents: Engr. James, Dr. (Mrs.) Ndububa and Mr. Baiyeri for their prayers and advices.

Finally, I would like to appreciate my friends that supported me through this period, listed in no particular order- Aloye Benjamin, Adaralegbe Segun, Omega Prince, Ojo Bukunmi, Ogunleye Olamide, Baderinwa Damilola, Akinyemi Titilope, Ojo Eric, Opasina Collins, Edewho Esther, Olaiya Korede and Akinteye Damaris, to mention but a few. I love you all.

UNIVERSITY LIBRARY
FEDERAL UNIVERSITY
OYE - EKITI
(FUOYE)

CHAPTER 1

1.0 INTRODUCTION

The currency counting machine or CCM is one of the miracles of science and technology. A currency counting machine is a machine that counts money- either stacks of banknotes or loose collections of coins [1]. The counters may be purely mechanical or use electronic components. The machines typically provide a total count of all money, or count off specific batch sizes for wrapping and storage .The CCM works on the principle of the breadth of the bundle of currency and there is a roller which has rods in a continuous pattern and the roller moves these rods with a particular speed. The machine, since invented, has helped man in the fast counting of money in banks, malls, etc. as well as the detection of counterfeit notes.

The different types of currency counting machines that we have include: banknote-only counters, banknote and coin counters, coins sorter and coins counter [1]. The banknote counters provide a total count of the notes in the supply hopper. More advanced counters can identify different bill denominations to provide a total currency value of mixed banknotes, including those that are upside down. The banknote and coin counters are able to count batches of notes or of coins without having to process them individually. They are faster and more versatile than the traditional notes-only and coins-only equipment, but cannot detect counterfeits. The coins sorter sorts a random collection of coins into separate bins for various denominations. It makes no attempt at counting; providing only collections of uncounted coins to be separately passed through a counter. The coins counter can sort and count coins at the same time, or it only counts presorted coins that are all the same size [1].

Fake note can be defined as an imitation currency produced without the legal sanction of the state or government [2]. Producing and using fake currency is a form of fraud or forgery.

Counterfeiting is almost as old as money itself. Before the introduction of paper money, the most prevalent method of counterfeiting involved mixing base metals with pure gold or silver. Some of the ill-effects that counterfeit money has on society include a reduction in the value of real money, an increase in prices due to more money getting circulated in the economy- an unauthorized artificial increase in the money supply, a decrease in the general acceptability of paper money, and losses, as traders are not reimbursed for counterfeit money detected by banks, even if it is confiscated.

To distinguish between fake and real currency notes has become increasingly difficult mainly due to the fact that counterfeits are now printed with the latest technology using security paper. Due to great technological advancement, counterfeiting problems have become more and more serious. Therefore the issue of efficiently distinguishing counterfeit banknotes from genuine ones via automatic machines has become more and more important. The fake currency detection system is developed to detect the fake currency by applying different techniques and methods on currency note. The fake currency detection system should be able to recognize the note quickly and correctly [2].

In subsequent chapters, we will see how the machine works, the components that make up the machine and their different functions as well as its advantages and its applications.

1.1Background of Project.

Manual testing of all notes in transactions is usually very time consuming, an untidy process and also there is a chance of tearing while handling notes [3]. No one can ever be 100 percent confident about the manual recognition. Fake or Counterfeit notes are one of the biggest problems occurring in cash transactions. For many countries of the world, it is becoming a big hurdle.

Because of the advances in printing and scanning technologies, it is easily possible for a person to print fake notes with the help of the latest hardware tools. Detecting fake notes manually becomes time-consuming and an untidy process hence there is need of automation techniques with which currency identification process can be efficiently done [4]. Therefore, involving machines with the assistance of the human experts makes notes identification process simpler and efficient. For the detection of forged notes (take a bank as example) it needs to identify the denomination every time they use the device which consists of ultraviolet light. The bank employee keeps the paper currency note on the device and tries to find whether the watermark identification, serial number and other characteristics of the notes are proper to get the denomination and check its authentication. This increases the work of the employee. Instead, if the banker uses this system, the result could be more accurate. Same is the case with areas such as shopping malls, investment firms where such systems can be used.

Various researchers have worked for fake note identification. Until now, there are several ways for fake note recognition. They may include watermark, latent image, holograms, and security thread amongst others.

In a survey taken in Nigeria as at 2017, it was revealed by NOI Polls Limited [5] that the markets are now the most common physical places where counterfeit currencies are being circulated. With about 67 percent of respondents in a poll confirming this, it came as no surprise, given that some counterfeiters may see the market place as the most porous place to spread fake notes due to the wide range of small business establishments who may not notice during transactions. Some businesses suffer losses due to their inability to recoup their money as banks confiscate fake notes at sight. Commercial banks (20 percent), public transport (five percent) and ATMs (three per cent) were also mentioned as avenues for circulation. Further probing revealed that only five per cent of the respondents admitted to spending the fake naira notes that came into their possession.

The poll result also noted 56 percent of the respondents are of the opinion that the Central Bank of Nigeria is not doing enough to create awareness about the circulation of these counterfeit currencies, neither are they giving citizens adequate tips on how to detect them. The implication of this is that more fake Naira notes may be allowed to circulate in the society. This in turn will lead to a reduction in the value of the genuine currency; increase in prices (inflation) due to more money getting circulated in the economy, an unauthorized artificial increase in money supply; and losses, when traders are not reimbursed for counterfeit money detected and confiscated by banks.

Thus, if these traders get this machine in the markets and suspect that a particular currency is a counterfeit, they will be able to check with the machine and this will effectively mitigate the circulation of counterfeit notes in the country.

1.2Statement of Problem.

One of the issues this country as well as some other parts of the world faces as regards money is that counterfeit of these currencies are now being made with the use of the newer technologies. This has resulted in situations where some people receive fake currencies unknowingly and end up in loss because once a bank is aware of that, it confiscates the money. The original currencies have key features that make them different from the counterfeit notes and it's with this knowledge that we decided to design a fake note detection system.

This device will detect the originality of banknote automatically and display the image of the banknote surface that will usually absorb the UV light and will show special marks made with fluorescent ink.

1.3Motivation.

The rate at which counterfeit note is being circulated in countries like India and The United States of America is on the increase today. The Central Banks in these countries spend a lot of money in making sure these currencies are produced with security features but with the advancement in technology, counterfeiters are producing currencies that almost match that of the original currencies; hence my reason for embarking on this project.

1.4 Significance of the Study.

This study will contribute to the efficient handling and counting of currencies and to minimize the circulation of counterfeit notes in malls, banks, etc.

1.5 Aim and Objectives.

The aim of this project is to design and construct a currency counting machine with fake note detection. The objectives of this project are:

- To provide a device that can detect counterfeit new banknote.
- To provide a device that can count the amount of banknote automatically.
- To provide a device that uses UV light and programming language software to detect a value and originality of banknotes.
- To evaluate the performance of the developed currency recognition machine.

1.6 Scope of the Project.

To analyze how to detect banknote from the security feature of the new banknotes issued by the Central Bank of Nigeria, this project selected several features to be used as a guide to identify the genuine banknote. The hardware that is used to detect genuine banknote is the UV light lamp and a camera to capture and send images of banknote to be processed. The software is then developed for counting and processing images to identify whether the banknote is genuine or fake. After that the count value or the result of the process image will be sent to the display screen.

The remaining sections are further arranged as follows: Chapter two describes the literature review of the fake note recognition system. Chapter three explains the methodology of the fake note recognition system. The testing and analysis of results as regards the fake note currency recognition system is in Chapter four. Chapter five gives the conclusion of the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

A large number of researchers have made several contributions toward developing techniques for currency recognition. The different properties between banknotes make researchers deal with the recognition task differently for each one of them. In this section, we review previous works in currency recognition techniques.

2.1RELATED WORKS

The authors in [6] propose a counting machine that uses the embedded system Arduino for the functioning of the machine; it utilizes a sensing technology to sense the count entered and sends the corresponding signals to the input stations of the IC in the Arduino board. The usage of Arduino board makes the machine more precise in functioning. The Arduino board on receiving the signals sends signals to input pins of a display which shows the number of the papers counted. The usage of Arduino makes the interfacing of the display and programming of the proposed project more favourable. The desirable count of papers can be counted out from a bundle by inputting the number. The automatic paper counting machine finds a plentiful application in many fields and is proposed as a remedial measure for the problem raised in the exam cell of the college (on counting papers like a question and answer sheets) which was displayed as a publication within the campus on various notice boards welcoming remedial measures.

In [7], the authors describe an efficient automatic framework for detecting fake money notes. Also, it symbolizes a classification framework for linking original notes to their source printing presses. Experimental results the detection and classification frameworks have a number of accuracies.

In [8], authors propose fake currency detection using image processing. In image pre-processing the image was cropped, adjusted and smoothed. Then the image converted into gray scale. After conversion the edges are detected. In edge detection, sobel operator was used. Next the image segmentation is applied. After segmentation the features are extracted and then compared to find out if the currency is original or fake.

In summary, the system consists of eight steps including image acquisition, grey scale conversion, edge detection, feature extraction, image segmentation, comparisons of images and output.

Authors in [9] propose fake currency detection using six parameters- Features such as Luminance, Chrominance, Saturation, Intensity, Entropy and Peak Signal to Noise Ratio (PSNR). Experimental results on sample images show that the approach performs well in terms of calculating parameters value. Their work was motivated by the desire to overcome the shortcomings of general purpose Fake Currency Detection approaches which cannot be viewed by normal eye. An overview of content based Fake Currency Detection provided and investigated some techniques for color image processing. The experiment was carried out on variety of note images.

In [10], the authors propose an Indian Currency Recognition System using Neural Network [NN] Pattern Recognition tool. The experiment was conducted with 540 images of some denominations of the rupees. Canny edge detector was chosen for segmentation and classification. The result shows the recognition accuracy to be 95.6%.

In [11], the authors proposed to develop a system to detect fake currency for Indian Notes. In their work, they took the input of the given image and preprocessed the given image and converted the Red, Green, Blue [RGB] image into the gray scale image. After preprocessing, they applied sobel algorithm for extraction of the inner as well as outer edges of the image. Clustering was done using k-means algorithm; in which it formed the clustering of feature one by one. After it recognized the input image as a 200, 500, or 2000 and compared the features of the image, it then classified it as original or fake with the help of Support Vector Machines (SVM) algorithm.

The authors in [12] propose to provide coins equivalent to note. The circuit uses microcontroller with mechanical structure which have motors to perform requested tasks. Here the machine accepts note and checks whether a note is fake or real. If a note is real, camera takes picture of note and checks which note it is (10 or 20 rupees) with the help of computer-installed MATLAB program. Once the note is recognized coins will be dispensed by coin dispensing unit.

The authors in [13] propose a technique that consists of decomposing original images of 256 gray levels into their equivalent 8 binary images. This technique is useful in analyzing the relative importance contributed by each bit of the original image. Higher order bit levels are evaluated for grayscale banknote images with the application of Canny edge detection algorithm.

In [14], the authors study banknotes from different countries as the main objective was to recognize currencies used in various countries. Features such as texture analysis, color analysis, and the size of the currency notes were used for currency recognition. A different study, also based on currency recognition, presents an approach to recognize serial numbers on the current Chinese currency notes [15]. This study uses various components of image processing, including image binarization, morphological filtering, feature extraction, segmentation, and digit recognition. However, it did not focus on distinguishing between authentic and counterfeit currency notes.

To verify Indian currency, the work in [16] used image processing techniques such as edge detection and image segmentation to compare between the output images of genuine and counterfeit banknotes. Their approach was used to extract characteristics of the Indian paper currency such as identification mark, security thread, and watermark. In [17], the authors also used image processing techniques such as edge detection and image segmentation to compare between the output images of genuine and counterfeit banknotes. Their approach was used to extract characteristics of the Indian paper currency such as latent mark, security thread, ultraviolet fluorescence and watermark.

In [18], canny operator was used for edge detection to capture and extract currency characteristics. The process of identifying original from counterfeit money in this paper was done by comparing the images after extracting important characteristics from both versions. The authors concluded that by using canny operator for edge detection and image segmentation, the process of detecting original and counterfeit paper currency would be considerably more rapid and effective. In [19], the authors explained fake note detection for a deposit ATM. They posited that the genuineness of a bill is ultimately decided by the fact whether the bill has the security thread or not. Based on the decision, a Go – No Go signal is generated and the currency is accepted or rejected.

The authors in [20] presented a review of paper currency recognition system. They opined that the recognition system mainly consists of three parts-the image of interest is first pre-processed by reducing dimensionality and extracting the feature by applying image processing toolbox of MATLAB, known as feature extraction. The second part is currency recognition, where classifier such as neural network is used. The result is then displayed. The authors in [21] presented currency recognition system using image processing. They aimed at designing an easy but efficient algorithm that would be useful for maximum number of currencies using colour and feature analysis. The currencies used were the Indian Rupees, Australian Dollar, Euro, Saudi Arabia Riyal and the US Dollar. The result showed that the algorithm worked well for four of the five currencies as the US Dollar had minute differences in its colour and size.

The authors in [22] included the feature of bill sorting of different denominations for a particular currency asides the counting and fake note detection. They proposed the use of an optical sensing and correlation technique based on the sensing of bill reflectance characteristics obtained by illuminating and scanning a bill along its narrow dimension. A series of detected reflectance signals were then obtained by sampling and digital processing, under microprocessor control, the reflected light at a plurality of predefined sample points as a currency bill is moved across an illuminated strip with its narrow dimension parallel to the direction of transport of the bill; the sample data was then subjected to digital processing, including a normalizing process, whereby the reflectance data represents a characteristic pattern that is unique for a given bill denomination and incorporates sufficient distinguishing features between characteristic patterns for discriminating between different currency denominations.

In [23], the authors presented an embedded system for the detection of counterfeit Indian Paper Currency. They used the properties of the HSV (Hue, Saturation and Value) color space with emphasis on the visual perception of the variation in Hue, Saturation and Intensity values of an image pixel. In this technique, Fitting tool of Neural Network is used for the purpose of paper currency verification and recognition. Crucial features from Indian banknotes were extracted by image processing and experimented on Neural Network classifier. The success-rate of the counterfeit detection with properly captured image was 100%.

The authors in [24] present an algorithm with low computational complexity, which can meet the high speed requirement in practical applications. However, the proposed technique may not be able to distinguish counterfeit notes from genuine notes. The authors in [25] propose a new intelligent system for Pakistani paper currency recognition. This proposed system requires less time compared with other systems. Three layer feed-forward Back propagation Neural Network (BPN) is used for classification. The system is tested with 350 Pakistani banknotes. The result indicates that the system had 100% recognition accuracy. This technique is applied on banknotes without any distortion (e.g., wrinkled or folded)

Debnath et al. [26] presents a paper currency recognition system using ensemble neural network (ENN). The individual neural networks (NNs) in an ENN are qualified through negative correlation learning (NCL). The used banknotes are from three types new, old and noisy. The banknote image is converted into gray scale and then compressed. Then each pixel of the compressed image is passed as an input to the network. This method can recognize and match noisy currency images and it produces good results when compared to single network and ensemble network with independent training. The results show the recognition accuracy range from 100% to 54% depending on the noise level of the input image.

The authors in [27] conducted heuristic analysis of characters and digits for Indian currency notes for recognition. This process is invariant to light conditions, use font type and deformations of characters caused by a skew of the image. Heuristic analysis of the characters is performed for this purpose to get the exact features of characters before feature extraction. One of the challenges raised in the character segmentation part is that two characters are sometimes joined together. These techniques focus on extracting the number on the paper currency. However, such technique is not feasible in the case of wrinkled or folded banknote.

The authors in [28] developed a mobile currency recognition system using scale-invariant feature transform (SIFT) to recognize partial images. The system is evaluated using a limited sample set with different state as: folded, incomplete or having orientation and rotation effects. The results indicate that the nearest neighbor algorithm provides an accuracy of 75% and the nearest to second nearest neighbor ratio algorithm provides an accuracy of 93.83%. In [29], the authors developed a banknote recognition system to recognize many banknotes in different perspective views and scales. Feature detection, description and matching were used to enhance the confidence in the recognition results. The banknote contour was computed using a homography. The system was evaluated with 82 test images, and all the Euro banknotes were successfully recognized. The system provided robust results to handle folded and wrinkled banknotes with several kinds of illumination. The algorithm needed several steps with high computation overhead which made it not suitable to be used by a smartphone.

The authors in [30] presented a survey on Fraud Detection Techniques by using performance metrics. The various fraud detections like credit card fraud, computer intrusion and telecommunication fraud were surveyed. The main methods behind the credit card fraud detections and computer intrusion are neural networks and model based reasoning, some with data mining. In telecommunication fraud detection, the visualization methods were used. In [31], the authors present a fake currency detection using image processing and other standard methods such as watermarking, optically variable ink, florescence, security thread, intaglio printing, latent image, micro lettering and identification mark. By combining two various components of two images then, the variation is decreased.

In [32], the authors present an Indian paper currency authentication system based on feature extraction by edge based segmentation using sobel operator. To do this, the features are extracted from the original image and the edges are identified. Then, the edges are segmented and compared with the dataset in order to enable fake detection. According to the authors in [33], the expansion of modern banking services necessitates the need for automatic currency recognition and authentication system, thus encouraging many researchers to develop high accuracy, reliable and high processing speed techniques. To detect the authenticity of currency note there are two methods i.e. first line inspection method and second line inspection method. First line inspection method includes varied density watermarks, ultraviolet fluorescence, intaglio printing, micro text and hologram while the second line inspection methods include isocheck/ isogram, fiber based certificates of authenticity, color and feature analysis. The authors in [34] were of the view that the currency notes are provided with few special identification marks only for the blind people so that they may easily recognize the denomination correctly. Every currency note has its denomination engraved at the top right end which is sensitive to touch, but this mark fades away after the currency note goes in circulation for some time. This aids the impaired people to correctly determine the denomination of the currency note. It uses a currency localization technique to extract the currency note from a color image. The technique requires feature based currency note localization. This is applied using the Image Processing toolbox available in Matlab.

In [35], the authors focus on an advanced mobile based application that is used to identify fake money. The application for counterfeit notes is to empower the common man with an easily available device to help him detect fake notes. This application can be used on day-to-day basis by us for identifying fraudulent currency notes. Unlike the existing money detectors in banks, the proposed counterfeit currency detector will provide user friendly and portable application to detect forged banknotes.

The authors in [36] conducted a research on money counting machine with the use of an arm microcontroller. The counter is designed to count notes in addition to detect fake notes. The whole system is controlled by the microcontroller (type Teensy) which is based ARM processor. The currency counting machine works on the principle on the pack of the bundle of money and there is a roller which has penises in a continual pattern and the roller moves these rods with a particular speed and the roller moves these rods in conjunction with the bunch of money at a steady and high speed in a manner that singles out the money one after the other. There is also a transducer which detects the number of times a single currency passes out in front of it. For fake detection, it is based on used UV detection. This research was based on the fact that the fake currency created by color copier or printer will produce an image that rests on the surface of paper which can easily be seen when UV light is placed over it.

In [37], authors propose an efficient and simple machine which that fulfills the need of coins for transactions so that people will not face problem of coins. The proposed machine would provide coins for genuine note. This is to be done using feature extraction. This technique uses four characteristics of currency including watermark, note size, serial number, and identification mark of the note. The proposed system has been helpful in day to day life of every common man where people have to suffer for change at many public places. The authors in [38] also propose a note to coin exchanger with a fake note detection unit. Here, the UV LED mechanism is the basis for its fake note detection unit. Different image processing techniques are then used to detect note denomination e.g. RGB image, HIS model and edge detection (using sobel operator).

The authors in [39] propose coin recognition system using the direction of the gradient vectors and Fast Fourier Transform. The classification is done using the nearest neighbor search. The results show that the directional information is good enough to design a reliable classification system that achieves 97% accuracy. In [40], the authors present an Indian coin recognition system. Segmentation technique is applied by traversing row wise and column wise through the image. The image is selected for comparison based on the radius matching. The paper mentions that the proposed method achieved good accuracy of coin recognition with no more details about the accuracy rate.

The authors in [41] developed an Artificial Neural Network (ANN) Automated Indian Coin Recognition System with rotation invariance. Hough transformation and pattern averaging techniques are used to extract the image features. Then, the extracted features are passed as input to train neural network. The trained neural network is tested and validated using 5040 images of all the Indian coin values that are rotated at different angles. Experiments show that the system had 97.74% correct recognition rate. In [42], the authors presented a simple Indian coin recognition method with rotation invariance. The HT algorithm combines the features of straight line detection HT algorithm, curve detection and circle detection HT algorithm. The results show that the method obtains 100% correct recognition.

The authors in [43] proposed the design of a coin recognition system by applying adaptive hinging hyperplanes (AHH) algorithm with rotation invariance to classify the Indian coins. The system takes the parameters of Indian coins such as size, shape, weight, surface and so on. The system provides good result of coin identification in different rotation degrees with no information about the achieved accuracy. These techniques take one invariant of the taken image which is rotation. Other invariants when the image is taken were not considered. However, such multiple invariants are necessary to be considered to achieve accurate recognition in an uncontrolled environment.

In [44], the authors propose a method to design a neural network (NN) using a genetic algorithm (GA) and simulated annealing (SA). The similar characteristics of the coin images (i.e., size, weight, color and pattern) cause a trouble for currency recognition. The proposed scheme discovered several features and the recognition rate was approximately 98%. This technique needs long time and high computational power. So, it is not suitable for smartphone.

The authors in [45] propose an image processing technique to extract paper currency denomination. The extracted Region of Interest (ROI) is used with pattern recognition and neural networks matching technique. In this method, images are captured by a simple flat scanner with a fixed size and then some filters are applied to extract the denomination value of the banknote. However, the accuracy of their proposed algorithm could not be well ascertained.

CHAPTER 3

MATERIALS AND METHODOLOGY.

3.0 METHODOLOGY.

The Naira notes are protected by some security features to enable the recognition of genuine notes. We will need to analyze some of these features in order to design the machine to differentiate genuine notes from the counterfeits as counterfeiting has been occurring ever since humans grasped the concept of valuable items. Some of the features [46] include:

- Water marks
- Kinegrams (the gold foil).
- Security thread
- UV fluorescence.
- Presence of scattered fibres.

Water marks: For example, in the 1000 naira note, you can see a water mark in the pinkish area on the front of the note. When held against the light, the portraits of Dr. Clement Isong and Alhaji Aliyu Mai-Bornu can be seen with the letters "CBN" in water mark.

Kinegrams (the gold foil): Also noticeable in the 1000 naira note is the gold foil on the front of the note which usually has magnetic properties.

Security thread: The security thread is the metallic strip on the back of the note. When tilted, the colour changes with the letters "CBN" visible. When held against the light, the strip will as a continuous dark line with the letters "CBN" more visible.

UV fluorescenence: It is possible to see the black serial numbers with the eye but under ultraviolet light, the numbers fluoresce green. Also, the back of a 1000 naira note shows two large numerals as well as a small circle near the top of the note when viewed under UV Light. The two solid segments in the circle are blue under normal light but turn to light blue and green when viewed under UV Light. The white section of small circle also turns violet UV Light.

Presence of scattered fibres: The naira banknote paper has florescence scattered fibers which appear red and blue under ultra violet light (UV Light).

The distinguishing features which can be immediately recognized by touch and visibility are raised print, the security thread and the watermark. Other areas such as the portrait, lettering and the denominational numerals on the front and the back are embossed.

3.1 REQUIREMENTS SPECIFICATION/COMPONENTS USED.

The circuit diagram below for this project was designed with the aid of the Proteus software.

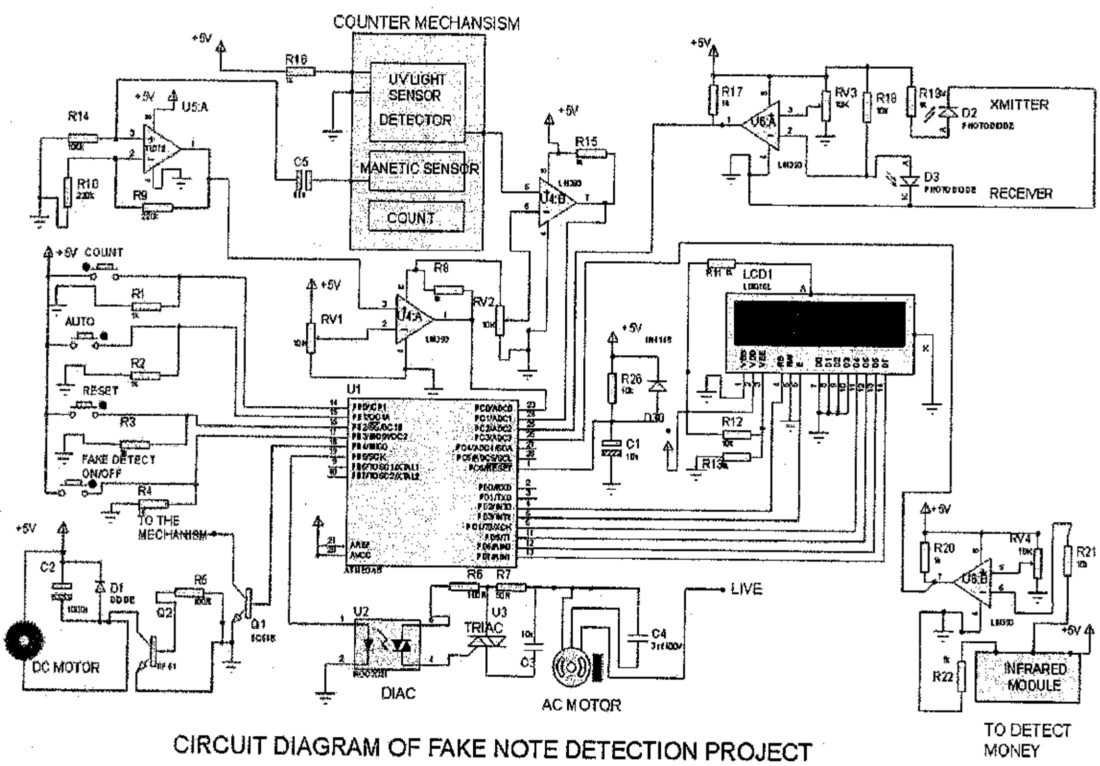


Figure 3.1: Circuit diagram of the Currency Counting Machine

The components used in designing this machine are:

1. The Atmega 8 microcontroller.
2. The Magnetic sensor.
3. The Infrared sensor.
4. The UV Light Sensor.
5. Resistors
6. Capacitors.
7. Transistors.
8. Diac and Triac.
9. Voltage comparators.
10. AC Motor.
11. DC Motor.
12. Amplifiers.
13. Diodes.

The fake note detection circuitry is majorly controlled by the Atmega 8 microcontroller.

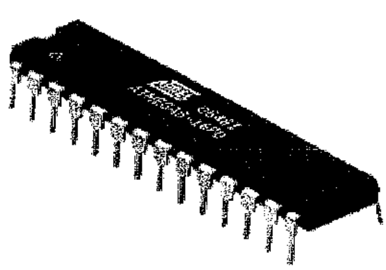


Figure 3.2: The Atmega 8 Microcontroller

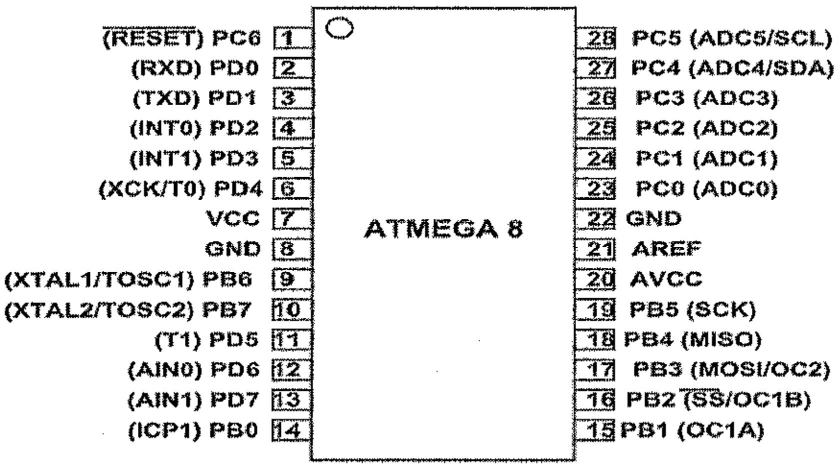


Figure 3.3: The pins of the Atmega 8 Microcontroller.

It is a 28-pin integrated circuit (IC) with 23 I/O lines. It has 3 I/O ports named B, C and D ports. Ports B and D consist of 8 I/O lines each while port C consists of 7 I/O lines [47]. It consists of inputs and output pin, positive and negative pins and reset pin. The reset pin is pin 1- on it are components like resistors, diode (LN4148) and capacitor. All these serve as protection for this pin against damage, before +5V is fed into it as the IC can only be powered by this voltage value as designed by the manufacturer in the datasheet of the IC. The other pins are input pins by default and made outputs using the programming language for them. The microcontroller has the following features [48]:

- High-performance, Low-power Atmel AVR 8-bit Microcontroller
- Advanced RISC Architecture
  - 130 Powerful Instructions
  - Most Single-clock Cycle Execution
  - 32 × 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16MIPS Throughput at 16MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
  - 8Kbytes of In-System Self-programmable Flash program memory
  - 512Bytes EEPROM
  - 1Kbyte Internal SRAM

❖ Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
❖ Data retention: 20 years at 85°C/100 years at 25°C(1)
❖ Optional Boot Code Section with Independent Lock Bits
❖ In-System Programming by On-chip Boot Program
❖ True Read-While-Write Operation
❖ Programming Lock for Software Security

The microcontroller controls every other sections of this project. The mechanism part (counter) consists of some sensors that enable it to work effectively for counting money and also to detect fake note. The sensors are:

➢ Ultraviolet sensors;
➢ Magnetic sensors; and
➢ Infrared sensors.

One of the important features of ATmega8 is that except 5 pins, all other pins support two signals.

- Pins 23,24,25,26,27,28 and 1 are used for port C, whereas pins 9,10,14,15,16,17,18,19 are used for port B and pins 2,3,4,5,6,11,12 are used for port D.
- Pin 1 is also the Reset pin. Applying low level signal for a time longer than the minimum pulse length will generate a reset.
- Pins 2 and 3 are also used for serial communication for USART.
- Pins 4 and 5 are used as external interrupts. One of them will trigger when interrupt flag bit of status register is set and the other will trigger as long as the interrupt condition prevails.
- Pins 9 and 10 are used as external oscillator as well as timer counters oscillators where the crystal is connected directly between the pins. Pin 10 is used for crystal oscillator or low frequency crystal oscillator. If the internal calibrated RC oscillator is used as the clock source and the asynchronous timer is enabled, these pins can be used as a timer oscillator pins.
- Pins 11 and 6 are used as timer/counter sources.
- Pins 13 and 12 are used as Analog Comparator inputs.
- Pin15 can be used as an external output for the timer/counter.
- Pin16 is used as a slave select input. It can also be used as a timer/counter1 compare match by configuring the PB2 pin as an output.

- Pin 17 is used as Master data output, slave data input for SPI channel. It is used as 'A' input when enabled by a slave and is bidirectional when enabled by the master. This pin can also be used as 'A' output compare match output, which serves as an external output for the timer/counter compare match.
- Pin 18 is used as Master clock input, slave clock output.
- Pin 19 is used as Master Clock output, slave clock input for SPI channel.

Their activities are thus controlled by the microcontroller as follows:

On pin PCO/ADCO: The magnetic sensor in the counter mechanism senses when money is placed, detects the magnetic/foil part of the money and then sends the signal to the amplifier. The low noise amplifier TL072 which has a gain >10, the output is then fed to the LM393 voltage Comparator. The LM393 IC converts the analog voltage signal to digital form which is in 0 or 1. This will now be sent to the atmega microcontroller which gives the output on the Liquid Crystal Display (LCD) as to when the money is fake or original.

On pin PC1/ADC1: This uses the ultraviolet light sensor to detect the fake note as the UV sensor sends the analog voltage signal to the voltage comparator LM393 which compares voltages and sends it output in form of logic '0' or '1'.

On pin PC2/ADC2: this is the pin for controlling the money counting- this pin detects based on the two infrared sensors attached to it. The transmitter and receiver, when money is placed in the mechanism, the light in between the two sensors (Tx and Rx) is broken or abridged. This sends the information to the LM393 which communicates with the microcontroller. If the logic level is '1', the microcontroller stars counting but if its '0', then there is nothing to count.

On pin PC3/ADC3: is another infrared module sensor which is responsible for detecting when the money is fake or original. The component attached to the voltage comparator LM393 are used based on specification in its datasheet.

Connected to the microcontroller are some control buttons: PB0, PB1, PB2, PB3 and PB4.

Pin PB0: It is pressed to count money when placed in the mechanism.

Pin PB1: it is pressed to count money automatically such that when money is placed in the counter, no button needs to be pressed again- it just starts counting.

Pin PB2: Is used to reset the counting machine.

Pin PB3: It is pressed 'ON' to detect fake note, and 'OFF' to just count but not detect fake note.

Pin PB4: It is used to control the DC Motor in the counter. This motor is controlled by the microcontroller. The transistor BC548 is connected to the pin to prevent the flow of back emf. Also connected to the transistor is another transistor TIP41 which is used as an electronic switch for the motor. The DC motor is the smaller of the two motors in the counter for bringing out the money after counting.

Pin PB5: Here, the microcontroller controls the AC motor with this pin. In order for this pin to work effectively, TRIAC BT139 is used as its switch but for every triac to work, there is the need for a diac, hence DIAC MOC3021 is used for this purpose. The AC motor is responsible for counting the money as soon as it is placed in the counter and it is the bigger of the two motors.

On the LCD, the LCD gives the result or output by giving a count of the number of notes that enter the counter and it stops and a loud sound is heard if the fake note buzzer is 'ON'.

- Resistors

Resistors (R), are the most commonly used of all electronic components, to the point where they are almost taken for granted. There are many different resistor types available with their principal job being to "resist" the flow of current through an electrical circuit, or to act as voltage droppers or voltage dividers. They are "Passive Devices", that is they contain no source of power or amplification but only attenuate or reduce the voltage signal passing through them. When used in DC circuits the voltage drop produced is measured across their terminals as the circuit current flows through them while in AC circuits the voltage and current are both in-phase producing 0o phase shift.

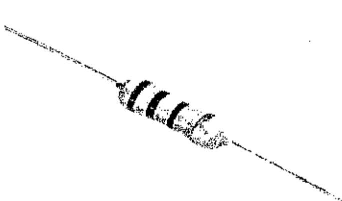


Figure 3.4: A resistor

Resistors produce a voltage drop across themselves when an electrical current flows through them because they obey Ohm's Law, and different values of resistance produces different values of current or voltage. This can be very useful in Electronic circuits by controlling or reducing either the current flow or voltage produced across them. There are many different Resistor Types and they are produced in a variety of forms because their particular characteristics and accuracy suit certain areas of application, such as High Stability, High Voltage, High Current etc., or are used as general purpose resistors where their characteristics are less of a problem. Some of the common characteristics associated with the humble resistor are; Temperature Coefficient, Voltage Coefficient, Noise, Frequency Response, Power as well as Temperature Rating, Physical Size and Reliability.

- Capacitor

Just like the Resistor, the Capacitor or sometimes referred to as a Condenser is a passive device, and one which stores energy in the form of an electrostatic field which produces a potential (Static Voltage) across its plates. In its basic form a capacitor consists of two parallel conductive plates that are not connected but are electrically separated either by air or by an insulating material called the Dielectric.

When a voltage is applied to these plates, a current flows charging up the plates with electrons giving one plate a positive charge and the other plate an equal and opposite negative charge. This flow of electrons to the plates is known as the Charging Current and continues to flow until the voltage across the plates (and hence the capacitor) is equal to the applied voltage Vc.

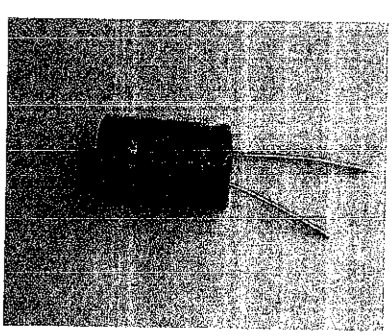


Figure 3.5: A Capacitor

- UV Detector

UV detectors function on the capacity of many compounds to absorb light in the wavelength range 180 to 350 nm. The sensor cell usually consists of a cylindrical cavity about 1 mm I.D and a few mm long, having a capacity that ranges from about two micro-liters to eight micro-liters.

Light from a UV light sources passes through the sensor onto a photoelectric cell, the output from which is electronically modified and presented on a potentiometric recorder, a computer screen, or printer. By interposing a monochrometer between the light source and the cell, light of a specific wavelength can be selected for detection and, thus, improve the detector selectivity.

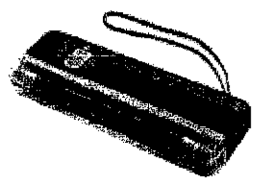


Figure 3.6: A UV Light Detector

Alternatively a broad band light source can be used and the light after passing through the cell can be optically dispersed by prism or grating and allowed to fall onto a diode array. By monitoring a specific diode, the detector can be made specific for those substances that absorb at that particular wavelength. If the output from all the diodes is scanned then a UV absorption spectrum can be obtained to aid in solute identification. The fixed wavelength UV detector has a sensitivity of about 1 x 10-8 g per ml at a signal to noise ratio of two are the UV detector (fixed and variable wavelength) the electrical conductivity detector, the fluorescence detector and the refractive index detector.

- Diacs and Triacs.

Diac is a two-terminal, four layer semiconductor device (thyristor) that can conduct current in either direction, when polarity is active. Diacs are electronic components which offer no control or amplification but act much like a bidirectional switching diode as they can conduct current from either polarity of a suitable AC voltage supply [49]. A triac is a type of thyristor that can conduct current in both directions when the polarity is activated. The Triac is like a Diac, but with a gate terminal. Diacs are primarily used as trigger devices in phase-triggering and variable power control applications because a diac helps provide a sharper and more instant trigger pulse (as opposed to a steadily rising ramp voltage) which is used to turn "ON" the main switching device. The diac is commonly used as a solid state triggering device for other semiconductor switching devices, mainly SCR's and triacs. Triacs are widely used in applications such as lamp dimmers and motor speed controllers and as such the diac is used in conjunction with the triac to provide full-wave control of the AC supply as shown. In this case, the triac is used as a speed controller for the AC Motor.

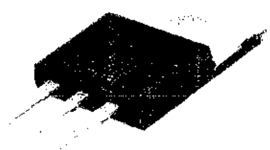


Figure 3.7: A Triac

➢ Comparators [LM393].

The comparator is used to compare two voltages or currents which are given at the two inputs of the comparator. That means it takes two input voltages, then compares them and gives a differential output voltage either high or low-level signal. The comparator is used to sense when an arbitrary varying input signal reaches reference level or a defined threshold level. The comparator can be designed by using various components like diodes, transistors, op-amps. The comparators find in many electronic applications that may be used to drive logic circuit. Some of the features of the circuit include [50]:

- Wide Single–Supply Range: 2.0 Vdc to 36 Vdc
- Split–Supply Range: ±1.0 Vdc to ±18 Vdc
- Very Low Current Drain Independent of Supply Voltage: 0.4 mA
- Low Input Bias Current: 25 nA
- Low Input Offset Current: 5.0 nA
- Low Input Offset Voltage: 5.0 mV (max) LM293/393
- Input Common Mode Range to Ground Level
- Differential Input Voltage Range Equal to Power Supply Voltage

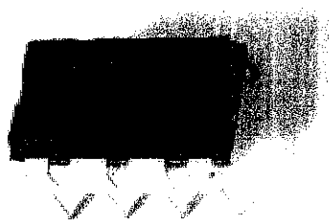


Figure 3.8: LM393 IC

➢ DC Motor.

This DC or direct current motor works on the principle, 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.

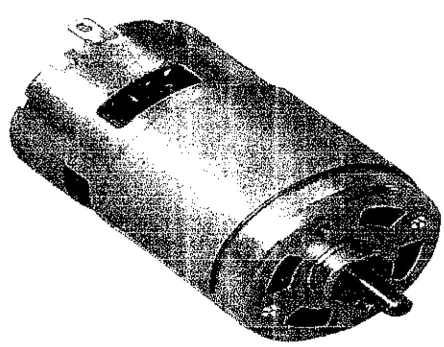


Figure 3.9: A DC Motor.

The direction of rotation of a this motor is given by Fleming's left hand rule, which states that if the index finger, middle finger, and thumb of your left hand are extended mutually perpendicular to each other and if the index finger represents the direction of magnetic field, middle finger indicates the direction of current, then the thumb represents the direction in which force is experienced by the shaft of the DC motor. The dc motor here helps to collect the money at the frontal platform and rated at 12V.

- AC Motor.

Unlike toys and flashlights, most homes, offices, factories, and other buildings aren't powered by little batteries: they're not supplied with DC current, but with alternating current (AC), which reverses its direction about 50 times per second (with a frequency of 50 Hz). If you want to run a motor from your household AC electricity supply, instead of from a DC battery, you need a different design of motor.

In an AC motor, there's a ring of electromagnets arranged around the outside (making up the stator), which are designed to produce a rotating magnetic field. Inside the stator, there's a solid metal axle, a loop of wire, a coil, a squirrel cage made of metal bars and interconnections (like the rotating cages people sometimes get to amuse pet mice), or some other freely rotating metal part that can conduct electricity. Unlike in a DC motor, where you send power to the inner rotor, in an AC motor you send power to the outer coils that make up the stator. The coils are energized in pairs, in sequence, producing a magnetic field that rotates around the outside of the motor.

The AC Motor in this circuit helps to count the money as it is coming in from the hopper section.

- Infrared Sensors.

An infrared sensor is an electronic instrument that is used to sense certain characteristics of its surroundings [51]. It does this by either emitting or detecting infrared radiation. Infrared sensors are also capable of measuring the heat being emitted by an object and detecting motion. IR (infrared) sensors detect infrared light. The basic concept of IR (infrared) obstacle detection is to transmit the IR signal (radiation) in a direction and a signal is received at the IR receiver when the IR radiation bounces back from a surface of the object. The IR light is transformed into an electric current, and this is detected by a voltage or amperage detector. A property of light-emitting diodes (LEDs) is that they produce a certain wavelength of light when an electric current is applied--but they also produce a current when they are subjected to the same wavelength light.

A pair of IR LEDs can be used as motion detectors in the currency counting machine. The first IR LED is wired to emit LED and the second LED is wired to transmit a signal when it receives an IR input. When an object comes within range of the emitted IR, it reflects the IR back to the receiving LED and produces a signal. This signal can be used to open sliding doors, turn on a light or set off an alarm. Some of the features include:

- There is an obstacle, the green indicator light on the circuit board
- Digital output signal
- Detection distance: 2 ~ 30cm
- Detection angle: 35 ° Degree
- Comparator chip: LM393
- Adjustable detection distance range via potentiometer:
- Clockwise: Increase detection distance
- Counter-clockwise: Reduce detection distance.

Its specifications are:

- Working voltage: 3 - 5V DC
- Output type: Digital switching output (0 and 1)
- 3mm screw holes for easy mounting

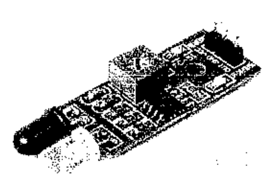


Figure 3.10: Infrared Sensor.

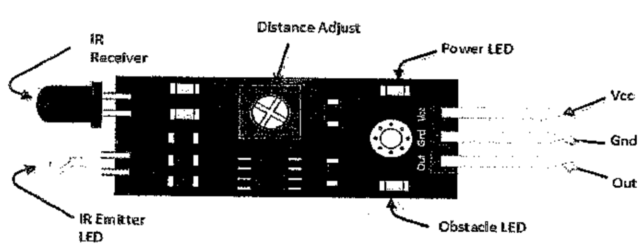


Figure 3.11: Internal Structure of the Infrared Sensor.

Pin, Control Indicator	Description
Vcc	3.3 to 5 Vdc Supply Input
Gnd	Ground Input
Out	Output that goes low when obstacle is in range
Power LED	Illuminates when power is applied
Obstacle LED	Illuminates when obstacle is detected
Distance Adjust	Adjust detection distance. CCW decreases distance. CW increases distance.
IR Emitter	Infrared emitter LED
IR Receiver	Infrared receiver that receives signal transmitted by Infrared emitter.

- Magnetic sensors.

Magnetic sensors convert magnetic or magnetically encoded information into electrical signals for processing by electronic circuits. Magnetic sensors are solid state devices that are becoming more and more popular because they can be used in many different types of application such as sensing position, velocity or directional movement. The magnetic sensors check for magnetic properties in the currencies to confirm if they are genuine or counterfeit.

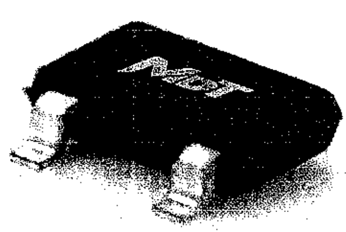


Figure 3.12: A Magnetic Sensor.

UNIVERSITY LIBRARY
FEDERAL UNIVERSITY
OYE - EKITI
(FUOYE)

3.2 DESIGN.

The power supply unit for the currency counting machine is an a.c source which is about 220V which is stepped down to 12V and then to 5V using a step-down transformer. When money is dropped in the hopper of the counter and the count button is pressed, the ac motor drives the money in and with the use of a transducer it counts the number of currencies that pass through it and gives the result of the count on the LCD. For the fake note detection unit, three major sensors are used: the ultraviolet light sensor, the magnetic sensor and the infrared sensor. The ultraviolet sensor checks for missing marks & irradiation response of the counterfeit notes. The magnetic sensor checks for magnetic ink & different patterns of security strip which can be detected by using the magnetic head with a precision amplification scheme. The Infrared sensors are used for the thickness detection of the banknote & the absorption of infrared signals to identify the genuine banknotes. If the currency passes the tests of these sensors, then the money comes out of the machine and is seen by the machine as "genuine". If the money does not pass the tests of these sensors the machine immediately stops counting when it detects a counterfeit note and then a buzzing sound is heard to show that the note is fake.

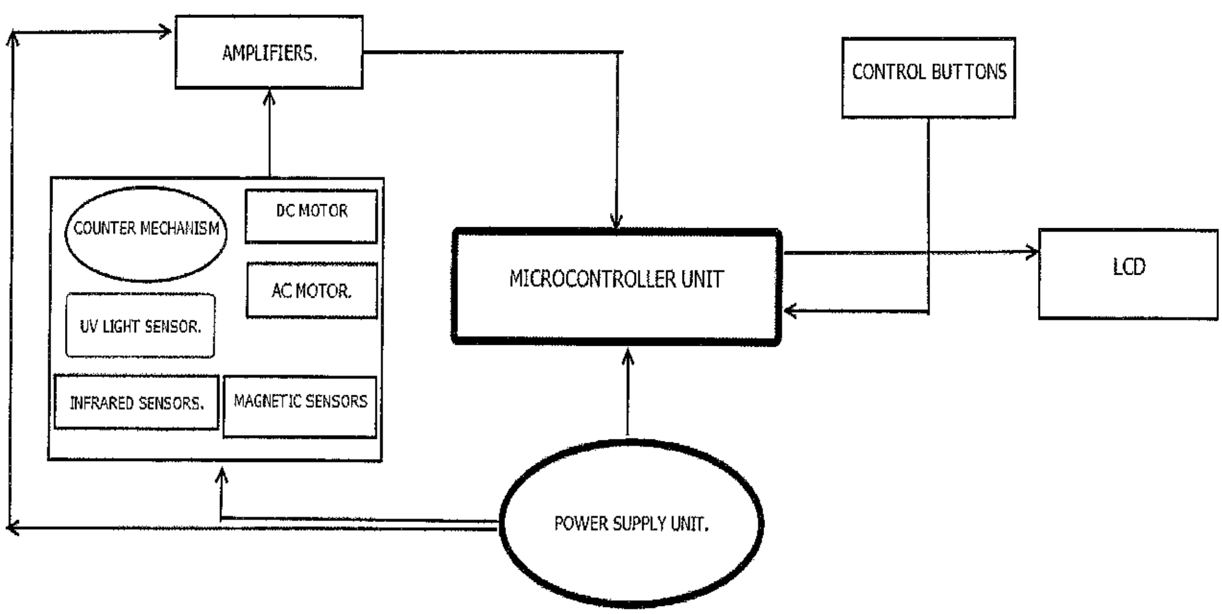


Figure 3.13: Block diagram of the currency counting machine with fake note detection

3.2.1 ARCHITECTURE OF THE ATMEGA 8 MICROCONTROLLER.

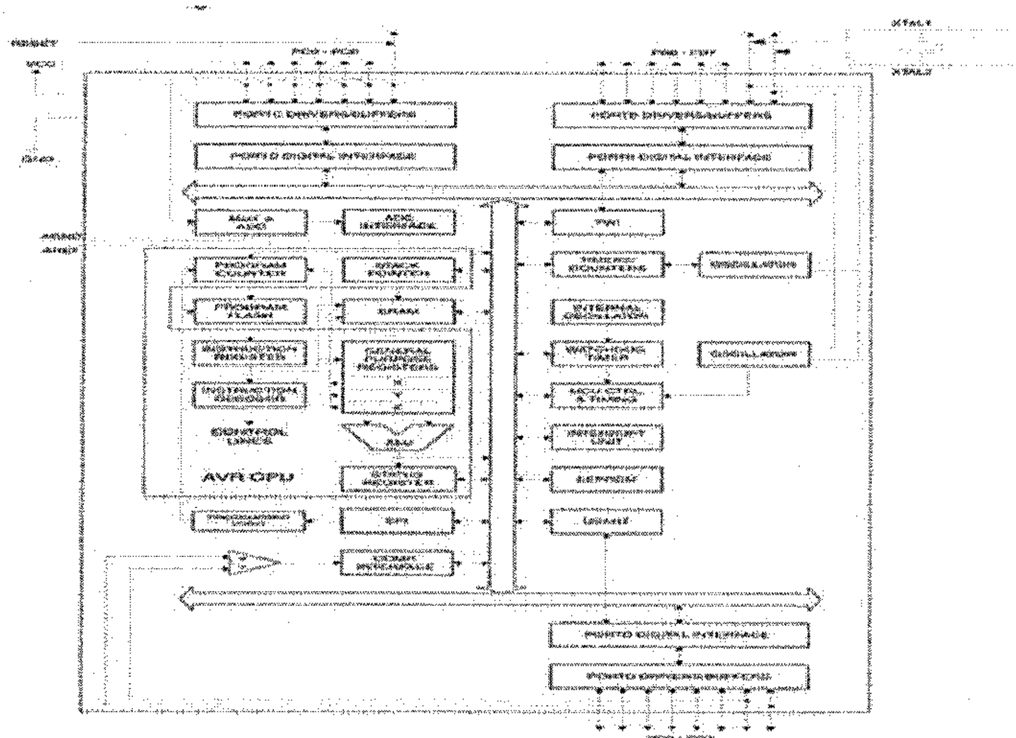


Figure 3.14 Architecture of the Atmega8 Microcontroller.

The atmega8 microcontroller is an 8-bit CMOS built microcontroller from the AVR family and is built on the RSIC (Reduced Instruction Set Computer) architecture. Its basic advantage is it doesn't contain any accumulator and the result of any operation can be stored in any register, defined by the instruction [47]. The architecture consists of the program counter, SRAM, ADC Interface, Timers/Counters, Oscillators, Interrupt unit, EEPROM, USART etc.

Memory

It consists of 8KB of flash memory, 1KB of SRAM and 512 Bytes of EEPROM. The 8K flash is divided into 2 parts- lower part used as boot flash section, and upper part used as application flash section. The SRAM contains 1K bytes along with 1120 bytes of general purpose registers and I/O registers. The lower 32 address locations are used for 32 general purpose 8 bit registers. The next 64 address are used for I/O registers. All the registers are connected directly to the ALU. The EEPROM is used to store user defined data.

Input/output ports

It consists of 23 I/O lines with 3 I/O ports, named B, C and D. Port B consists of 8 I/O lines, Port C consists of 7 I/O lines and Port D consists of 8 I/O lines. Registers corresponding to any port X (B, C or D) are:

DDRX: Port X data direction register

PORTX: Port X data register

PINX: Port X input register

Timers and Counters

It consists of 3 timers with comparable modes. Two of them are 8-bit whereas the third one is 16 bit.

Oscillators

It incorporates internal reset and oscillator which makes it possible to eliminate the need for any external input. The internal RC oscillator is capable of generating internal clock which can run at any frequency of 1MHz, 2MHz, 4MHz or 8MHz as programmed. It also supports external oscillator with maximum frequency of 16MHz.

Communication

It provides both synchronous and asynchronous data transfer schemes through USART (Universal Synchronous and Asynchronous Receiver Transmitter), i.e. communication with modems and other serial devices. It also supports SPI (Serial Peripheral Interface) which is used for communication between devices based on the master-slave method. Another type of communication supported is the TWI (Two wire Interface). It allows commutation between any two devices by using 2 wires along with a common ground connection.

It also has a comparator module integrated in the chip to provide comparison between two voltages connected to the two inputs of the Analog comparator through the external chips. It also contains a 6 channel ADC out of which 4 have 10 bit accuracy and 2 have 8 bit accuracy.

Status Register: It contains information about the currently executed arithmetic instruction set.

Microcontroller Sleep Modes

The Microcontroller operates in 5 sleep modes.

- Idle Mode: It stops the functioning of the CPU, but allows operation of SPI, USART, ADC, TWI, Timer/Counter, and Watchdog and interrupts system. It is achieved by setting SM0 to SM2 bits of MCU register flag to zero.
- ADC Noise Reduction Mode: It stops the CPU but allows functioning of ADC, external interrupts, timer/counter2 and watchdog.
- Power down Mode: It enables external interrupts, the 2-wire serial interface, and watchdog while disabling the external oscillator. It stops all generated clocks.
- Power save Mode: It is used when Timer/Counter is clocked asynchronously. It halts all clocks except clk ASY.
- Stand By mode: In this mode, the oscillator is allowed to operate, halting all other operations.

3.2.2 FEATURES OF THE MACHINE.

No	Specifications	Functionality/value
1	Counting Speed	200 notes/minute
2	Hopper Capacity	40 notes [tested]
3	Power Source	230AC +10 % 50Hz
4	Operation Mode	Auto/manual
5	Types of Notes	Designed to suit all Nigerian currency notes.
6	LED Display	1 LED display. Displays the number of notes placed on the hopper for counting.
7	Detection	Suspected/Fake Note
8	Function	Verification through Ultraviolet Detection, IR Detection and Magnetic Detection.

CHAPTER 4

4.0 TESTING, ANALYSIS OF RESULTS AND DISCUSSION.

The project is a prototype designed to handle counting of the money as well as to detect fake notes in the system. A prefabricated approach was employed in the design of this project, by implementing and creating the design on a breadboard, in order to ensure that the hardware is working well before permanently executed on a Vero board. The microcontroller used in the project is the Atmega8, which is especially suitable for such applications.

All the necessary components were made available and connected properly to ensure the desired results.

4.1. TESTING

Testing is one of the important stages in the development of any new product or repair of existing ones. Because it is very difficult to trace a fault in a finished work, especially when the work to be tested is too complex. For the purpose of this project, two stages of testing are involved.

- Pre-implementation testing.
- 3Post-implementation testing.

4.1.1 PRE-IMPLEMENTATION TESTING

It is carried out on the components before they are soldered to the veroboard. This is to ensure that each component is in good working condition before they are finally soldered to the board.

I ensured I checked with the aid of a digital multi-meter, the performance of each components and their values.

4.1.2 POST-IMPLEMENTATION TESTING

After implementing the circuit on a veroboard, the different sections of the complete system were tested to ensure that they were in good operating condition. The continuity test carried out is to ensure that the circuit or components are properly linked together. This test was carried out before power was supplied to the circuit. Finally, after troubleshooting has been done on the whole circuit, power was supplied to the circuit. Visual troubleshooting was also carried out at this stage to ensure that the components do not burn out. The circuit was tested multiple times and the results were precise and correct. The counting machine was able to count some notes that were put on the hopper of the counter and made a buzzing sound when it detected a fake note as a fake note was put between the genuine notes.

After proper testing was conducted, the packaging of the design into a model and casing was done. The connecting wires were properly connected and well insulated. Also, these wires were well packaged inside the casing.

4.2. ANALYSIS OF RESULTS AND OBSERVATION

The idea was to create a currency note counting machine with fake detection which would circumvent the manual detection involved in detecting fake currency. Currency created by color copier or printer produces an image that rests on the surface of paper that can easily be seen when UV light is placed over it. Real notes are printed on optical fiber paper fake ones on thick paper made of bamboo pulp. Money Counter & Counterfeit Note Detector offers exclusive peace of mind. Provided with a top mounted numeric count display screen as well as a detachable LCD display for customers, this helps keep your counts accurate and quick. The machine is built with UV and Thread detection, this unit prevents any fakes from being passed on to you. Detecting fake bills just by looking at it, is not exactly the most efficient or even reliable way of knowing for sure if a bill is fake. Counterfeit notes are becoming more difficult to detect with the naked eye, that's where advanced machines like this come to play.

As the counting machine is connected to an a.c source, when the bills of money is placed in the hopper of the counter, if the voltage supplied to the machine is not high enough, one might have to drive the motors manually before it picks. If the voltage is high enough, the ac motor is driven and then the notes are counted in about 3 seconds and then gives a result on the LCD. The fake note buzzer is also turned on and a counterfeit note is placed between the original notes, the machine stops counting when it sees the fake note and then in a few seconds, the buzzer sounds to indicate that a fake note has been detected. Once the fake note is removed and the count button is pressed, the counter immediately counts the remainder of the notes and displays how many of such notes were placed in the stack. I observed that whenever the voltage the machine received is low, it does not drive the motor if placed in the auto mode until it is manually supported with our hand.

The machine was tested with 30 naira notes and three fake notes between them. The machine successfully counted the original notes as well as detecting the fake notes and makes an alarming sound as well as stopping the counting at that moment until the fake note is removed from the machine.

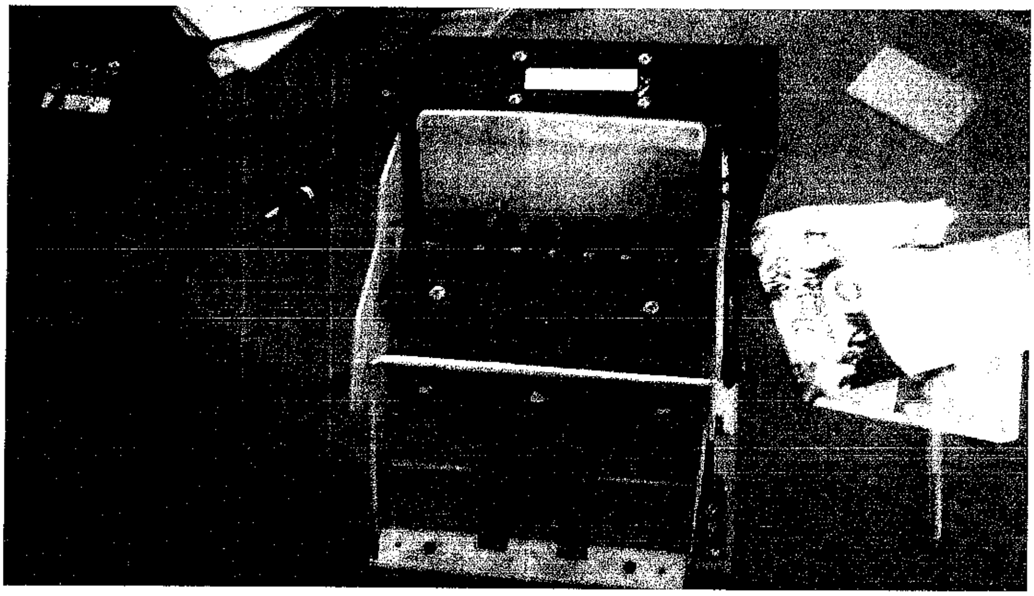


Figure 4-1 The complete project of the currency counting machine with fake note detection.

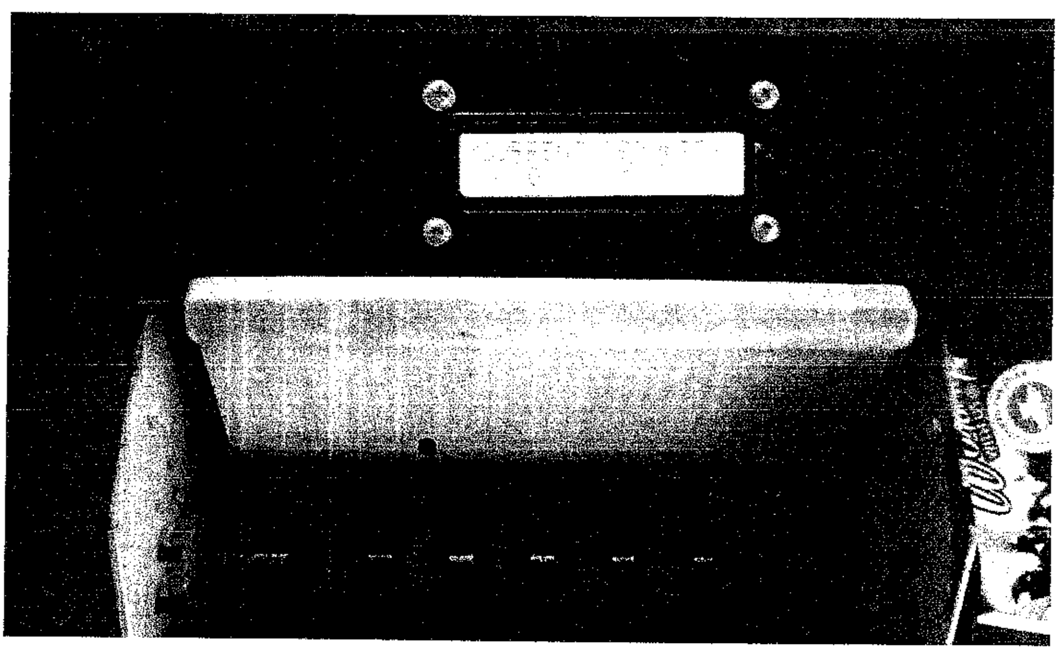


Figure 4-2 The complete project showing the LCD.

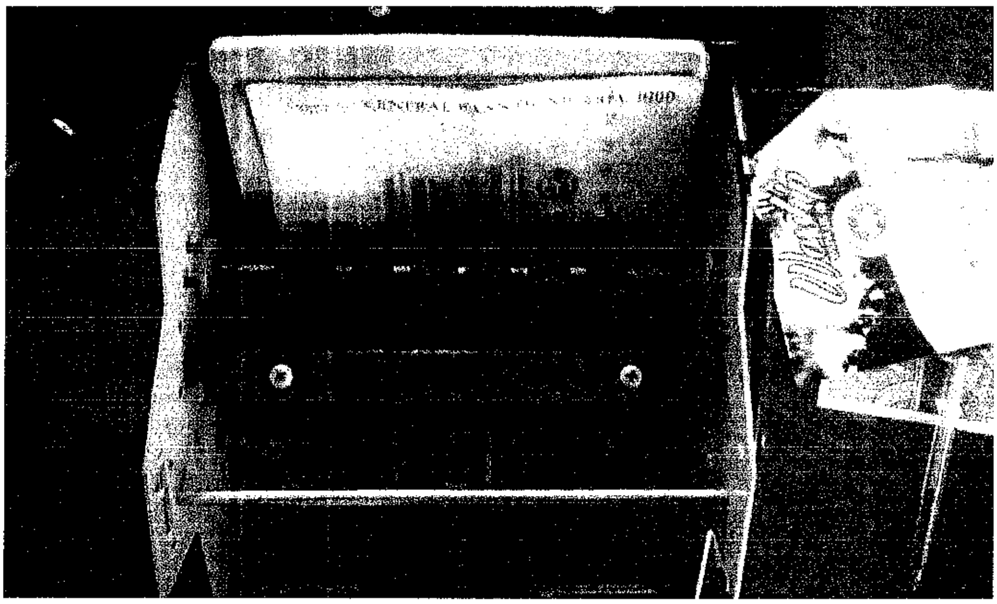


Figure 4-3 The machine with two 1000 naira notes placed inside it.

Figure 4-4 The result on the LCD by putting two 1000 naira notes in it.

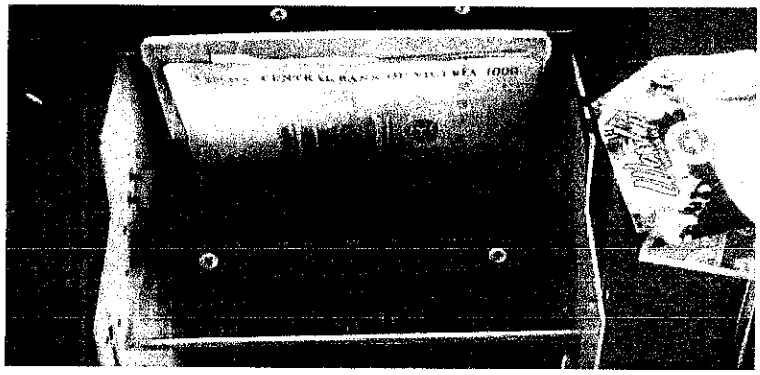


Figure 4-5 Two 1000 naira notes with a fake note placed in the hopper of the counting machine.

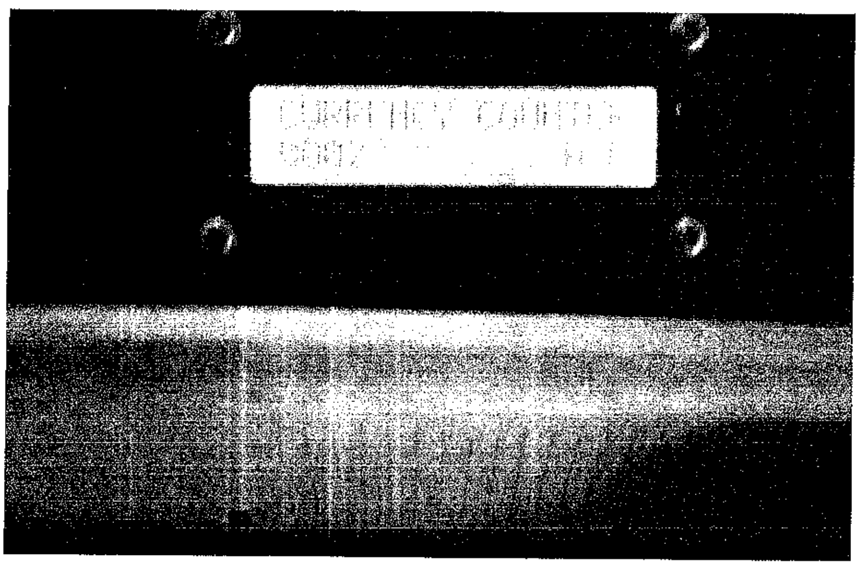


Figure 4-6 The result on the LCD from putting two 1000 naira notes with a fake note.

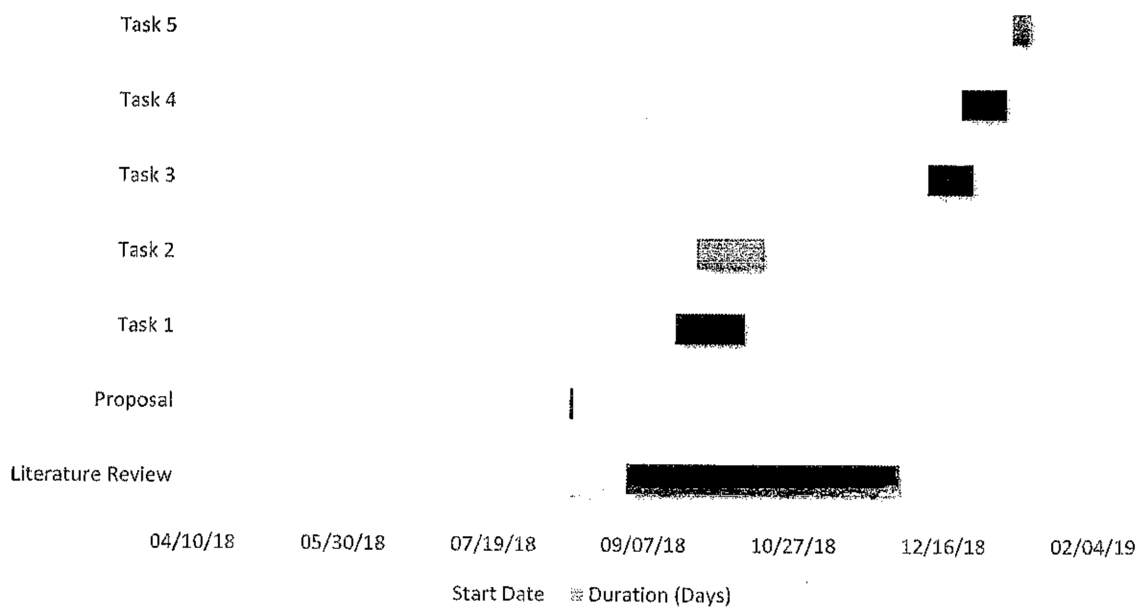
4.3 PROJECT MANAGEMENT

The subsections below show how the aim of this project was achieved.

4.3.1 PROJECT SCHEDULE

The chart below shows the tasks involved in this project and the time period to complete each of this task.

Fig 4.7- A gantt chart showing the different tasks performed and the duration for each task



Task 1- Simulation of project circuit

Task 2- Acquisition and gathering of components needed

Task 3- Programming the Atmega8 microcontroller.

Task 4- Hardware implementation and soldering of components.

Task 5- Testing and Casing of the project.

4.3.2 RISK MANAGEMENT.

Some of the risks taken in the course of completing this project involved:

- The project was at risk of not being completed as some of the components were difficult to find and when they were seen, the cost of transporting it to where I would implement it was high.
- Component Failure as some were shipped and so there was no way of checking that they were working before acquiring them.
- Electric Shock as we know that dealing with electricity could be very dangerous if proper precautions are not taken.

UNIVERSITY LIBRARY
FEDERAL UNIVERSITY
OYE - EKITI
(FUOYE)

These risks were mitigated by:

- Getting the necessary components and getting surplus from a reliable company so as to reduce the risk of getting bad components.
- By wearing protective equipment and giving careful attention to what I was doing.

4.3.3 SOCIAL, LEGAL, ETHICAL AND PROFESSIONAL CONSIDERATIONS.

This project was ensured to have been designed and implemented to meet and conform to the standards of Institute of Electrical and Electronics Engineers (IEEE). I also ensured that all safety rules and regulations were duly observed during the course of the project. I engaged in negotiations with those that helped me with the project and ensured I minimized risks to people and my environment in designing this project.

CHAPTER 5

CONCLUSION AND RECOMMENDATION.

5.0 CONCLUSION.

Fake currency poses a grave threat to national security and could also result in economic destabilization. According to intelligence agencies, anti-national elements and crime syndicates open several accounts and use the ATMs to deposit the fake currencies. If they see that the amount has been credited to their account, they continue to deposit fake money. If the amount is not credited they know that their game is up and no longer operate that account. In the past, it was easy to detect fake currencies as they were printed by people with limited expertise, using crude facilities. But with the forgers attaining a high level of sophistication, it is increasingly difficult to detect fake notes.

This project presents a design and construction of currency counting machine. It involves the use of the Atmega8 microcontroller, the UV light sensor, the magnetic sensor, the infrared sensor and so on. The CCM works on the principle on the breadth of the bundle of currency and there is a roller which has rods in a continuous pattern and the roller moves these rods with a particular speed. The fake note detection unit uses the three sensors to verify the genuineness of a currency and sends its result to the microcontroller to interpret and the result is heard by a buzzer if it is counterfeit.

The machine was tested with a few notes of the same denomination and gave an accurate result. A piece of paper was also used as a fake note and this was tested in the machine and the machine stopped as well as making a loud counting as soon as it noticed the fake note passing through it.

5.1 CONTRIBUTION TO KNOWLEDGE.

The design and construction of a currency counting machine has given me an insight into the C+ programming language and how to implement it on a microcontroller. It has also helped me understand how the sensors used work, and how sensitive it is. Finally, the auto mode was added to the work such that while the machine is in this mode, the money just has to be placed in the hopper part. The machine senses it and then counts the money and displays the number of the denominations without the operator having to press any other button.

5.2 PROBLEMS ENCOUNTERED.

The following are problems encountered during the course of the project:

- Programming the Micro-controller: The micro-controller was programmed via the C+ programming language platform after which the programmed is compiled into the micro-controller. Understanding this programming language and know-hows proved tricky but after consultations and studying, the desired results were achieved.
- In-depth Practical Knowledge: Due to insufficient knowledge of the components, their properties and the connections to be carried, there was difficulty in carrying out the connections effectively and accurately and thus, there was delay in the construction of the project. This was eventually solved by the means of seeking the required knowledge and resources from individuals with the practical know-how, video tutorials and online discussions necessary for the successful construction and implementation of the project.

5.3 FUTURE WORKS.

The following are the recommendations based on findings from this project:

- ✓ More advanced counters can be constructed that will identify different bill denominations to provide a total currency value of mixed banknotes, including those that are upside down as this type only gives how many notes of the same denomination that are in the counter.
- ✓ A currency counting machine with fake note detection can also be constructed that will work with DC, that is batteries so it will not always depend on an a.c source.
- ✓ The machine could also be made to be more user friendly by indicating on the LCD that a fake note has been detected and not just the alarming sound.

5.4 CRITICAL APPRAISAL.

Knowing that counterfeiters are still in vogue and producing fake notes and then going to spend it in places like market places, stalls and even churches, this machine will easily be able to detect these fake currencies. With the aid of an infrared sensor which the counterfeiters have not been able to find a way around it like they have done with the ultraviolet sensor, the machine may be a little expensive but will be very effective in getting these fake notes immediately before the notes get to the bank. This will in effect reduce losses by the traders, as some of them would have taken it to the bank before the bank's machine detects it as a counterfeit and then confiscates it.

REFERENCES

[1] Wikipedia contributors. (2019, January 22). Currency-counting machine. In *Wikipedia, The Free Encyclopedia.* Retrieved 04:09, January 26, 2019, from https://en.wikipedia.org/w/index.php?title=Currency-counting_machine&oldid=879612033

[2] M. Thakur and A. Kaur, "Various Fake Currency Detection Techniques," *International Journal For Technological Research In Engineering (IJTRE),* vol.1, no.11, pp. 1309-1313, 2014.

[3] B.P Yadav, C.S Patil, R.R Karhe and P.H Patil, "An Automatic Recognition of Fake Indian Paper Currency Note Using MATLAB," *International Journal of Engineering, Science and Innovative Technology (IJESIT),* vol.3, no.4, pp.560-566, 2014.

[4] S. Pahade and S. Meshram, "A Study of Different Counterfeit Note Detection Algorithm," *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE),* vol.7, no.5, pp.2769-2772, 2018.

[5] Polls, NOI, "New Poll Confirms Circulation of Counterfeit Naira Notes," 2017. Retrieved January 26, 2019, from https://www.noi-polls.com/root/index.php?pid=427&ptid=1&parentid=13

[6] S. Anju, S. R Chippy, H. Haritha, V.C Nijo, and A.O Beena, "Automatic Paper Counting Machine," *International Journal of Science Technology & Engineering (IJSTE)* vol.2, no.10, pp.917-921, 2016.

[7] D.A Shaikh, A.H Kedare, P.B Sonawane, and S.P Jogdand, "Cash Validation and Exchange Using ARM 7," *International Journal of Advance Research and Innovative Ideas in Education (IJARIIE)*, vol.2, no.2, pp. 994-1002, 2016.

[8] D. Swetha, M. Artheeshwari, J. Ishwarya and Kavitha, "Fake currency detection using image processing," *International Journal of Advance Research, Ideas and Innovations in Technology (IJARIIT)*, vol.4, no.2, pp.1169-1176, 2018.

[9] K.R Nandakumar, and D.G Hindurao "Fake Currency Detector," *International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE),* vol.5, no.8, pp.523-524, 2016.

[10] V.N Patel, U.K Jaliya and K.N Brahmbhatt, "Indian Currency Recognition using Neural Network Pattern Recognition Tool," *International Conference on Research In Science,*

Engineering and Technology (ICRISET), vol.2, pp.67-72, 2017.

[11] A. Kamble, and M.S. Nimbarte, "Design and Implementation of Fake Currency Detection System,"*International Journal on Future Revolution in Computer Science & Communication Engineering (IJFRCSCE)* vol.4, no.4, pp.40-44, 2018.

[12] A.B Kanwade, S. Peharkar, S. Muktapure, and R. Mhaske, "Intelligent Note to Coin Exchanger with Fake Note Detection," *International Engineering Research Journal (IERJ)* vol.2, no.3, pp.1606-1609, 2016.

[13] M.H Alshayeji, M. Al-Rousan and D.T Hassoun, "Detection Method for Counterfeit Currency Based on Bit-Plane Slicing Technique," *International Journal of Multimedia and Ubiquitous Engineering* vol.10, no.11, pp.225-242, 2015.

[14] H. Hassanpour, A. Yaseri and G. Ardeshiri, "Feature Extraction for Paper Currency Recognition," *Proceedings of the 9th International Symposium on Signal Processing and Its Applications (ISSPA), Sharjah, United Arab Emirate,* 2007.

[15] J. Qian, D. Qian and M. Zhang, "A Digit Recognition System for Paper Currency Identification Based on Virtual Instruments," *International Conference on Information and Automation, China,* 2006.

[16] R. Mirza and V. Nanda, "Paper Currency Verification System Based on Characteristic Extraction Using Image Processing," *International Journal of Engineering and Advanced Technology (IJEAT),* vol.1, no.3, pp.68-71, 2012.

[17] B.S Prasanthi, and D.R Setty "Indian Paper Currency Authentication System using Image processing," *International Journal of Scientific Research Engineering & Technology (IJSRET),* vol.4, no.9, pp.973-981, 2015.

[18] M. Akbar, A. Sedayu, A. Putra and S. Widyarto, "Original and Counterfeit Money Detection Based on Edge Detection," *International Conference on Instrumentation, Communication, Information Technology and Biomedical Engineering, Indonesia,* 2013.

[19] K. Satish, Y.K. Viswanadham, and I.L Priya, "Money to ATM – Fake Currency Detection" *International Journal of Computer Science and Information Technologies (IJCSIT)*, vol.3, no.5, pp.5046-5050, 2012.

[20] A.A Shirsath and S.D Bharkard, "A Review of Paper Currency Recognition System," *IOSR Journal of Computer Engineering (IOSR-JCE),* vol.10, no.1, pp.71-76, 2013.

[21] C. Bhurke, M. Sirdeshmukh and M.S Kanitkar; "Currency Recognition using Image

Processing," *International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)*, vol.3, no.5, pp.4418-4422, 2015.

[22] T. L Alumona, G. C Nwalozie, A.N Aniedu, and T.A Alade, "Appraisal of Currency Counters Used in the Banking Industry," *International Journal of Electrical and Telecommunication System Research,* vol.8, no.8, pp.80-89, 2016.

[23] T. Pathrabe, and S. Karmore, "A Novel Approach of Embedded System for Indian Paper Currency Recognition," *International Journal of Computer Trends and Technology*, pp.152-156, 2011.

[24] T. Pathrabe, and N.G Bawane, "Feature Extraction Parameters for Genuine Paper Currency Recognition & Verification," *International Journal of Advanced Engineering Sciences and Technologies,* vol.2, no.1, pp.86-90, 2011.

[25] A. Sargano, M. Sarfraz, and N. Haq, "Robust features and paper currency recognition system," *In: The 6th International Conference on Information Technology, ICIT, Amman, Jordan,* 2013.

[26] K. Debnath, A. Ahmed, M. Shahjahan, "A paper currency recognition system using Negatively Correlated Neural Network" *Ensemble. J. Multimedia* vol.5, no.6, pp.560–567, 2010.

[27] P. Reel, G. Krishan, and S. Kotwal, "Image Processing based Heuristic Analysis for enhanced Currency Recognition," *International Journal of Advancements in Technology (IJoAT),* vol.2, no.1, pp.83-89, 2011.

[28] N. Paisos, A. Rubinsteyn, and L. Subramanian, "Exchanging cash with no fear: A fast mobile money reader for the blind," *In: Workshop on Frontiers in Accessibility for Pervasive Computing,* vol. 6. 2012.

[29] C. da Costa, "Multiview Banknote Recognition with Component and Shape Analysis," [online] available: https://www.researchgate.net/publication/260392128_multiview_banknote_recognition_with_component_and_shape_analysis accessed on 16th January, 2019.

[30] Y. Kou, C.T Lu, S. S Sinvongwattana and Y.P Huang, "Survey of Fraud Detection Techniques," *IEEE International Conference on Networking, Sensing & Control,* pp. 749-754, 2004.

[31] D. Alekhya, G.D.S Prabha and G.V.D Rao, "Fake Currency Detection Using Image Processing and Other Standard Methods," *International Journal of Research in Computer and Communication Technology*, vol.3, no.1, pp.128-131, 2014

[32] R. Mirza and V. Nanda, "Design and Implementation of Indian Paper Currency Authentication System Based on Feature Extraction by Edge Based Segmentation Using Sobel Operator," *International Journal of Engineering Research and Development (IJERD),* vol.3, no.2, pp.41-46, 2012.

[33] R.C Gonzalez and R.E Woods, "Digital Image Processing," *2nd ed,* Prentie Hall,2002 B. S Manjunath and W. Ma, "texture features for browsing and retrieval of image data,"*IEEE Trans.Pattern Anal,* vol.18, no.8, 1996.

[34] K. Verma, B.K Singh, and A. Agrawal,"Indian Currency Recognition Based On Texture Analysis", *Institute of Technology, Nirma University, Ahmedabad* , pp. 1-5, 2011.

[35] M. Gogoi, S.E Ali, and S. Mukherjee, "Automatic Indian Currency Denomination Recognition System based on Artificial Neural Network," *IEEE,* 978-1-4799-5991-4/15, 2015.

[36] O.Saadi, and E. Ercelebi, "Development of money counting machine by Arm Based Microcontroller", *International Journal of Electrical, Electronics and Data Communication* vol.6, no.5, pp.27-31, 2018.

[37] S.V Walke, and D.M. Chandwadkar , "Counterfeit Currency Recognition Using SVM With Note to Coin Exchanger", *International Journal of Modern Trends in Engineering and Research (IJMTER),* vol.2, no.7, pp.1356-1360, 2015.

[38] P. Bhongale, R. Padalkar, R. Bhongale and P.S.Togrikar, "Intelligent Note To Coin Exchanger With Fake Note Detection", *International Journal of Modern Trends in Engineering and Research (IJMTER),*vol.3, no.2, pp.480-486, 2016.

[39] M. Reisert, O. Ronneberger, and H. Burkhardt, "An Efficient Gradient based Registration Technique for Coin Recognition", *In: Proc. of the Muscle CIS Coin Competition Workshop, Berlin, Germany,* pp. 19–31, 2006.

[40] S.A Mahajan, and C.M Gaikwad, "Rotation invariable method for Currency Coin Detection," *International Journal of Computer Science and Information Technology,* vol.5, no.2, pp.1117–1119, 2014.

[41] S. Modi, and S. Bawa, "Automated coin recognition system using ANN," *International Journal of Computer Applications,* vol.26, no.4, 2011.

[42] C. Velu, P. Vivknandand, "Indian coin recognition system of image segmentation by Heuristic Approach and Houch Transform (HT)," *International Journal of Open Problems in Computer Science and Mathematics (IJOPCM),* vol.2, no.2, pp.254-271, 2009.

[43] M. Meenakumari, "Indian coin identification and worth calculation system by high intensity point detection," *Automation and Autonomous System,* vol.5, no.3, pp.114–117, 2013.

[44] Y. Mitsukura, M. Fukumi, M., and N. Akamatsu, "Design and evaluation of neural networks for coin recognition by using GA and SA," *In: proceedings of the IEEE-INNS-ENNS International Joint Conference on Neural Networks, IJCNN,* vol.5, no.5, pp.178–183, 2000.

[45] R. Vijay, V.K Jain, "Indian currency denomination identification using image processing technique," *International Journal of Computer Science and Information Technology,* vol.4, no.1, pp.126–128, 2013.

[46] Central Bank of Nigeria, "Currency Management- Security Features," Retrieved February 4, 2019, from https://www.cbn.gov.ng/Currency/securityfeatures.asp.

[47] ElProCus, "AVR Atmega 8 Microcontroller Architecture and Its Applications," Retrieved February 4, 2019, from www.elprocus.com/avr-atmega8-microcontroller-architecture-applications/.

[48] Atmel, "Atmega 8(L) datasheet," Retrieved February 5, 2019, from ww1.microchip.com/downloads/en/DeviceDoc/Atmel-2486-8-bit-AVR-microcontroller-Atmega8_L_datasheet.pdf.

[49] Electronics Tutorials, "Diac, Triac and Quadrac for AC Power Control," Retrieved February 5, 2019, from www.electronics-tutorials.ws/power/diac.html.

[50] ON Semiconductor, "LM393- Low offset Voltage Dual Comparators," 2018, Retrieved February 5, 2019, from www.onsemi.com/pub/Collateral/LM393-D.PDF.

[51] A. Chilton, "The Working Principle and Key Applications of Infrared Sensors," 2018, Retrieved February 5, 2019, from www.azosensors.com/article.aspx.

APPENDIX.

CODES. [THEY ARE SPLIT INTO TWO COLUMNS ON THE PAGES].

```
.EQU PORTB = 0X18
.EQU DDRB = 0X17
.EQU PINB = 0X16
.EQU PORTC = 0X15
.EQU DDRC = 0X14
.EQU PINC = 0X13
.EQU PORTD = 0X12
.EQU DDRD = 0X11
.EQU PIND = 0X10
.EQU SPH = 0X3E
.EQU SPL = 0X3D
.EQU UBRRH = 0X20
.EQU UCSRC = 0X20
.EQU UBRRL = 0X09
.EQU UCSRB = 0X0A
.EQU UCSRA = 0X0B
.EQU UDR = 0X0C
.EQU ADMUX = 0X07
.EQU ADCSRA = 0X06
.EQU ADCH = 0X05
.EQU ADCL = 0X04
.EQU TCCR0 = 0X33
.EQU TCNT0 = 0X32
.EQU TIMSK = 0X39
.EQU TIFR = 0X38
.EQU SREG = 0X3F
.EQU TCCR1A = 0X2F
.EQU TCCR1B = 0X2E
.EQU TCNT1H = 0X2D
.EQU TCNT1L = 0X2C
.EQU OCR1AH = 0X2B
.EQU OCR1AL = 0X2A
.EQU OCR1BH = 0X29
.EQU OCR1BL = 0X28
.EQU SFIOR = 0X30
.EQU TCCR2 = 0X25
.EQU TCNT2 = 0X24
.EQU GICR = 0X3B
.EQU MCUCR = 0X35
.EQU ASSR = 0X22
```

```
.EQU  EEARH     = 0X1F
.EQU  EEARL     = 0X1E
.EQU  EEDR = 0X1D
.EQU  EECR = 0X1C
.EQU  OSCCAL    =    0X31

.ORG  0X00

; R19 FOR BUZZER ON PD0 AND PD1 ,R20
FOR AUTO ,R21 FOR FAKE COUNTER
R22,R23,R24,R25,
START:
      LDI   R17,0XA8
      OUT   OSCCAL,R17

      LDI   R17,0X5F
      OUT   SPL,R17

      LDI   R17,0X04
      OUT   SPH,R17

      CLR   R17
      OUT   PORTB,R17
      OUT   PORTC,R17
      OUT   PORTD,R17

      LDI   R17,0XF0
      OUT   DDRB,R17

      LDI   R17,0X03
      OUT   DDRC,R17

      LDI   R17,0XFF
      OUT   DDRD,R17

      CLR   R19
      CLR   R20
      CLR   R21
      CLR   R22
      CLR   R23
      CLR   R24
      CLR   R25

      CLR   R3
      CLR   R4
```

```
        CLR   R5

        CLR   R6
        CLR   R7
        CLR   R8

        RCALL       INTLCD

        LDI   R17,0X04
        OUT   SFIOR,R17

        ;for adc use

        RCALL       DSP

REDO:
        RCALL       AUTO
        RCALL       COUNT
        RCALL       RESET
        RCALL       KEYAUTO
        RCALL       KEYFAKE
        RJMP  REDO

KEYAUTO:
        SBIS  PINB,1
        RJMP  KEYAUTOE
        MOV   R17,R5
        CPI   R17,0X00
        BREQ  KEYAUTOB
        RET
KEYAUTOB:
        MOV   R17,R4
        CPI   R17,0X00
        BREQ  KEYAUTO2
        RET
```

```
KEYAUTO2:
        MOV  R17,R3
        CPI     R17,0X00
        BREQ KEYAUTO3
        RET
KEYAUTO3:
        INC     R20
        ANDI R20,0X01
        LDI     R17,0X02
        MOV  R5,R17
        LDI     R17,0XFF
        MOV  R4,R17
        MOV  R3,R17

        LDI     R18,0XD0
        LDI     R16,0XC0
        RCALL         RSLOW

        SBRS R20,0
        RJMP KEYAUTO4

        LDI     R18,0X10
        LDI     R16,0X40
        RCALL         RSHIGH

        RET

KEYAUTO4:
        LDI     R18,0X00
        LDI     R16,0X20
        RCALL         RSHIGH

        RET



KEYAUTOE:
        MOV  R17,R5
        CPI     R17,0X00
        BRNE KEYAUTOEB
        MOV  R17,R4
        CPI     R17,0X00
        BRNE KEYAUTOEB
        MOV  R17,R3
        CPI     R17,0X00
        BRNE KEYAUTOEB
        RET
```

```
KEYAUTOEB:
        DEC   R3
        MOV   R17,R3
        CPI   R17,0XFF
        BREQ  KEYAUTOE2
        RET
KEYAUTOE2:
        DEC   R4
        MOV   R17,R4
        CPI   R17,0XFF
        BREQ  KEYAUTOE3
        RET
KEYAUTOE3:
        DEC   R5
        RET

KEYFAKE:
        SBIS  PINB,3
        RJMP  KEYAUTOEF
        MOV   R17,R8
        CPI   R17,0X00
        BREQ  KEYAUTOBF
        RET
KEYAUTOBF:
        MOV   R17,R7
        CPI   R17,0X00
        BREQ  KEYAUTO2F
        RET
KEYAUTO2F:
        MOV   R17,R6
        CPI   R17,0X00
        BREQ  KEYAUTO3F
        RET
KEYAUTO3F:
        INC   R21
        ANDI  R21,0X01
        LDI   R17,0X02
        MOV   R8,R17
        LDI   R17,0XFF
        MOV   R7,R17
        MOV   R6,R17
```

```
        LDI     R18,0XF0
        LDI     R16,0XC0
        RCALL       RSLOW

        SBRS  R21,0
        RJMP  KEYAUTO4

        LDI     R18,0X60
        LDI     R16,0X40
        RCALL       RSHIGH

        RET

KEYAUTO4F:
        LDI     R18,0X00
        LDI     R16,0X20
        RCALL       RSHIGH

        RET

KEYAUTOEF:
        MOV   R17,R8
        CPI     R17,0X00
        BRNE KEYAUTOEBF
        MOV   R17,R7
        CPI     R17,0X00
        BRNE KEYAUTOEBF
        MOV   R17,R6
        CPI     R17,0X00
        BRNE KEYAUTOEBF
        RET
KEYAUTOEBF:
        DEC   R6
        MOV   R17,R6
        CPI     R17,0XFF
        BREQ KEYAUTOE2F
        RET
KEYAUTOE2F:
        DEC   R7
        MOV   R17,R7
        CPI     R17,0XFF
        BREQ KEYAUTOE3F
        RET
KEYAUTOE3F:
```

```
    DEC   R8
    RET

AUTO:
    SBIC  PINC,5
    RET
    SBRS  R20,0
    RET
    RCALL       SEC1
    RCALL       SEC1
    RJMP  COUNTFA

COUNT:
    SBIS  PINB,0
    RET
COUNTFA:
    SBIC  PINC,5
    RET

    CLR   R0
    CLR   R1
    CLR   R2

    CLR   R22
    CLR   R23
    CLR   R24
    CLR   R25

    LDI   R17,0X03
    OUT   PORTC,R17

    RCALL       DELAY100MS

    LDI   R17,0X02
    OUT   PORTC,R17

    LDI   R17,0X20
    OUT   PORTB,R17

COUNTB:
    SBIS  PINC,4
```

UNIVERSITY LIBRARY
FEDERAL UNIVERSITY
OYE - EKITI
(FUOYE)