Automatic Gadget Charger using Coin Detection

A project report submitted in partial fulfillment of the requirements
for the award of degree,

Master of Technology

in

Computer Science & Engineering

with specialization in

Artificial Intelligence and Neural Network

by

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CERTIFICATE

This is to certify that the project work entitled "**Automatic Gadget Charger using Coin Detection**" done by **Gunjan Chhabra, Enrollment No. R102212003** for partial fulfillment of the requirements for the award of the degree of Master of Technology in Computer Science & Engineering with Specialization in Artificial Intelligence and Neural Networks, to Centre for Information Technology, University of Petroleum & Energy Studies is a bonafide report of the work carried by them under our guidance and supervision.

To my best of knowledge, the literature embodied in this project work has not been submitted to any other University/Institute for the award of any degree or diploma.

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CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in this dissertation entitled **Automatic Gadget Charger using Coin Detection** in partial fulfillment of the requirements for the award of the Degree of Master of Technology in Computer Science & Engineering with specialization in Artificial Intelligence and Neural Networks and submitted in the Department of Center for Information Technology, University of Petroleum & Energy Studies, Dehradun, is an authentic record of my own work carried out during a period from January, 2014 to April, 2014 under the supervision of **Mr. Sunil Sharma** and **Mr. Pankaj Badoni**, Assistant Professor, Center for Information Technology, CoES.

The matter presented in this thesis has not been submitted by me for the award of any other degree of this or any other Institute.

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ABSTRACT

The **coin-based mobile battery charger** that is being developed would provide a unique service to the rural public where grid power is not available for partial/full daytime and a source of revenue for site providers. The coin-based mobile battery charger would be quickly and easily installed outside any business premises. The mobile phone market is a vast industry, and has spread into rural areas as an essential means of communication. While the urban population uses more sophisticated mobiles with good power batteries lasting for several days, the rural population buys the pre owned mobile phones that require charging frequently. Many times battery becomes flat in the middle of conversation particularly at inconvenient times when access to a standard charger isn't possible. The coin-based mobile battery chargers would be designed to solve this problem. The user would have to plug the mobile phone into one of the adapters and insert a coin; the phone would then be given a micro-pulse for charging. It would not bring a mobile from 'dead' to fully charged state. The charging capacity of the mobile is designed with the help of pre defined values. It is, of course, possible to continue charging the mobile by inserting more coins. This compact and lightweight product is designed to cater for the growing number of rural mobile users worldwide. A suitable microcontroller is programmed for all the controlling applications. The source for charging is obtained from direct power grid and solar energy in case of non-availability of grid power.

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1. INTRODUCTION

1.1 About Project

Mobile phones have become an essential technological advancement that has enabled every individual to keep in contact with everyone else from anywhere. They have become a major source of communication, be it with regards to the business aspect or personal communication. Due to the widespread use of mobiles, the mobile phone industry is booming and has currently become worth more than billions of dollars, while supporting millions of phones at a time.

These days' mobile phones have become a mini portable computing device that can serve multiple purposes, thus increasing the use of mobile phones and its requirement in the community. Due to the continuous usage of mobile phones for various reasons, there is a requirement for frequent charging. As every application that runs on mobiles require battery power and more the applications in use, more the battery power is utilized. This results in faster discharge of the battery power.

In our day to day lives where our routines are fixed, the mobile phone can be charged in such a manner that the battery power is always available. But in cases where the routine is not fixed or due to sudden changes in routine, there may be various situations where the battery power level would become too low or be completely discharged because of which even emergency use of the phone would not be possible. In such Many critics have argued that a public mobile phone charging service would not be a lucrative business because most of the users can charge their phones at home, in their offices or in their cars. But for the multitude of situations where the normal routine is not followed such a public system would be very useful.

Students and many people who use public transportation may not know that the level of their mobile battery is low and can be prospective customers for a public mobile phone charger service. Automatic Mobile Phone/Gadgets Charging System or alternatively known as Coin Based Charging System **(CBCS)** brings a very wonderful solution for commuters and travelers who need to charge their mobile phones and gadgets immediately.

Coin operated mobile phone charger is a new business milestone as many are attending business conventions and forgetting their charger at home or in hotel rooms. This device is like a vending machine for mobile battery charging at kiosks and the users have to plug the phone into one of the adapters and insert a coin for charging at a constant current for a definite duration.

Recommended locations include: Hotels, Conference centers, Exhibition halls, Serviced offices, Exchange halls, Motels, Leisure centers, Health clubs, Training centers, Golf clubs, Retail outlets, Shopping malls, Internet cafes, Universities, Colleges, Hall of residence, Airports, Train terminals, etc., so that the mobile phone users can reactivate a low or dead battery by simply plugging in and charging for one rupee. Anyone who needs to charge mobile phone can place a coin of Rs. 1 or Rs. 2.

In the event of unpredictable grid power and availability of abundant solar power, a coin based universal mobile battery charger is designed and developed in this project.

The coin-based mobile battery chargers are designed to solve the problem of low battery. The user has to plug the mobile phone into one of the adapters and insert a coin; the phone will then be given a micro-pulse for charging. It does not bring a mobile from 'dead' to fully charged state. The charging capacity of the mobile is designed with the help of predefined values. It is, of course, possible to continue charging the mobile by inserting more coins. This compact and lightweight product is designed to cater for the growing number of rural mobile users worldwide. A suitable microcontroller is programmed for all the controlling applications. The source for charging is obtained from the direct power grid and solar energy in case of non availability of grid power.

The solar power application to battery charging has been studied in the past. Solar chargers convert light energy into DC current for a range of voltage that can be used for charging the battery. In this project, the design and development of a coin based universal mobile battery charger based on the main power and solar power is discussed and this is primarily for rural areas where the mobiles are basic needs for communication and the main power is not available all the time.

1.2 Purpose of the project

The basis of this project is to apply **computer vision** and **image processing** techniques to develop a program which should be able to recognize a coin from an image, captured in real time, and enumerate its value. Based upon the value of the coin it should then allow the microcontroller to switch on the power supply. That is to have a computer continuously "watch" for the image of a coin, recognize the value of the coin and then allow the passage of current for a sufficient period of time, according to requirement of the user.

1.3 Aim of the project

Initial Goals

The primary goals of this project are:

- ❖ Recognize the value of the coin in the image.
- ❖ Count the value of a coin, and then switch on the power supply.

The secondary goals for the project are:

- ❖ Identification of coin having different texture, shape, size and so on but have same value.
- ❖ Switching on of power for a specific period of time, depending on the value of the coin, inserted by the user.
- ❖ Use of Solar power, for the working of system, in the absence of AC supply.
- ❖ Continuation of power supply on re-insertion of coin by the user.
- ❖ LED/LCD display on/off for the indication of power supply on/off.

1.4 Motivation

Nowadays, mobile phones have become a major part of everyone's life, be it either by means of communication or other day to day activities such as internet search, games, GPS and so on. The regular usage of mobile phones makes it necessary to have the convenient supply of charging facilities/charged batteries, the travelling battery gadgets must be regularly charged. Therefore, he/she must charge their gadget at home, office, cars, etc. sufficiently so that mobile phone doesn't get discharged in between any important communication/journey. But, such types of problems occur repeatedly whenever one has to move out of their routine life and/or in case of an emergency. In such situations, there is a need for charging the mobile phone's battery. This results in the need for the provision of a public charging system.

Moreover, due of globalization, mobile phones are being used by people living in urban and rural areas both. Most of the people living in rural areas buy second hand or lower quality mobile phones or mobile phones manufactured by local parties, to fulfill their needs, with a short life span of the batteries. Also, at most of the rural and high altitude areas, where power supply by the government is not so frequent, results in the need for the alternative of such a system which can work using solar energy.

The world economy is categorized into three major aspects: Developed nations, Developing nations and Least Developed Nations (LDCs), this categorization is solely based upon economic and developmental basis. Similarly, the energy infrastructure is very poor in LDCs as well as developing nations. This product may act as a voluntary and alternative energy harvester for utilizing non-conventional source of energy.

There are pioneer technologies used in various types of ticket vending machines installed at various locations, it was initialized at Central Railway Station, Thiruvananthapuram, Kerala for ticketing from 7th July, 2006. Delhi Metro Rail Corporation (DMRC) initiated the same venture in 2013, but neither of them, nor any organization or any institute has come out with such an initiative to harvest non-conventional sources as an alternative in addition to a source for mobile/gadgets charging.

1.5 Properties

By configuring Microcontroller, Servo motor, Max232, LM358, Infrared Sensors and MATLB tool and PICkit2 provide a number of characteristic properties to CBCS:

- Automatic Detection of the coin using Image Processing Technique.
- Intelligent power management system.
- Portable Machine.
- Makes avail a variety of charging ports.
- Less expensive.
- Harnessing of Solar Energy.
- Can be installed anywhere including train, station, bus stand, market etc.
- Coin Collection Mechanism.
- Reduce manpower
- Low power consumption.

1.6 Applications

CBCS is a micro-switching/flow device which allows the charging equivalent for a defined economic term. This device can be further used by scaling up to utilize similar other economic, financial/energy consuming applications:

- ✓ Mobile charging
- ✓ Electronic Gadget Charging
- ✓ Home appliances Charging (Battery based)

Other applications

- ✓ It can be used in petrol pumps for supplying fuel (petrol, diesel, CNG), image processing, data scaling can help us in identifying the equivalent conversion of the currency into fuel.
- ✓ Prepaid electricity supply:
- ✓ Rationing of water supply: it can replace online methodology of prepaid supply of water and in rural/high altitude areas also.

A lot other applications can be identified by scaling up or by making electronic modifications.

1.7 Organization of the dissertation

This report is organized as follows: **Chapter 2** provides a presentation of the terminology concerning existing coin image detection and recognition systems. Overview of the related projects and literature to the domain with existing terminology is briefly explained. It also includes some technical review about the related domain and then the report proceeds to next chapter. **Chapter 3** gives details about planning and designing of the project, which will cover the working conditions, designing stages and overall algorithm definitions. In **Chapter 4**, description about the Implementation and Validation with proposed system of the project has been given. The test plan of the project and discussion of the test result is detailed in **Chapter 5**. **Chapter 6** includes the review of the complete project, its advantages, limitations, and other details. The study ends with concluding remarks and future scope. **Chapter 7** shows the output screen shots and **Chapter 8** states conclusion and future scope of the project. **Chapter 9** enlists the references used for the complete study and development of the project.

Chapter 2

LITERATURE REVIEW

- General background information
- Theoretical Concept
- Similar Projects and survey
- Technical Review

2. LITERATURE REVIEW

2.1 General Background Information

Computer vision refers to the application of human vision techniques to a computer, teaching the computer to see. The subject itself has been around since the 1960s, but it is only recently that it has been possible to build useful computer systems using ideas from computer vision. This subject is driven by three main areas: computational geometry, artificial intelligence, and image processing. [2]

Computational geometry now is widely used in every corner of science and engineering, from design and manufacturing to astrophysics, molecular biology and fluid dynamics. To build 3D computer models, lots of problems can be solved in these areas.

In the artificial intelligence field, people use computer vision technique as a tool to involve both the acquisition and processing of visual information. For instance, recently some companies and research groups focus on face recognition technique, which is widely used in virtual reality, national ID, security trading terminal, CCTV control etc. [3].

Image processing is the base of the other two areas. It refers to processing digital images by means of a digital computer. We know that 80% of the information that we get from the outside world are captured by the vision, so it is not surprising that images play the single most important role in human perception. However, humans are limited to the visual band of the electromagnetic spectrum, such as ultrasound, electron microscopy. Therefore, we need the imaging machines which cover almost the entire electromagnetic spectrum, ranging from gamma to radio waves. They can operate on images generated by sources that human are not accustomed to associating with image. Thus, digital image processing is applied a wide and varied fields (Gonzalez 2002, p. 1-2). For example, in medical imaging, it can be used to enhance imagery, or identify important phenomena or events.

2.2 Theoretical Concept

One cannot imagine his/her life without coins. A person uses coins in daily life almost everywhere like in banks, supermarkets, grocery stores, etc. They have been the integral part of our day to day life. So there is a basic need of highly accurate and efficient automatic coin recognition system. In-spite of daily uses coin recognition systems can also be used for the research purpose by the institutes or organizations that deal with the ancient coins. There are three types of coin recognition systems available in the market based on different methods:

- Mechanical method based systems
- Electromagnetic method based systems
- Image processing based systems

The mechanical method based systems use parameters like diameter or radius, thickness, weight and magnetism of the coin to differentiate between the coins. But these parameters cannot be used to differentiate between the different materials of the coins. It means if we provide two coins, one original and other fake having same diameter, thickness, weight and magnetism, but with different materials to the mechanical method based coin recognition system then it will treat both the coins as the original coin so these systems can be fooled easily.

The electromagnetic method based systems can differentiate between different materials because, in these systems, the coins pass through an oscillating coil at a certain frequency and different materials bring different changes in the amplitude and direction of frequency. So these changes and the other parameters like diameter, thickness, weight and magnetism can be used to differentiate between coins. The electromagnetic method based coin recognition systems improve the accuracy of recognition but still they can be fooled by some game coins. [4]

With the recent years' coin recognition systems based on images have also come into the picture. In these systems first of all the image of the coin to be recognized is taken either by camera or by some scanning. Then these images are processed by using various techniques of image processing like FFT, Gabor Wavelets, DCT, edge detection, segmentation, image subtraction, decision trees etc. and various features are extracted from the images. Then, based on these features different coins are recognized. [4]

2.3 Similar projects and survey

2.3.1 Related Projects

These projects are based on the image processing area as just mentioned above. The main goals of these are to recognize the coin and its value in the image captured in real time. There are several similar projects around. Here by some of them are exemplify to link the current project. One is coin images Seibersdorf-Benchmark (CIS-Benchmark) project. The second one is called automatic coin counter that was designed by J. Provine, Mike McClintock, Kristen Murray, and Angela Chau, who were students from Rice University in Houston. And some of the other projects are discussed in the coming sections.

2.3.1.1 Automatic coin counter

This project was constructed by J. Provine, Mike McClintock, Kristen Murray, and Angela Chau who had to write a program using feature extraction technique for a course work.

The physical setup of the problem is considered to be that the coins run along on a conveyor belt and are filmed by a digital video camera from which frames are taken and analyzed at intervals to count the change on the belt. Then they set the background of the testing image that was black and a shade of bright yellow. They assumed the coin counting machine had a mechanical sweeper arm, which made certain coins were only lying flat. There were four U.S. coins- the quarter, dime, nickel and penny that are used to be detected. They use median filters to smooth out the small edges and then use Robert's gradient method function to work out the edges of the coins. Then the radiuses of each particular coin were calculated. Finally, for each pixel, the program checked in eight directions for edges. If it found more than a certain threshold number of edges that are of the same length from the center pixel, it would mark that pixel as a possible center and then checked in eight more different directions from that radius. If within the entire set of sixteen checks, the number of hits exceeds a certain threshold, it will declare that pixel as the center of a certain type of coin. This program worked extremely well under all the assumption they have made [10].

This project provides a guideline for our coin based system. This project provides few important instructions to as a start up for the development of current project. First of all, one must set some working conditions for the program and rest of the system so that complete system can work well. Rather, if a developer/implementer does not do so, there are huge numbers of conditions for the detection of coin with the image, such as, size of the coin, different lightening conditions, shape of the coin and so on. Although such types of problems can be sought out but requires extra computations, which may increase the complexity of the program. Due to the shortage of time for the development of present system, it was difficult to run through all the conditions. Another thing is being highlighted in this project is use of different image processing techniques like edge detection, smoothing, edge enhancement and so on. So one can consider those techniques for the development of coin detection and value calculation based projects. Generally saying, this project could be assumed as a good starting point of our project as it provides the information about the various techniques that can be used for the coin detection.

2.3.1.2 CIS-Benchmark project

The CIS - Benchmark project was proposed to sort and re-calculation of high volumes of coins according to the individual prerequisites of the national banks. For the development of this project, the sorting criteria were thickness, diameter and the images of both sides of the coins. For each type of coin, there are at least two coin classes that were defined, one for the front side and one for the opposite side of the coin. For every class of coin, there are up to 30 training images, uncommon coin faces might be represented by only a few or even one training image. There is also a parameter file containing the coin class, angle to rotate the learn image into position of average image, minimum and maximum thickness and diameter of the coin. The number of images used to calculate the smallest and biggest values is also included in the parameter file. This system basically uses matching method. For each coin on the image, search the matching image in the database. Then the coin could be identified. This is a really large, complex system. The database consists of roughly 2000 patterns (classes) of coins from many different countries. And there are 100 000 coin images collected during the automatic sorting process. However, there is no further information about the running time of this system. And also there are no details of the algorithm they used for each step [11].

Considering about CBCS (current project), the size of each coin that is to be detected will remain same, but the texture of the coin could change for the same valued coin. For example, for Re. 1 coins, in the market, have different texture and pictures printed over them. Texture analysis can be considered as one criterion for the detection of coin in our project.

There are few more existing projects which can provide more ideas, which may help in the development of CBCS. Below section provides the brief summary of prior related art.

2.3.2 Related Literature

R. Bremananth et al. in 2005 proposed a system that focuses only on the numerals rather than the use of other images presented on the front and rear side of the coin. For experiment they used 1-rupee, 2-rupee, and 5-rupee Indian coin. Extract numeral image from the given coin image and this image is used for character recognition procedure. This proposed approach can easily be implemented in any real time business transactions. The system resulting from this research recognizes numerals using neural pattern analysis with a 92.43% success rate of our test data. [12]

Lu Zhang et al. in 2005-06 developed a program, as dissertation work, for counting coins in computer vision approach using MATLAB. The main purpose of this project is to apply computer vision techniques to develop a program which should recognize coins in an image, and enumerate their value. That is to have a computer, read the image and calculated the total value of the coins which are on the image. There are several techniques involved, such as image color segmentation, image edge detection, noise filtering, and Hough transformation and so on. The key to accomplish this project is the color segmentation of coins and edge enhancement, which separates coins with their color difference and provides the efficiency. After the computer programs are established, an experiment which applies the programs with UK coins shows that it works well and the error depends on the qualities of the coins' images. A database containing large number of images is required by using this method. [13]

Adnan Khashman et al. in 2006 proposed an intelligent coin identification system (ICIS) that uses coin patterns for identification helps preventing confusion between different coins of similar physical dimensions. For recognition of rotated coins of various degrees, ICIS used pattern averaging and neural network. In pre-processing phase ICIS apply thresholding, cropping, compressing, trimming, pattern averaging on images. And then neural network is trained using these images. ICIS used 1 TL and 2 EURO coins in recognition. ICIS used a 3layer back propagation neural network with 400 input neurons, 25 hidden neurons and 2-output neuron. The neural network is trained using 20 images out of available 120 coin images. The Accuracy rate achieved was 96.3%. [14]

C.M.Velu and P.Vivekanandan et al. in 2009 developed a system for Indian coin recognition system of image segmentation by heuristic approach and Hough transformation method. This system is developed mainly to classify the coins offered in the Hundi by the devotees of Tirumala Tirupati Devasthanam (TTD), Tirupati, India. The objective is to count money by recognizing the coins and count the total sum based on its value. The system is proposed to design coin recognition by applying heuristic approach, based on the coin table. This table stores parameters of each coin. This paper concentrates on affine transformations such as scaling, shearing and so on. This method yields 97% of result in recognizing the coin image. [15]

Hussein R. Al-Zoubi et al. in 2010 [3] suggested a coin recognition method using a statistical approach to classify Jordanian coins. There are seven different coins used in Jordan: 500fils, 250fils, 100fils, 50fils, 25fils, 10fils, and 5fils. Color and area of a coin was the key feature for classification. First convert the colored image into gray level and then apply the threshold value to convert it into black and white image. Then the binary image is cleaned by opening and closing through erosion and dilation, after that calculate the value of each RGB color. Then on the basis of these value decisions is made that to which category the coin belongs. Total 1050 experiments, 150 for each coin were carried out to examine the proposed system. The Accuracy rate achieved was 97%. [16]

C.M.Velu and P.Vivekanandan et al. in 2011 presented a methodology for Indian Coin Recognition and Sum Counting System of Image Data Mining Using Artificial Neural Networks. The objective of this paper is to classify, recognize and count the total value of newly released Indian coins of different denomination, in terms of Indian National Rupees. The features of old coins and new coins of different denominations are considered for classification. In this paper, it is proposed to introduce ML-CPNN approach. This approach is then compared with other approaches. The Robert's edge detection method gives 93% of accuracy and Laplacian of Gaussian method 95% of the result, the Canny edge detection method yields 97.25% result and the ML-CPNN approach yields 99.47% of recognition rate. [17]

Vaibhav Gupta et al. in 2011 presented a method based on image subtraction for recognition of Indian coins of different denomination. The Process performs 3 checks (radius, coarse and fine) on the input image. Instantly compute the radius of the input image and then based on the radius a test image is selected from the database. Then subtraction between the input image and database image is performed. By plotting the resultant values we get a minimum value which if less than a standard threshold provides the identification of the coin. [18]

Shatrughan Modi et al. in 2011 presented an Artificial Neural Network based Automated Coin Recognition System for Indian coins. They used Indian coins of denominations `1, `2, `5, and `10. This system takes images of coins from both sides. First of all apply pre-processing for images like cropping, trimming, pattern averaging, etc. and then passed the input data set to Neural Network for training. 4536 images are used for training and 252 images are used for validation and testing each. It cased back propagation neural network with 400 input units, 30 hidden layers and 14 output units. This system gives 97.74% recognition rate. [19]

Saranya das.Y.M et al. in 2013 presented a system to classify Indian coins discharged recently. This system is based on Advanced Harris-Hessian Algorithm, used the parameters such as size, weight, surface, etc. of coins and also used the concept of rotation invariance. The primary goals of this project are: Recognize the coins, count the coins and then get the total value. First, we apply preprocessing of the image and then pre-processed images are passed to the Harris-Hessian detector, it detects interest points. Now these features are fed to the Hough Transform, it detects circles and calculates the radius of coins. . It is a low cost system having recognition rate close to 100%. [20]

Deepika Mehta et al. in 2013 presented a system to detect and recognize the Overlapped coins using Otsu's Algorithm based on the Hough Transform technique. This project includes three step detection, extraction and recognition. For segmentation uses an Otsu's algorithm, for detecting overlapping uses the Hough transform and for recognition uses radius thresholding. The Detection rate of overlapped coins is 91% and recognition rate is 40% to 50%. [21]

2.3.3 Other Prior Art

In 1992 [22] Minoru Fukumi et al. presented a rotational invariant neural pattern recognition system for coin recognition. They performed experiments using 500 yen coin and 500 won coins. In this work, they have created a multilayered neural network and a preprocessor consisting of many slabs of neurons to provide rotation invariance. They further extended their work in 1993 [23] and tried to achieve 100% accuracy for coins. In this work they have used BP (Back Propagation) and GA (Genetic Algorithm) to design neural networks for coin recognition. Adnan Khashman et al. [24] presented an Intelligent Coin Identification System (ICIS) in 2006. ICIS uses neural network and pattern averaging for recognizing rotated coins in various degrees. It shows 96.3% correct identification, i.e. 77 out of 80 variably rotated coin images were correctly identified. Mohamed Roushdy [25] had used Generalized Hough Transform to detect coins in the image.

In 2011, Shatrughan Modi and Dr. Seema Bawa, presented their work based on Automatic Coin Recognition System using ANN, which involves following steps as work flow:

- Acquire RGB Coin Image
- Generate Pattern Averaged Image
- Remove Shadow from Image

- Crop and Trim the Image
- Convert RGB Image to Grayscale
- Generate Feature Vector and pass it as Input to Train NN
- Give Appropriate Result according to the Output of NN

In this ANN based Automated Coin Recognition System, for the recognition of Indian Coins of denomination `1, `2, `5 and `10 with rotation invariance, images of both sides of the coin has been captured. In this system, firstly preprocessing of the images is done, then the features are extracted from images using techniques of Hough Transformation, Pattern Averaging etc and then these processed images are fed to the trained neural network. The neural network has been trained, tested and validated using 5040 sample images of denominations `1, `2, `5 and `10 rotated at 50, 100, 150...., 3550.. 97.74% recognition rate has been achieved during the experiments i.e. only 2.26% miss recognition, which is quite encouraging. [26]

Hence the above mentioned literature and project study guided the various techniques and algorithms which can be applied for the development of CBCS. Here in the next section some of the technical analysis is being done to choose the appropriate development methodology.

2.4 Technical Review

Various different technical methodologies exist in the field of image processing for object recognition, feature extraction and others. Here by, few technical concepts have been discussed which can be applicable for the development of current project.

1. **Hough transformation:** The Hough Transform is a very useful tool to find a pattern in an image such as lines and curves. By transforming a point into a parameter space, it recognizes local patterns easily. Especially it is good for noisy and sparsely digitized images. First, a point in an image which is edge-detected makes a curve in the parameter space, a 2-D for lines and 3-D for circles. Whenever a point of the image is defined a valid candidate for a line or a circle, a curve in parameter space is updated. [27]
2. **Texton:** Textons are defined as fundamental micro-structures of natural images. Every natural images consist of those micro-structures, and they are smallest elements that human can recognize or discriminate; therefore, if we can find universal Textons that can generate every textures in the natural world like alphabet in English, then we

can build more rigid rules that can be used as segmenting, classifying, and even synthesizing images. [27]

3. **Artificial Neural Networks:** ANN is another method which can help in identifying the pattern on each coin and also helps in calculating its value. Various projects has been developed based on ANN concept, some of them are discussed in the previous section. ANN provides us better and accurate results but require highly maintained database and training sets which may increase system complexity.
4. **Pattern Matching:** This is another technique in the field of image processing which helped in identifying the pattern in an image and matches them. Segmentation, masking, texture analysis, feature extraction and matching and so on are few methods which can be used for pattern matching process.
5. **Threshold Matching:** This is very simple and basic method for the identification of any object in an image. In this method, a threshold value is being set for any object and hence then it is being matched with other captured image for matching.
6. **Histogram Matching:** Histogram matching is another very effective technique for the matching, recognition and identification of any object in an image. In this process, histogram of an image is being matched with the other for the detection. The results obtained under this method are quite accurate.

These are some of the technical approaches that are being used and can be applied for other related projects. In this current project, threshold range matching concept has been used, initially, but one can apply other techniques for its enhancement. The upcoming chapter shows the designing, implementation and other related processes of current project.

Chapter 3

PLAN & DESIGN

- Introduction
- Program working conditions
- Hardware & Software requirements
- Physical setup of the project
- Design phases
- Potential schemes for finding coins
- Stages of development
- Overall hardware description
- Overall Software Description
- Proposed System
- Summary

3. PLAN & DESIGN

3.1 Introduction

In this section the planned development of the project will be discussed. The operating conditions of our counting coin program will be set up. The development stages will be specified in this section. Then the algorithms used in the project will be discussed in details. There will be no technical definition of the algorithm used at each stage, since this will follow in the implementation part.

3.2 Program working conditions

As we discussed in the previous section, the program working conditions should be set up to improve the efficiency and effectiveness of the program. Because there are hundreds conditions about how the coins would be displayed on an image. For example, the size and shape of the same coin could also change according to the view of the camera that captures the coins. If the camera is placed just above the coin, the shape of the coin will be a circle. Otherwise, the shape of the coin will be an ellipse. And besides if the camera positioned near the coins, the size of the coin on the image captured by the camera will be relatively larger than the size of coins captured by the camera which placed far from the coins. Although these two problems can be worked out by using a scale, the time of this project is limited. So this plan is not considered working in these sorts of conditions.

3.3 Hardware & Software requirements

3.3.1 Hardware requirements/Used

- A computer with MATLAB software installed.
- Liquid crystal display (LCD) /LED
- Microcontroller (PIC16f887)
- Servo motor
- Camera
- Infrared sensor unit
- Relay switch
- LM358
- MAX 232

3.3.2 Software requirements/Used

MATLAB (R2009 or higher) is the development tool for this task. So the program will be working under MATLAB environment.

PIC kit2 (Programmer/Debugger) is the development tool for microcontroller PIC16f887.

3.4 Physical setup of the project

This task is broken under the physical setup stated below:

- The camera should be set up in its space and coin is brought in front of the camera via coin holder with the help of servo motor.
- The distance between the camera and the coins should be fixed.
- The coins should be located within the coin holder by the user and servo motor will help the coin holder to bring coin in front of the camera.
- A microcontroller is programmed to contain the overall working of the organization.
- A battery source is left to provide the power to the whole scheme.
- A solar panel is utilized for regular charging of battery.

3.5 Design phases

Although there wasn't really a need for a comprehensive software Lifecycle for this task, a certain quantity of planned design was even thought necessary. In this segment, the computation strategy was discussed first. And so, granting to the computation strategy, we found, the ontogeny of this task was divided into few main points. Referable to the algorithm we used each main level was too split down to sub-steps. These points will be hashed out in coming sections.

3.6 Potential schemes for finding coins

The appropriate computation strategy used in this project is threshold range matching (upper and lower limit for coins), because of usage of the low resolution camera. According to this strategy, when the image is captured in real time, the range is being matched by the program and indicates the value of the coin to the microcontroller for the further process/working of the system. The images of the coins are captured in different lightening conditions to decide the range for each valued (Re.1 or Rs. 2) coin.

This scheme is not being practiced while applying high resolution cameras in the arrangement. While using high quality of camera one can utilize various other techniques of picture processing, say Hough transformation, features extraction and pattern matching and hence along. On detection, the microcontroller will allow the power supply to the ports for the charging of gadget for a fixed duration. If any individual needs power for long duration then one can re-insert a coin to continue the process.

Nevertheless, counting the price, size and other facets of the evolution of the whole scheme, initially first strategy was chosen for this task. Farther, this task can be fine-tuned as per one's requirement or demand.

The expected flow of the project and the overall working of the system is as shown in the below diagram.

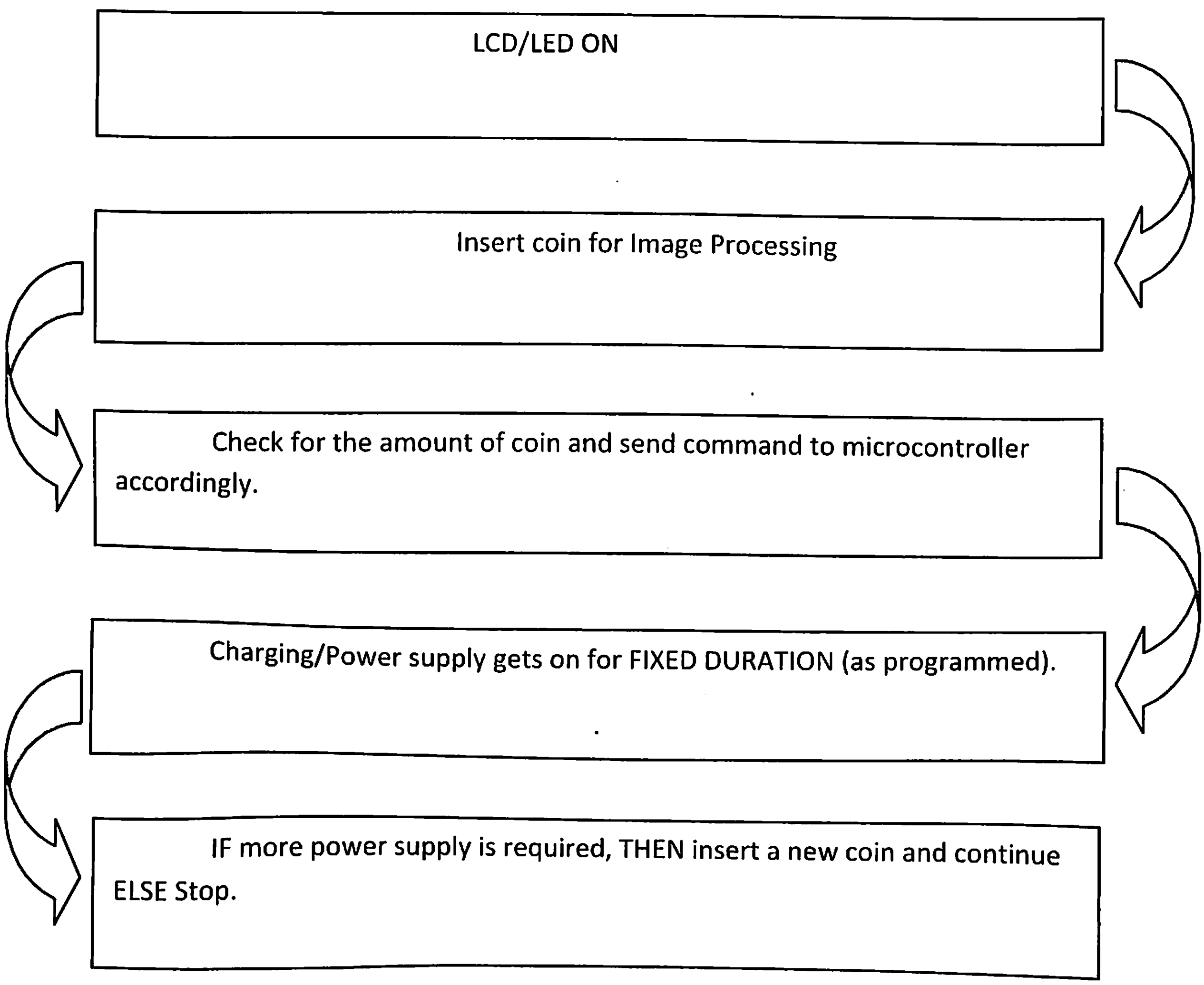

Figure 3-1: Showing expected project flow

3.7 Stages of development

The development of the CBCS system was divided into four main stages according to our development strategy. Then each main stage was broken into sub-steps according to the plan and study. Every sub-measure was planned as a distinct level, which could be filled out and tested separately, and then incorporated into the master task.

Stage 1: Circuit Designing & PCB layout

In this stage, basic circuit has been designed by using simulation tools to check the overall working of the circuit to be used in the development of CBCS system. Several parts were gathered using the simulator tool and hence the working of circuit was tested on the simulator. Granting to the circuit designed, PCB Layout was made such that the hardware components can be set up accordingly.

Stage 2: Assembling

At this stage of system evolution, all the elements are gathered together according to the circuit designed and PCB layout as presented in the old phases. After assembling of all the components, testing was performed to check the working of every component with each other. Hence the hardware testing was done in parallel.

Stage 3: Software

After detail study of hardware parts and their assembling, as reported in former levels, next we travel towards the software component of the arrangement. Software part includes two sub-steps as stated below:

a) **Programming of microcontroller**
   a. At initial stage of microcontroller programming, firstly an .asm file of the assembly code was coded for the working and performance of controller. Then microcontroller is burnt with the accumulated files of this codification.
   b. A C program is written to do interaction with.asm file code. Functions of .asm file called in a C program and the interaction of the whole operation is being performed.

b) **Using image processing techniques using MATLAB:** For the detection of value of coin, picture processing techniques have been applied. These techniques include masking, feature extraction, Hough Transformation, pattern matching and hence along. Granting to the initial setup of hardware, here by a threshold range matching technique is being utilized for the detection of value of coins.

Stage 4: Calculating the value of coins

After the development of above mention codes, we must integrate them with the hardware setup as assembled on stage 3. Microcontroller's code is debugged and complied and then the compiled files are shifted to the controller for its operation. It lets the coin - holder to move in-front of the camera on detecting something inside it. And so the camera will send the real time captured image to the MATLAB for calculating its value and hence sends command to the controller to switch-on the power for a limited period.

These are the five main stages covered for the designing of CBCS. An additional algorithm/technique can be used to improve the working of the system.

Compute the value of the coin by its either side

As we discussed in previous section, the distance between the camera and coins should be fixed. So when the program was set up at the first time, after the camera was set, we should put a coin under the camera, and then use this algorithm to find the value of the coin. We can improve the working of complete system and enhance our algorithm by allowing it to calculate the value of coin by looking at its either face (heads or tail) and hence remove the initial limitation of the system. We will discuss the reasons in the validation section in chapter 4.

3.8 Overall hardware description

As discussed in section 3.7, there were different stages and algorithms used to develop the project. Now in the upcoming sections description about the components and algorithms used in this project, by the stage of development, is provided.

3.8.1 LCD

This element is specifically constructed to be used with microcontrollers, which implies that it cannot be triggered off by standard IC circuits. It is utilized for displaying different messages on a miniature liquid crystal show. The model depicted here is for its low price and great capabilities most frequently employed in practice. It can display messages in two lines with 16 characters each. It can display all the letters of the alphabet, Greek letters, punctuation marks, mathematical symbols, etc. It is also possible to display symbols made up by the user. Other useful features include automatic message shift (left and right), cursor appearance, LED backlight etc.

Figure 3-2: LCD Outlook [*Source, courtesy:* www.mikroe.com/chapters/view/17/chapter-4-examples]

3.8.1.1 PIN Descriptions

Along one side of the small printed board of the LCD display there are pins that connect it to the microcontroller. There are in total, of 14 pins marked with numbers (16 if there is a backlight). The table shown below describes the function of each pin:

FUNCTION	PIN NUMBER	NAME	LOGIC STATE	DESCRIPTION
Ground	1	Vss	-	0V
Power supply	2	Vdd	-	+5V
Contrast	3	Vee	-	0 - Vdd
Control of operating	4	RS	0 1	D0 – D7 are interpreted as commands D0 – D7 are interpreted as data
	5	R/W	0 1	Write data (from controller to LCD) Read data (from LCD to controller)
	6	E	0 1 From 1 to 0	Access to LCD disabled Normal operating Data/commands are transferred to LCD
Data / commands	7	D0	0/1	Bit 0 LSB
	8	D1	0/1	Bit 1
	9	D2	0/1	Bit 2
	10	D3	0/1	Bit 3
	11	D4	0/1	Bit 4
	12	D5	0/1	Bit 5
	13	D6	0/1	Bit 6
	14	D7	0/1	Bit 7 MSB

Table 3-1: PIN description of LCD [*Source, courtesy:* www.mikroe.com/chapters/view/17/chapter-4-examples]

3.8.1.2 LCD Screen

An LCD screen can display two lines with 16 characters each. Every character consists of 5x8 or 5x11 dot matrix. But a 5x8 character display is most commonly used; hence we can use the same for the development of this project.

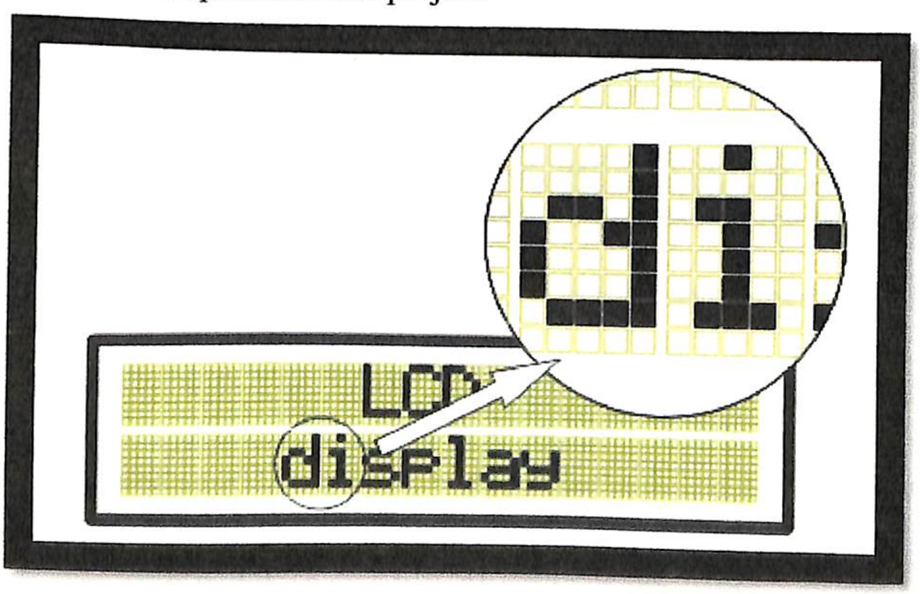

Figure 3-3: LCD display screen [*Source, courtesy:* www.mikroe.com/chapters/view/17/chapter-4-examples]

Display contrast depends on the power supply voltage and whether messages are displayed in one or two courses. For this reason, varying voltage 0-Vdd is applied to the pin marked as Vee. A trimmer potentiometer is normally employed for this function. Some of the LCD displays have a built-in backlight (blue or green LEDs). When applied during operation, a current limiting resistor should be serially connected to one of the pins for backlight power supply (similar to LED diodes).

If there are no characters to be displayed or if all of them are dimmed when the display is switched on, the first thing that should be done is to check the potentiometer for contrast adjustment. The same applies if the mode of operation has been changed (writing in one or two lines).

3.8.1.3 Pin Connection of LCD

Below figure shows the pin connection of the LCD.

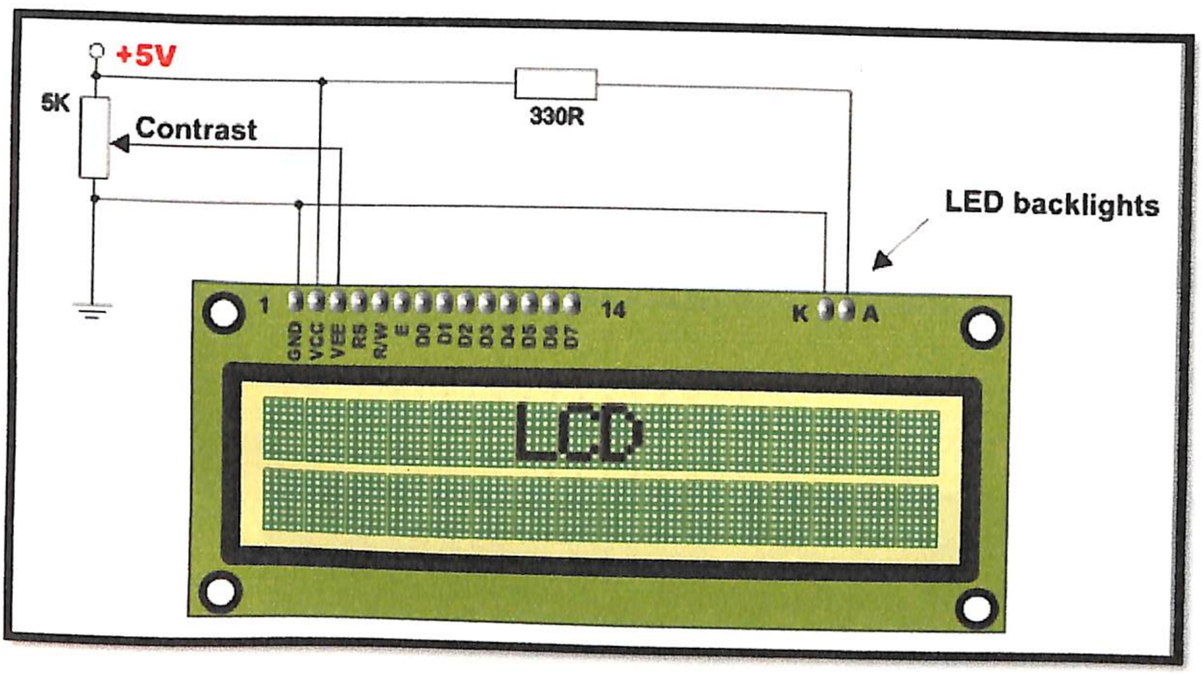

Figure 3-4: LCD pin connection [*Source, courtesy:* www.mikroe.com/chapters/view/17/chapter-4-examples]

3.8.1.4 LCD Connection with Controller

Depending on how many lines are used for connecting an LCD to the microcontroller, there are 8-bit and 4-bit LCD modes. The appropriate mode is selected at the beginning of the operation in the process called 'initialization'. The 8-bit LCD mode uses outputs D0- D7 to transfer data as explained on the previous page. The main purpose of the 4-bit LCD mode is to save valuable I/O pins of the microcontroller. Only 4higher bits (D4-D7) are used for communication, while others may be left unconnected. Each bit of information is beamed to the LCD in two steps- four higher bits are sent first (normally through the lines D4-D7) then four lower bits. Initialization enables the LCD to link and interpret received bits correctly. Information is seldom read from the LCD (it is mainly transferred from the microcontroller to the LCD) so it is frequently possible to preserve an extra I/O pin by simply connecting the R/W pin to the Ground. Messages will be normally displayed, but it will not be possible to read the busy flag since it is not possible to read the display either. Fortunately, there is a relatively simple solution. After sending a character or a command it is important to give the LCD enough time to do its job. Owing to the fact that the implementation of a command may last for approximately 1.64ms, it will be sufficient to wait about 2mS for the LCD.

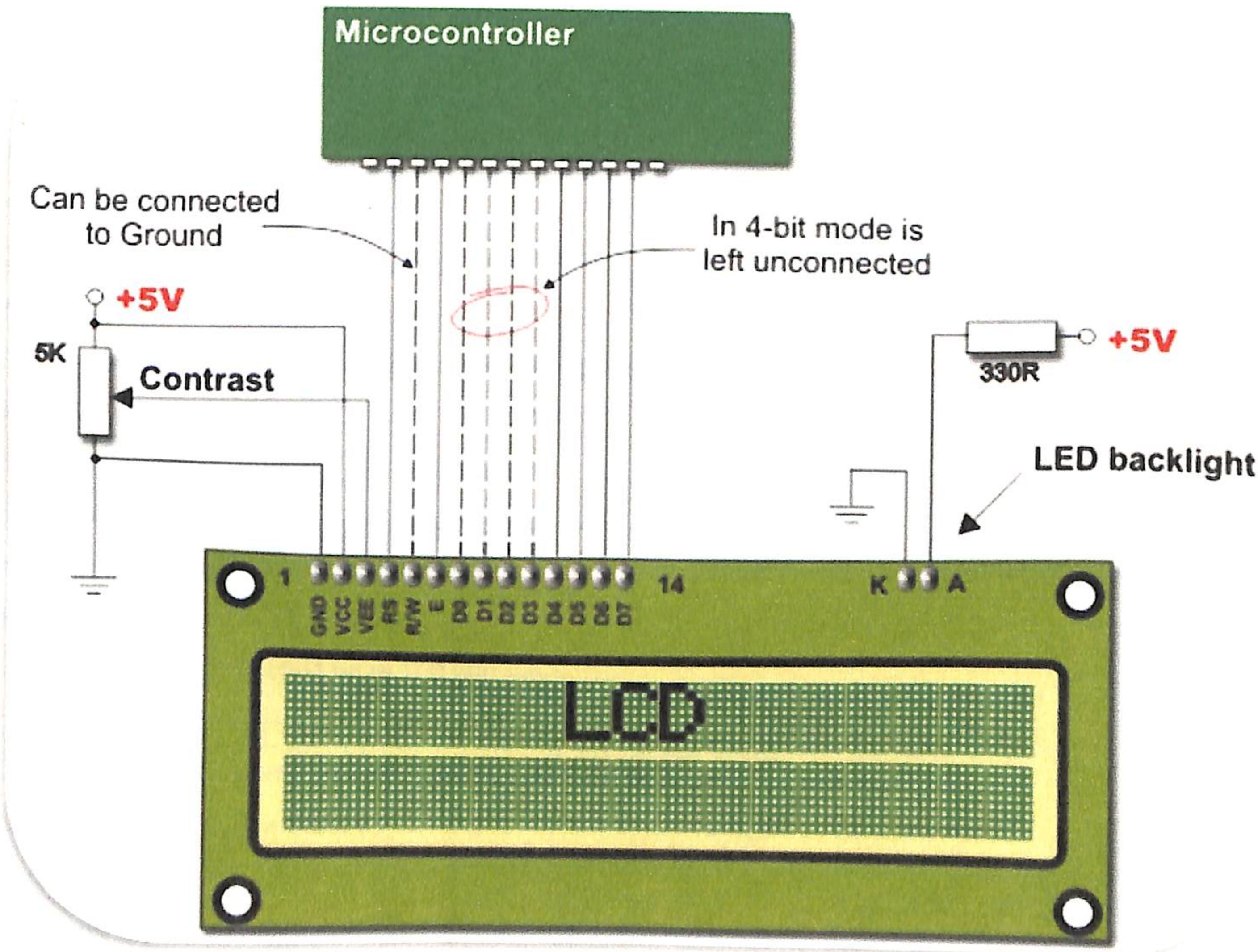

Figure 3-5: LCD and controller connection [*Source, courtesy:* www.mikroe.com/chapters/view/17/chapter-4-examples]

3.8.2 Microcontroller

The PIC16F887 is a well known product by Microchip. It features all the components which modern microcontrollers normally have. For its low price, wide range of application, high quality and easy availability, it is an ideal solution in applications such as the control of different processes in industry, machine control devices, measurement of different values etc. Some of its main features are listed below:

- **RISC architecture**
- Only 35 instructions to learn
- All single-cycle instructions except branches
- **Operating frequency 0-20 MHz**
- **Precision internal oscillator**
- Factory calibrated
- Software selectable frequency range of 8MHz to 31 KHz
- **Power supply voltage 2.0-5.5V**
- Consumption: 220uA (2.0V, 4MHz), 11uA (2.0 V, 32 KHz) 50nA (stand-by mode)
- Power-Saving Sleep Mode
- Brown-out Reset (BOR) with software control option
- **35 input/output pins**
- High current source/sink for direct LED drive
- Software and individually programmable *pull-up* resistor
- Interrupt-on-Change pin
- **8K ROM memory in FLASH technology**
- Chip can be reprogrammed up to 100.000 times
- ***In-Circuit Serial Programming* Option**
- Chip can be programmed even embedded in the target device
- **256 bytes EEPROM memory**
- Data can be written more than 1.000.000 times
- **368 bytes RAM memory**
- **A/D converter:**
- 14-channels
- 10-bit resolution
- **3 independent timers/counters**

- **Watchdog timer**
- **Analogue comparator module with**
- Two analogue comparators
- Fixed voltage reference (0.6V)
- Programmable on-chip voltage reference
- **PWM output steering control**
- **Enhanced USART module**
- Supports RS-485, RS-232 and LIN2.0
- Auto-Baud Detect
- **Master Synchronous Serial Port (MSSP)**
- Supports SPI and I2C mode

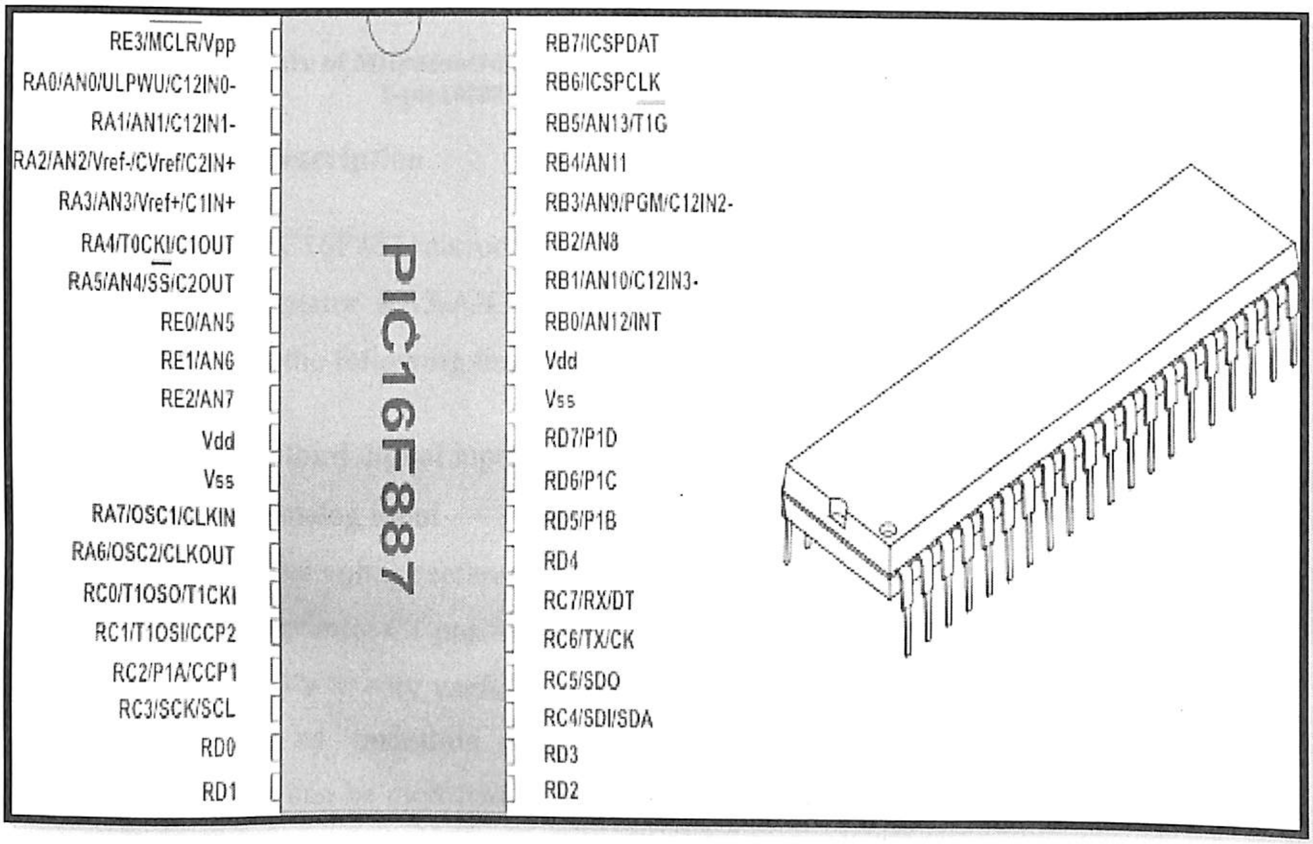

Figure 3-6: Pin configuration of Microcontroller PIC16f887 [*Source, courtesy:* www.mikroe.com/chapters/view/2/chapter-1-pic16f887-microcontorller-device-overview]

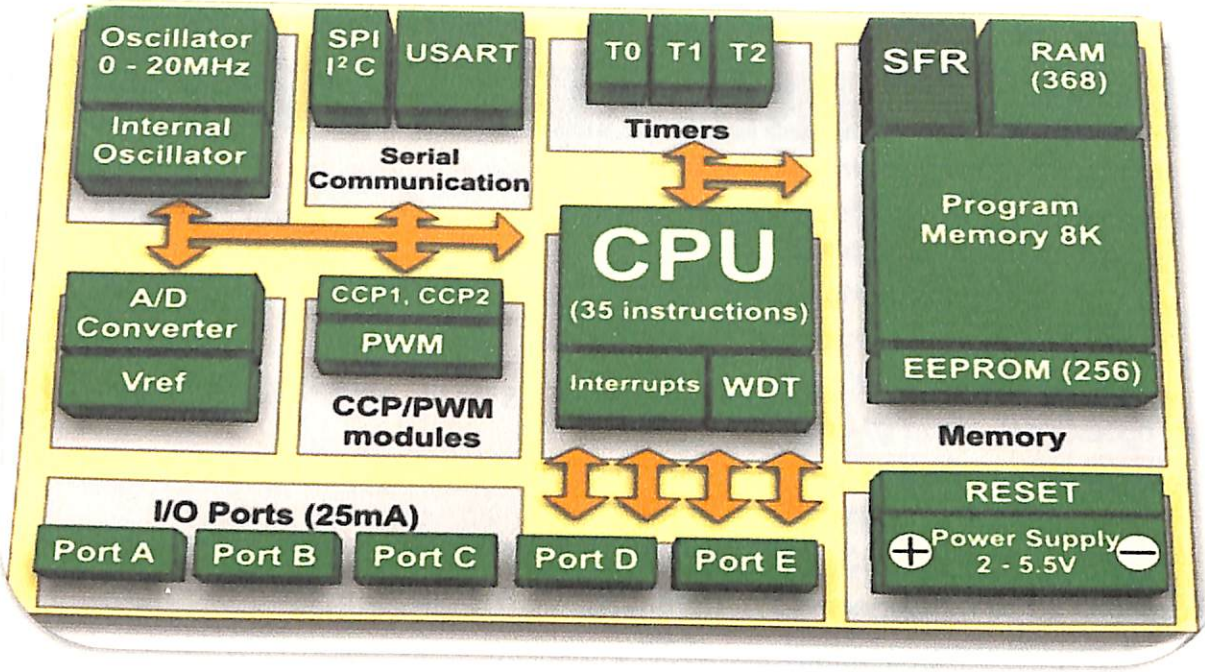

Figure 3-7: Architecture of Microcontroller [*Source, courtesy:* www.mikroe.com/chapters/view/2/chapter-1-pic16f887-microcontorller-device-overview]

3.8.2.1 PINOUT Description

Most pins of the PIC16F887 microcontroller are multi-functional as seen in the image above. For example, designator RA3/AN3/Vref+/C1IN+ for the fifth pin of the microcontroller indicates that it has the following functions:

- RA3 Port A third digital input/output
- AN3 Third analog input
- Vref+ Positive voltage reference
- C1IN+ Comparator C1 positive input

Such pin functionality is very useful as it makes the microcontroller package more compact without affecting its operation. These various pin functions cannot be practiced simultaneously, but can be modified at whatever level during operation. The following tables refer to the PDIP 40 microcontroller.

Name	Number (DIP 40)	Function	Description
RE3/MCLR/Vpp	1	RE3	General purpose input Port E
		MCLR	Reset pin. Low logic level on this pin resets microcontroller.
		Vpp	Programming voltage
RA0/AN0/ULPWU/C12IN0-	2	RA0	General purpose I/O port A
		AN0	A/D Channel 0 input
		ULPWU	Stand-by mode deactivation input
		C12IN0-	Comparator C1 or C2 negative input
RA1/AN1/C12IN1-	3	RA1	General purpose I/O port A
		AN1	A/D Channel 1
		C12IN1-	Comparator C1 or C2 negative input
RA2/AN2/Vref-/CVref/C2IN+	4	RA2	General purpose I/O port A
		AN2	A/D Channel 2
		Vref-	A/D Negative Voltage Reference input
		CVref	Comparator Voltage Reference Output
		C2IN+	Comparator C2 Positive Input
RA3/AN3/Vref+/C1IN+	5	RA3	General purpose I/O port A
		AN3	A/D Channel 3
		Vref+	A/D Positive Voltage Reference Input
		C1IN+	Comparator C1 Positive Input
RA4/T0CKI/C1OUT	6	RA4	General purpose I/O port A
		T0CKI	Timer T0 Clock Input
		C1OUT	Comparator C1 Output
RA5/AN4/SS/C2OUT	7	RA5	General purpose I/O port A
		AN4	A/D Channel 4
		SS	SPI module Input (*Slave Select*)
		C2OUT	Comparator C2 Output
RE0/AN5	8	RE0	General purpose I/O port E
		AN5	A/D Channel 5
RE1/AN6	9	RE1	General purpose I/O port E
		AN6	A/D Channel 6
RE2/AN7	10	RE2	General purpose I/O port E
		AN7	A/D Channel 7
Vdd	11	+	Positive supply
Vss	12	-	Ground (GND)

Table 3-2: PINOUT description of controller (I) [*Source, courtesy:* www.mikroe.com/chapters/view/2/chapter-1-pic16f887-microcontorller-device-overview]

<table>
<tr><th>Name</th><th>Number (DIP 40)</th><th>Function</th><th>Description</th></tr>
<tr><td rowspan="3">RA7/OSC1/CLKIN</td><td rowspan="3">13</td><td>RA7</td><td>General purpose I/O port A</td></tr>
<tr><td>OSC1</td><td>Crystal Oscillator Input</td></tr>
<tr><td>CLKIN</td><td>External Clock Input</td></tr>
<tr><td rowspan="3">RA6/OSC2/CLKOUT</td><td rowspan="3">14</td><td>OSC2</td><td>Crystal Oscillator Output</td></tr>
<tr><td>CLKO</td><td>Fosc/4 Output</td></tr>
<tr><td>RA6</td><td>General purpose I/O port A</td></tr>
<tr><td rowspan="3">RC0/T1OSO/T1CKI</td><td rowspan="3">15</td><td>RC0</td><td>General purpose I/O port C</td></tr>
<tr><td>T1OSO</td><td>Timer T1 Oscillator Output</td></tr>
<tr><td>T1CKI</td><td>Timer T1 Clock Input</td></tr>
<tr><td rowspan="3">RC1/T1OSO/T1CKI</td><td rowspan="3">16</td><td>RC1</td><td>General purpose I/O port C</td></tr>
<tr><td>T1OSI</td><td>Timer T1 Oscillator Input</td></tr>
<tr><td>CCP2</td><td>CCP1 and PWM1 module I/O</td></tr>
<tr><td rowspan="3">RC2/P1A/CCP1</td><td rowspan="3">17</td><td>RC2</td><td>General purpose I/O port C</td></tr>
<tr><td>P1A</td><td>PWM Module Output</td></tr>
<tr><td>CCP1</td><td>CCP1 and PWM1 module I/O</td></tr>
<tr><td rowspan="3">RC3/SCK/SCL</td><td rowspan="3">18</td><td>RC3</td><td>General purpose I/O port C</td></tr>
<tr><td>SCK</td><td>MSSP module Clock I/O in SPI mode</td></tr>
<tr><td>SCL</td><td>MSSP module Clock I/O in I²C mode</td></tr>
<tr><td>RD0</td><td>19</td><td>RD0</td><td>General purpose I/O port D</td></tr>
<tr><td>RD1</td><td>20</td><td>RD1</td><td>General purpose I/O port D</td></tr>
<tr><td>RD2</td><td>21</td><td>RD2</td><td>General purpose I/O port D</td></tr>
<tr><td>RD3</td><td>22</td><td>RD3</td><td>General purpose I/O port D</td></tr>
<tr><td rowspan="3">RC4/SDI/SDA</td><td rowspan="3">23</td><td>RC4</td><td>General purpose I/O port A</td></tr>
<tr><td>SDI</td><td>MSSP module Data input in SPI mode</td></tr>
<tr><td>SDA</td><td>MSSP module Data I/O in I²C mode</td></tr>
<tr><td rowspan="2">RC5/SDO</td><td rowspan="2">24</td><td>RC5</td><td>General purpose I/O port C</td></tr>
<tr><td>SDO</td><td>MSSP module Data output in SPI mode</td></tr>
<tr><td rowspan="3">RC6/TX/CK</td><td rowspan="3">25</td><td>RC6</td><td>General purpose I/O port C</td></tr>
<tr><td>TX</td><td>USART Asynchronous Output</td></tr>
<tr><td>CK</td><td>USART Synchronous Clock</td></tr>
<tr><td rowspan="3">RC7/RX/DT</td><td rowspan="3">26</td><td>RC7</td><td>General purpose I/O port C</td></tr>
<tr><td>RX</td><td>USART Asynchronous Input</td></tr>
<tr><td>DT</td><td>USART Synchronous Data</td></tr>
</table>

Table 3-3: PINOUT description of controller (II) [*Source, courtesy:* www.mikroe.com/chapters/view/2/chapter-1-pic16f887-microcontorller-device-overview]

Name	Number (DIP 40)	Function	Description
RD4	27	RD4	General purpose I/O port D
RD5/P1B	28	RD5	General purpose I/O port D
		P1B	PWM Output
RD6/P1C	29	RD6	General purpose I/O port D
		P1C	PWM Output
RD7/P1D	30	RD7	General purpose I/O port D
		P1D	PWM Output
Vss	31	-	Ground (GND)
Vdd	32	+	Positive Supply
RB0/AN12/INT	33	RB0	General purpose I/O port B
		AN12	A/D Channel 12
		INT	External Interrupt
RB1/AN10/C12INT3-	34	RB1	General purpose I/O port B
		AN10	A/D Channel 10
		C12INT3-	Comparator C1 or C2 Negative Input
RB2/AN8	35	RB2	General purpose I/O port B
		AN8	A/D Channel 8
RB3/AN9/PGM/C12IN2-	36	RB3	General purpose I/O port B
		AN9	A/D Channel 9
		PGM	Programming enable pin
		C12IN2-	Comparator C1 or C2 Negative Input
RB4/AN11	37	RB4	General purpose I/O port B
		AN11	A/D Channel 11
RB5/AN13/T1G	38	RB5	General purpose I/O port B
		AN13	A/D Channel 13
		T1G	Timer T1 External Input
RB6/ICSPCLK	39	RB6	General purpose I/O port B
		ICSPCLK	Serial programming Clock
RB7/ICSPDAT	40	RB7	General purpose I/O port B
		ICSPDAT	Programming enable pin

Table 3-4: PINOUT description of controller (III) [*Source, courtesy:* www.mikroe.com/chapters/view/2/chapter-1-pic16f887-microcontorller-device-overview]

3.8.3 Servomotor

A servo motor is a rotary actuator that allows for accurate control of angular position, speed and acceleration. It consists of a suitable motor coupled to a sensing element for position feedback. It too takes a relatively sophisticated controller, often a dedicated module designed specifically for use with servo motors. Servo motors are not a different class of motor, on the foundation of underlying operating principle, but use servomechanism to achieve closed loop control with a generic open loop motor.

Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing. As the name indicates, a servo motor is a servomechanism. More specifically, it is a closed-loop servomechanism that uses position feedback to control its movement and last spot. The input to its control is some signal, either analogue or digital, representing the position commanded for the output shaft.

The motor is paired with some type of encoder to provide position and speed feedback. In the most elementary example, only the position is valued. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

The very simplest servo motors use position-only sensing via a potentiometer and bang-bang control of their motor; the motor always rotates at full speed (or is terminated). This case of servo motor is not widely applied in industrial motion control, but it constitutes the groundwork of the simple and cheap servos used for radio-controlled models. More sophisticated servomotors measure both the position and also the speed of the output shaft. They may also manipulate the velocity of their motor, rather than constantly working at full velocity. Both of these enhancements, usually in combination with a PID control algorithm, allow the servo motor to be conveyed to its commanded position more quickly and more precisely, with less overshooting.

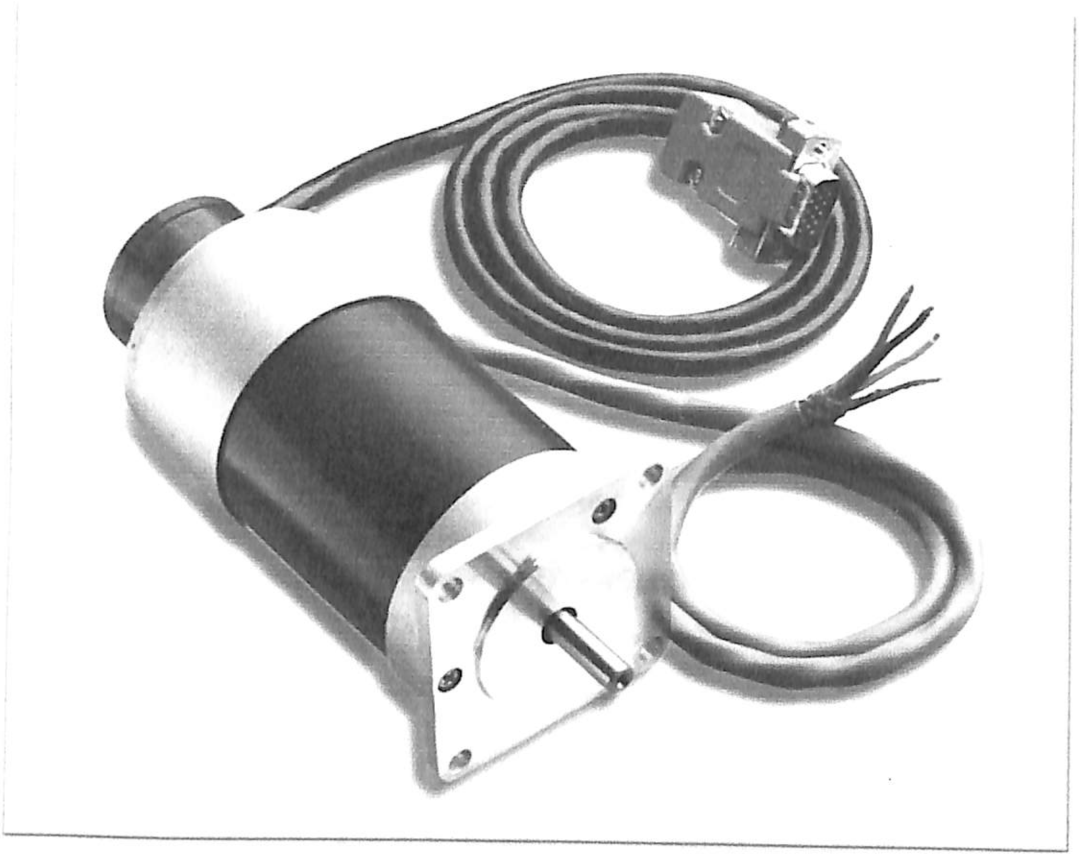

Figure 3-8: Servomotor [*Source, courtesy:* www.galilmc.com/products/servo-motor.php]

3.8.3.1 How to control servo?

Servos are controlled by sending an electrical pulse of variable width, or **pulse width modulation** (PWM), through the control wire. There is a minimum pulse, a maximum pulse, and a repetition rate. Servo motors can usually only turn 90 degrees in either direction for an aggregate of 180 degree movement. The motor's neutral position is determined as the place where the servo has the same quantity of potential rotation in the both the clockwise or counter-clockwise direction. The PWM sent to the motor determines the position of the shaft, and based on the duration of the pulse sent via the control wire; the rotor will turn to the desired position. The servo motor requires seeing a beat every 20 milliseconds (ms) and the length of the pulse will determine how far the motor works. For instance, a 1.5ms pulse will cause the motor turn to the 90-degree position. Shorter than 1.5ms moves it to 0 degrees, and any longer than 1.5ms will turn the servo to 180 degrees, as diagrammed below

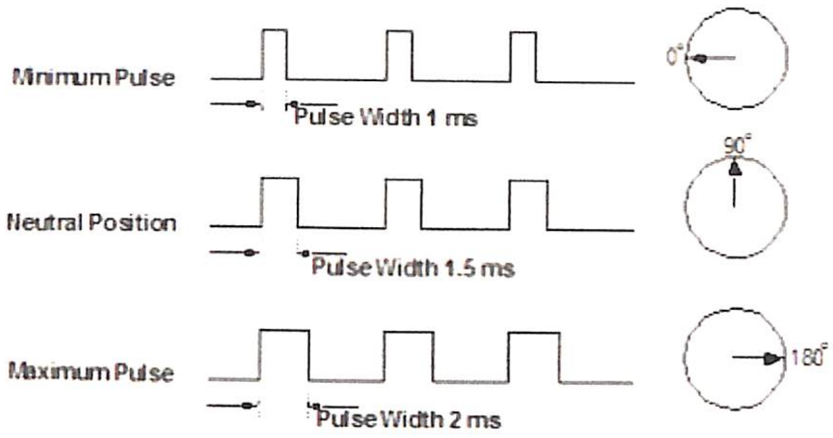

Figure 3-9: Variable Pulse width control servo [*Source, courtesy:* www.jameco.com/Jameco/workshop/howitworks/how-servo-motors-work.html?sp_rid=MjkxOTAwODE2NjQS1&sp_mid=4334065]

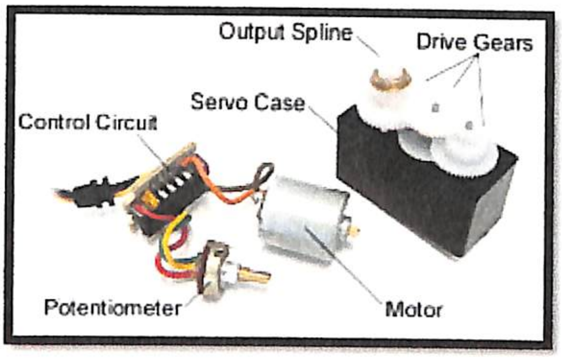

Figure 3-10: Internal parts of servomotor [*Source, courtesy:* www.jameco.com/Jameco/workshop/howitworks/how-servo-motors-work.html?sp_rid=MjkxOTAwODE2NjQS1&sp_mid=4334065]

When these servos are commanded to move, they will move to the position and hold that position. If an external force pushes against the servo while the servo is holding a posture, the servo will resist from moving out of that place. The upper limit amount of force the servo can exert is called the torque rating of the servomechanism. The servos will not take their position forever though; the position pulse must be repeated to instruct the servo to stay in place.

3.8.3.2 Types of Servo Motors

There are II types of servo motors - AC and DC. AC servo can handle higher current surges and tend to be utilized in industrial machinery. DC servos are not designed for high current surges and are usually better suited for smaller applications. Broadly speaking, DC motors are less expensive than their AC counterparts. These are also servo motors that have been made specifically for continuous revolution, making it an easygoing path to make your robot running. They feature two ball bearings on the output shaft for reduced friction and easy access to the rest-point adjustment potentiometer.

3.8.4 CAMERA

The camera is used only to capture images of the coin placed in the coin holder. It detects the amount of the coin placed and sends commands to the microcontroller for the specific duration of charging. The value of the coin is estimated by applying image processing technique and therefore depending on the value of the coin inserted power supply is switched on for limited duration by the microcontroller.

Figure 3-11: High resolution Camera [*Source, courtesy:* Internet]

3.8.5 Infrared Sensors (IR)

IR Sensors work by using a definite light sensor, to detect a specific light wavelength in the Infra-Red (IR) spectrum. By using an LED, which can produce light at the same wavelength as what the sensor is optimized for, and also evaluates the intensity of the light received. When a target is near to the detector, the light emitted from the LED reflects back from the object into the light sensing elements. This result in a large change in the intensity received, which is tantamount to the threshold value of the sensors. On receiving toned intensity of the light reflected, indicate the presence of coin within the holder. After receiving such indication, the controller will proceed further, i.e. coin holder will move towards the camera for further working of the system.

3.8.5.1 Detecting Brightness

Since the sensor figures out by looking for reflected illumination, it is potential to hold a sensor that can give the value of the reflected light. This character of detector can then be utilized to assess how "bright" the target is. This is useful for tasks like line tracking.

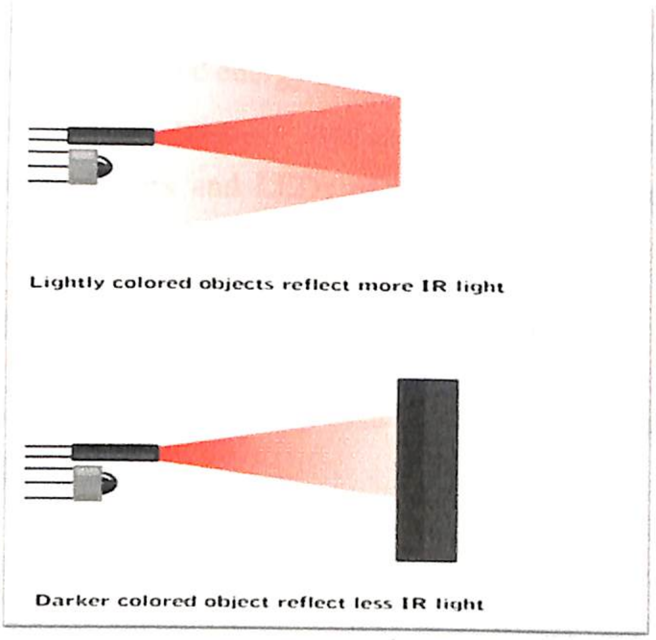

Figure 3-12: Reflected IR detection [*Source, courtesy:* www.education.rec.ri.cmu.edu/content/electronics/boe/ir_sensor/1.html]

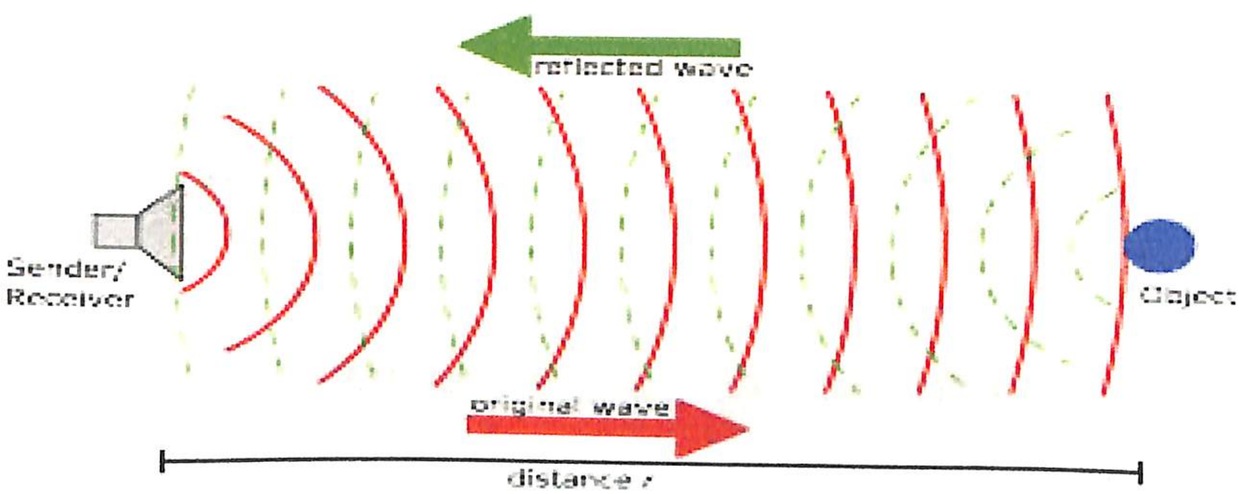

Figure 3-13: IR rays sending and receiving [*Source, courtesy:* www.education.rec.ri.cmu.edu]

3.8.5.2 Elements of Infrared detection system

The block diagram below shows a typical system for detecting infrared radiation process along with the brief description of each module.

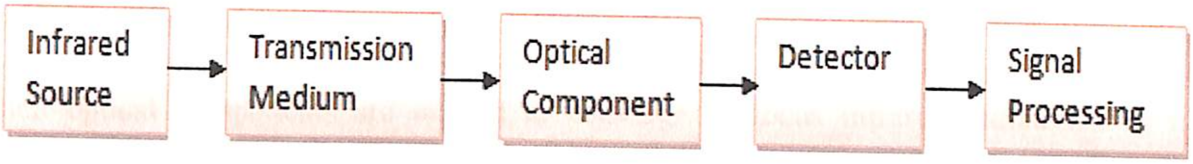

Figure 3-14: Typical system for detecting infrared radiation process

1. Infrared Source

All objects above 0 K radiate infrared energy and hence are infrared sources. Infrared sources also include blackbody radiators, tungsten lamps, silicon carbide, and various others. For active IR sensors, infrared Lasers and LEDs of specific IR wavelengths are used as IR sources.

2. Transmission Medium

Three principle types of transmission medium used for Infrared transmission are vacuum, the atmosphere, and optical fibers.

The transmission of IR – radiation is affected by the presence of CO2, water vapor and other constituents in the air. Due to absorption by molecules of water, carbon dioxide, ozone, etc. the atmosphere highly attenuates most IR wavelengths leaving some important IR windows in the electromagnetic spectrum; these are mainly applied by thermal imaging/ remote sensing applications.

- Medium wave IR (MWIR: 3-5 µm).
- Long wave IR (LWIR: 8-14 µm)

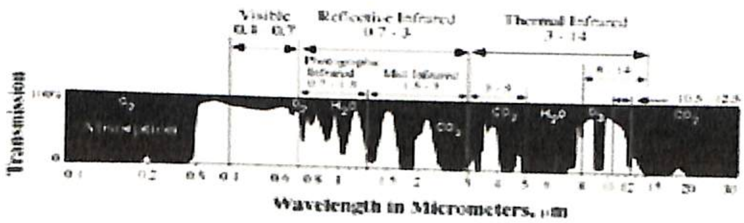

Figure 3-15 Transmission medium for IR [*Source, courtesy:* www.inpechopen.com]

Choice of IR band or a specific wavelength is dictated by the technical demands of a specific application.

3. Optical Components.

Often optical components are needed to converge or focus infrared radiations, to limit spectral response, etc. To converge focus radiations, optical lenses made of quartz, CaF2, Ge and Si, polyethylene Fresnel lenses, and mirrors made by Al, Au or a similar material are applied. For limiting spectral responses, bandpass filters are applied. Choppers are used to pass/ interrupt the IR beams.

4. Infrared detectors.

Various types of detectors are used in IR sensors. Important specifications of detectors are

- Photosensitivity or Responsivity

Responsivity is the Output Voltage Current per watt of incident energy.

- Noise Equivalent Power (NEP)

NEP represents detection ability of a detector and is the amount of incident light equal to the intrinsic noise level of a detector.

- Detectivity (D*: D-Star)

D* is the photosensitivity per unit area of a detector. It is a measure of the S/N ratio of a detector. D* is inversely proportional to NEP. Larger D* indicates better sensing element.

In addition, wavelength region or temperature to be measured, response time, cooling mechanism, active area, no of elements, package, linearity, stability, temperature characteristics, etc. are important parameters which need attention while selecting IR detectors.

5. Signal Processing

Since detector outputs are typically very small, Preamplifiers with associated circuitry are used to further process the received signals.

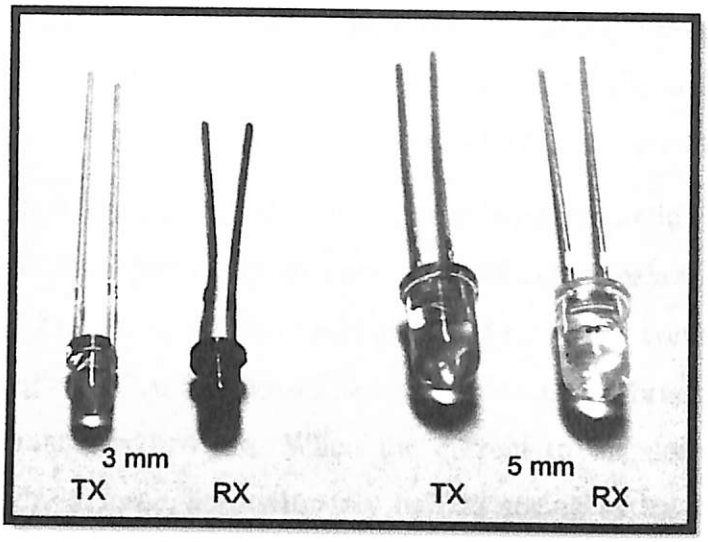

Figure 3-16: LEDs for IR emission [*Source, courtesy:* www.ledinside.com]

3.8.6 Relay Switch

A relay is simply an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are likewise applied. Relays are used where it is necessary to hold a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be held by one signal. The first relays were used in long distance telegraph circuits, repeating the signal coming from one circuit and re-transmitting it to another. Relays were used extensively in telephone exchanges and early computers to execute logical operations.

A type of relay that can handle the high power required to directly control an electric motor or other loads is called a contactor. Solid-state relays control power circuits with no moving parts instead of using a semiconductor device to perform switching. Relays with calibrated operating characteristics and sometimes multiple operating coils are applied to protect electrical circuits from overload or faults; in innovative electric power systems these functions are executed by digital instruments still called "protective relays".

A simple electromagnetic relay consists of a roll of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured). The armature is hinged to the yoke and mechanically connected to one or more sets of moving contacts. It is kept in position by a spring so that when the relay is de-energized there is an air gap in the magnetic circle. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their purpose. The relay in the picture also has a wire connecting the armature to the yoke. This assures continuity of the circle between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB.

When an electric flow is run through the coil it generates a magnetic field that activates the armature and the resultant move of the movable contact either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the move opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are constructed to work quickly. In a low-voltage application this reduces noise; in a high potential or current application it reduces arcing. When the coil is energized with direct current, a diode is often placed across the coil to dissipate the energy from the collapsing magnetic field at deactivation, which would otherwise generate a voltage spike dangerous to semiconductor circuit components. Some automotive relays include a diode inside the relay case. Alternatively, a contact protection network consisting of a capacitor and resistor in series may absorb the surge. If the coil is designed to be energized by alternating current (AC), a small copper "shading ring" can be crimped to the end of the solenoid, creating a small out-of-phase current which increases the minimum pull on the armature during the AC cycle.

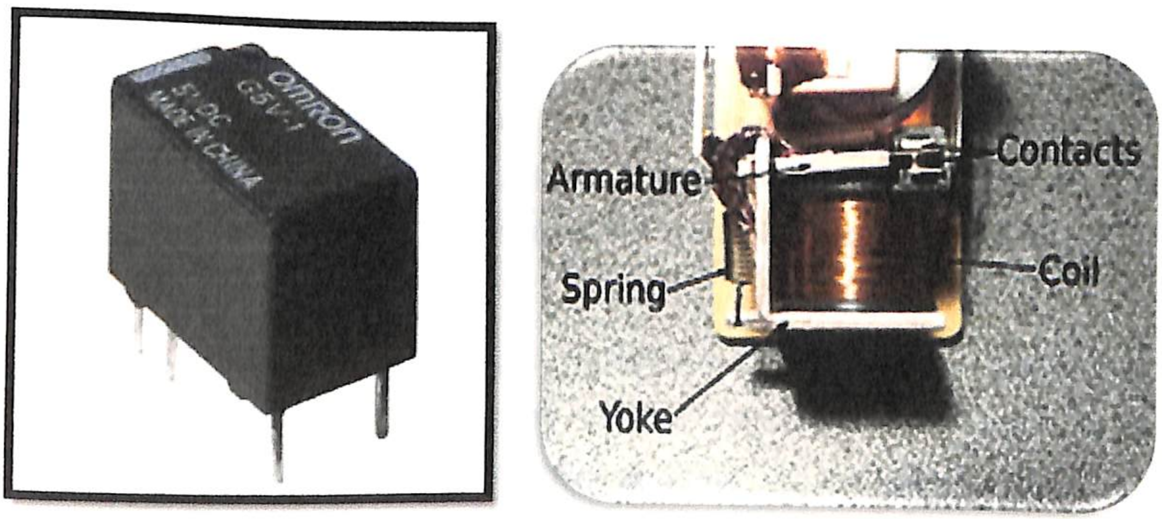

Figure 3-17: Relay Switch including internal look [*Source, courtesy:* www.allspectrum.com]

3.8.7 LM358

The LM158 series consists of two independent, high gains; internally frequency compensated operational amplifiers which were designed specifically to operate over a wide range of µA-essentially an Independent of Supply voltage. Operation from split power supplies is too independent of the magnitude of the power supply voltage. Application areas include transducer amplifiers, DC gain blocks and all the conventional op amp circuit. For instance, the LM158series can be directly operated off of the standard+5V power supply voltage which is utilized in digital systems and will easily provide the required interface electronics without requiring the additional ±15V power supplies.

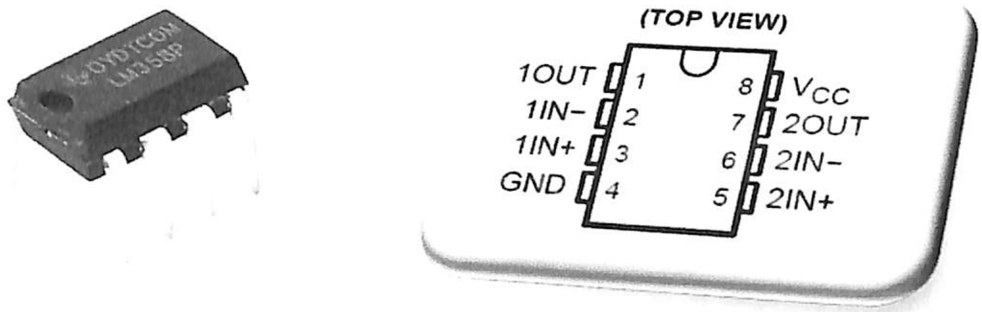

Figure 3-18: LM358 external look and pin configuration [*Source, courtesy:* www.protostack.com]

3.8.8 MAX232

The MAX232 is an IC, first produced in 1987 by Maxim Integrated Products, that converts signals from an RS-232 serial port to signals suitable for use in TTL compatible digital logic circuits. The MAX232 is a dual driver/receiver and typically converts the RX, TX, CTS and RTS signals.

The drivers provide RS-232 voltage level outputs (approx. ± 7.5 V) from a single + 5 V supply via on-chip charge pumps and external capacitors. This makes it useful for implementing RS-232 in devices that otherwise do not need any voltages outside the 0 V to + 5 V range, as power supply design does not need to be made more complicated just for driving the RS-232 in this instance. The receivers reduce RS-232 inputs (which may be as high as ± 25 V) to standard 5 V TTL levels. These receivers have a typical threshold of 1.3 V, and a typical hysteresis of 0.5 V.

The MAX232 (A) has two receivers (converts from RS-232 to TTL voltage levels), and two drivers (convert from TTL logic to RS-232 voltage levels). This implies only two of the RS-232 signals can be converted in each direction. Typically, a couplet of a driver/receiver of the MAX232 is used for TX and RX signals, and the second one for CTS and RTS signals.

There are not enough drivers/receivers in the MAX232 to also connect the DTR, DSR, and DCD signals. Normally these signals can be omitted when e.g. communicating with a PC's serial interface. If the DTE really requires these signals, either a second MAX232 is needed, or some other IC from the MAX232 family can be utilized. Likewise, it is possible to directly wire DTR (DB9 pin #4) to DSR (DB9 pin #6) without passing through any circuitry. This gives automatic (brain dead) DSR acknowledgment of an incoming DTR signal.

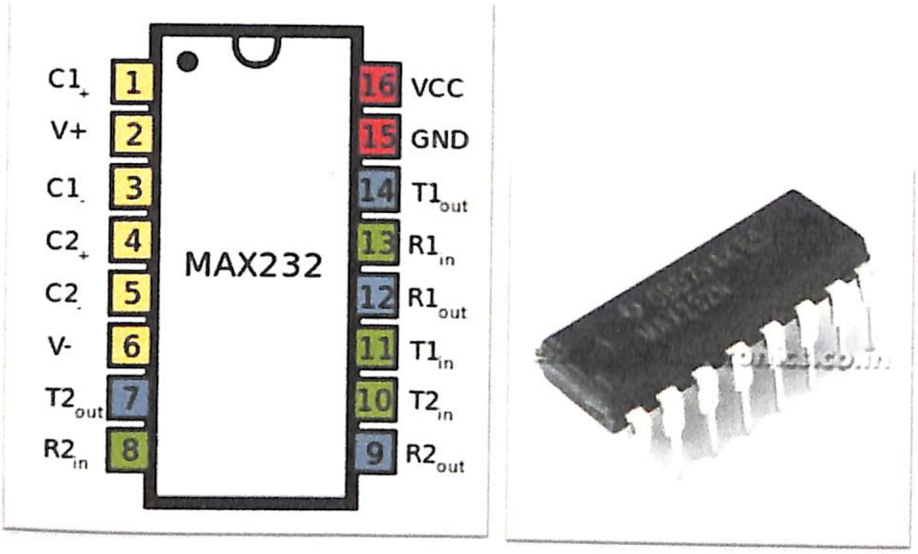

Figure 3-19: MAX232 Pin configuration with external outlook [*Source, courtesy:* store.extremeelectronics.co.in]

3.9 Overall Software Description

3.9.1 MATLAB Version 7.3 (R2011b) Image processing toolbox

Image Processing Toolbox which is a part of MATLAB software provides a complete set of reference-standard algorithms and graphical tools for image processing, analysis, visualization, and algorithm development. It assists in performing the techniques of image enhancement, image de-blurring, feature detection, noise reduction, filtering, morphology, image segmentation, spatial transformations, and image registration. Multithreaded functions are useable in the toolbox to take the benefit of multi-core and multiprocessor computers.

A multitude of image types is supported by this toolbox not just limited to high dynamic range, Giga-pixel resolution, ICC-compliant color, and tomographic images. The graphical tools and the algorithms can be utilized in the exploration of an image, examine a region of pixels, contrast adjustment, contours or histogram creation, and manipulation of regions of interest (ROIs), restoration of degraded images, detection and measurement of features, shape and texture analysis, and color balance adjustment.

The Image Processing Toolbox software is an aggregation of functions that draw out the capacity of the MATLAB numeric computing environment. The toolbox supports a full range of image processing operations, including:

1. Image transforms, FFT, DCT, Radon, and fan-beam projection
2. Workflows for processing, displaying, and navigating arbitrarily large images
3. Multidimensional image processing
4. Image-sequence and video display

Many of the toolbox functions are MATLAB files with a series of MATLAB statements that implement specialized image processing algorithms.

3.9.2 PICkit2 (Programmer/Debugger):

PICkit2 Debug Express interacts with MPLAB IDE which is required for the Debug Express to allow in-circuit debugging on specific PICmicro microcontroller units (MCUs). In-circuit debugging means that the designer is allowed to execute examine debug and modify the program while the PICmicro MCU is still embedded in the hardware. This permits the programmer to debug the software and the hardware together at the same time instead of debugging the program separately and then accomplishing it in the PIC microcontroller. Referable to the use of MPLAB IDE the program can be run, stopped, and single-stepped. One breakpoint can also be set and the processor can be reset. Register contents can be examined and modified when the processor is stopped.

Features

- PICkit2 Development Programmer and Debugger
- 44-pin demo board with PIC16F887 Midrange Peripheral Interface Controller microcontroller
- No additional hardware is required for the direct debugging of PIC16F887.
- For a complete code development environment microchip's MPLAB IDE software is utilized.
- The programming of Microchip's Flash family of microcontrollers has an easy to use Windows programming interface.
- UART Tool software for direct serial communications with a microcontroller RX/TX pins through the PICkit2.
- A 3-channel logic analyzer along with logic signal stimulus and monitoring is contained in the Logic Tool software.
- Allows programming without a PC.

3.10 Proposed System

The figure shows the block diagram of CBCS. This is the basic proposed model for the development of CBCS. The various components used in the project have its own importance and working. Each of these components will be described in detail in the upcoming chapter.

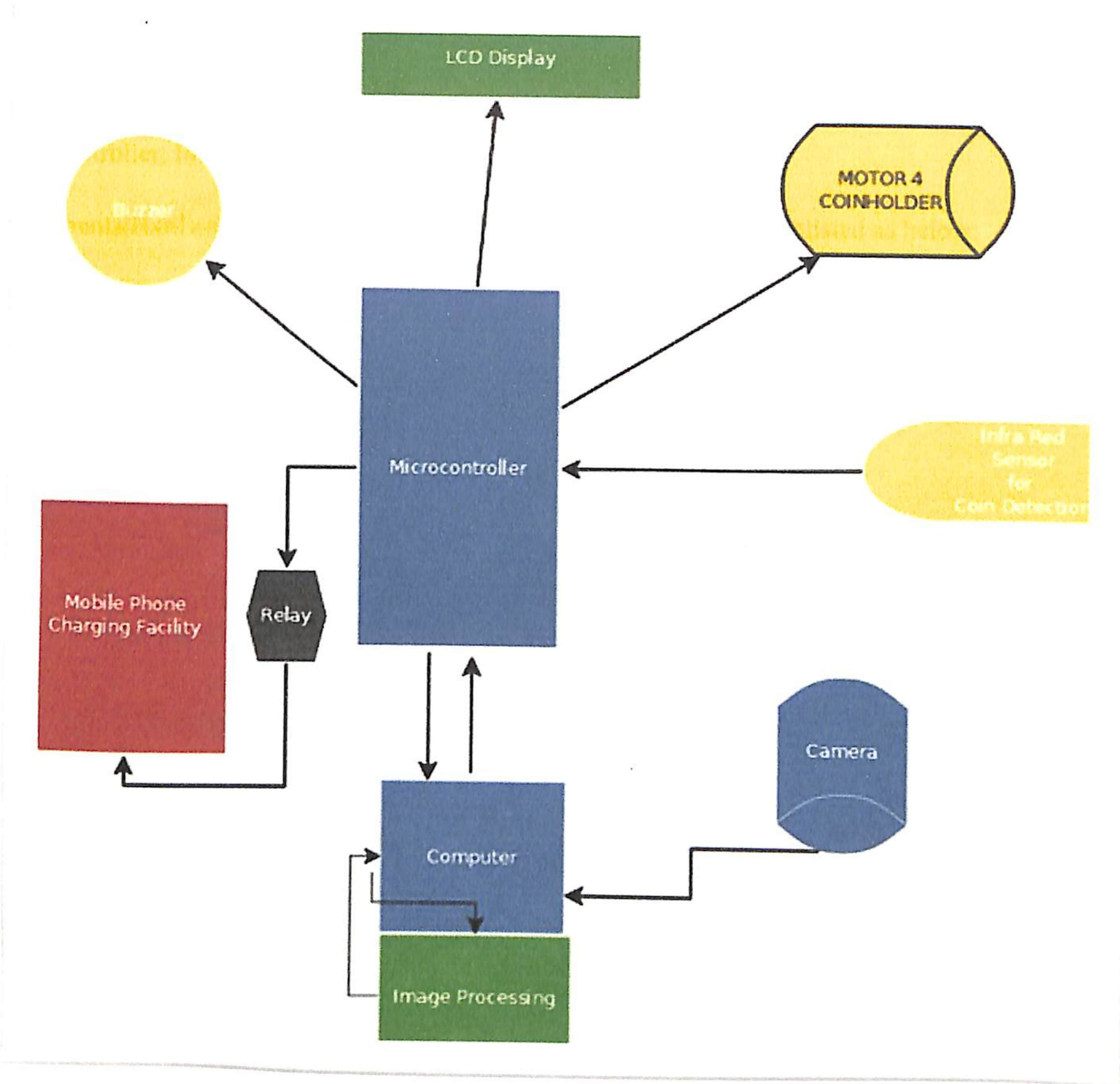

Figure 3-20: Proposed block diagram of the overall system

The microcontroller is the heart of the entire system. The microcontroller used here is a PIC series 16f887. The PIC16f887 is one of the latest products from *Microchip*. It features all the components which modern microcontrollers normally have. For its low price, wide range of application, high quality and easy availability, it is an ideal solution in applications such as: the control of different processes in industry, machine control devices, measurement of different values etc.

The microcontroller is connected to the infrared sensor for the detection of the coin. For the detection of coin in the holder, the microcontroller will allow the coin holder to bring coin in front of a camera to capture the image. The captured image is processed and sent to the computer that further processing of the image and sends information back to the processor as how much time the phone/gadget has to be charged. The connection between microcontroller and computer is a two way process. The servo motor is used in the system, is also connected to the controller, for the movement of the coin holder arm.

Components/Hardware used for the development of complete system is enlisted as below:

- Liquid crystal display (LCD) /LED
- Microcontroller
- Servo motor
- Camera
- Infrared sensor
- Relay switch
- Computer
- LM358
- MAX 232

3.10.1 Modules

1. **Infrared (IR) Sensors for detection of coin in the coin-holder:** IR Sensors work by using a definite light sensor, to detect a specific light wavelength in the Infra-Red (IR) spectrum. By using an LED, which can produce light at the same wavelength as what the sensor is optimized for, and also evaluates the intensity of the light received. When an object is close to the sensor, the light emitted from the LED reflects back from the object into the light sensors. This result in a large change in the intensity received, which is equivalent to the threshold value of the sensors. On receiving toned intensity of the light reflected, indicated the presence of coin within the holder.
2. **Servo motor control:** On detecting that something has been placed in the COIN-HOLDER, motor moves it towards the camera. The camera sends snaps to

MATLAB, which detects the coin and instructs Microcontroller via USART, to control the charging facility and other operations. This project uses a DC Motor whose shaft controls a COIN-HOLDER. The camera is placed to capture the image of the coin and indicate its amount. It will immediately capture the image and send the information to the microcontroller for further processing. The controller will perform the image processing with the help of MATLAB functions and check for the duration of charging.

3. **Detection of the value of the coin by the camera using image processing:** The coin is recognized efficiently by Image Processing technique and thus avoids the risk of misuse by placing some metal coin like rounded object. On detection of value of coin using image processing technique, the power supply will be on for a fixed duration. Time Left is shown on an LCD by the microcontroller. If a user wants to continue the charging one can place another coin before the charging time ends. On last moments of charging period, the system generates a beep sound to notify the user and displays the message on the LCD.
4. **Power supply control by the controller:** After detecting the coin, the system starts (Switch On) the charging slot for a fix period of time e.g. 5 Min. for One Rupee Coin and 12 Min. in case of Two Rupee Coin. The overall supply of power will be controlled by the microcontroller.

3.11 Summary

This chapter introduces the main stages of the development of the project. A general description about the hardware and software is supplied along with the detailed analysis of requirements. Also a general proposed system has been provided along with the basic information about the related modules. The next chapter not only provides an in depth implementation of all the stages explained above, but also the relevant algorithm used for the execution.

Chapter 4

IMPLEMENTATION & VALIDATION

- Introduction
- Implementation Stages
- Validation

4. IMPLEMENTATION & VALIDATION

4.1 Introduction

In this chapter, a description about the implementations of the design strategies chosen in previous sections is being discussed. There are total four stages, Circuit designs & PCB layout, Assembling, Software and calculating the value of coin as discussed in the previous chapter. The validation will be discussed at the end of this chapter.

4.2 Implementation Stages

4.2.1 Circuit designing & PCB layout

In this stage, the implementation was done in following manner:

- Firstly, a circuit was designed after a brief study on different components required (requirement analysis), their functionality and literature survey.

As discussed in the previous chapter, initially circuit designing was completed, using a simulator tool, and a rough idea of the overall system was generated. The figure given below shows the simulated circuit design of the CBCS.

- Secondly, according to the circuitry design, PCB layout was prepared.

PCBs are used in all but the simplest electronics products. PCBs require the additional design effort to lay out the circuit, but manufacturing and assembly can be automated. Manufacturing circuit with PCBs is cheaper and faster than other wiring methods as component are mounted and wired on one single part.

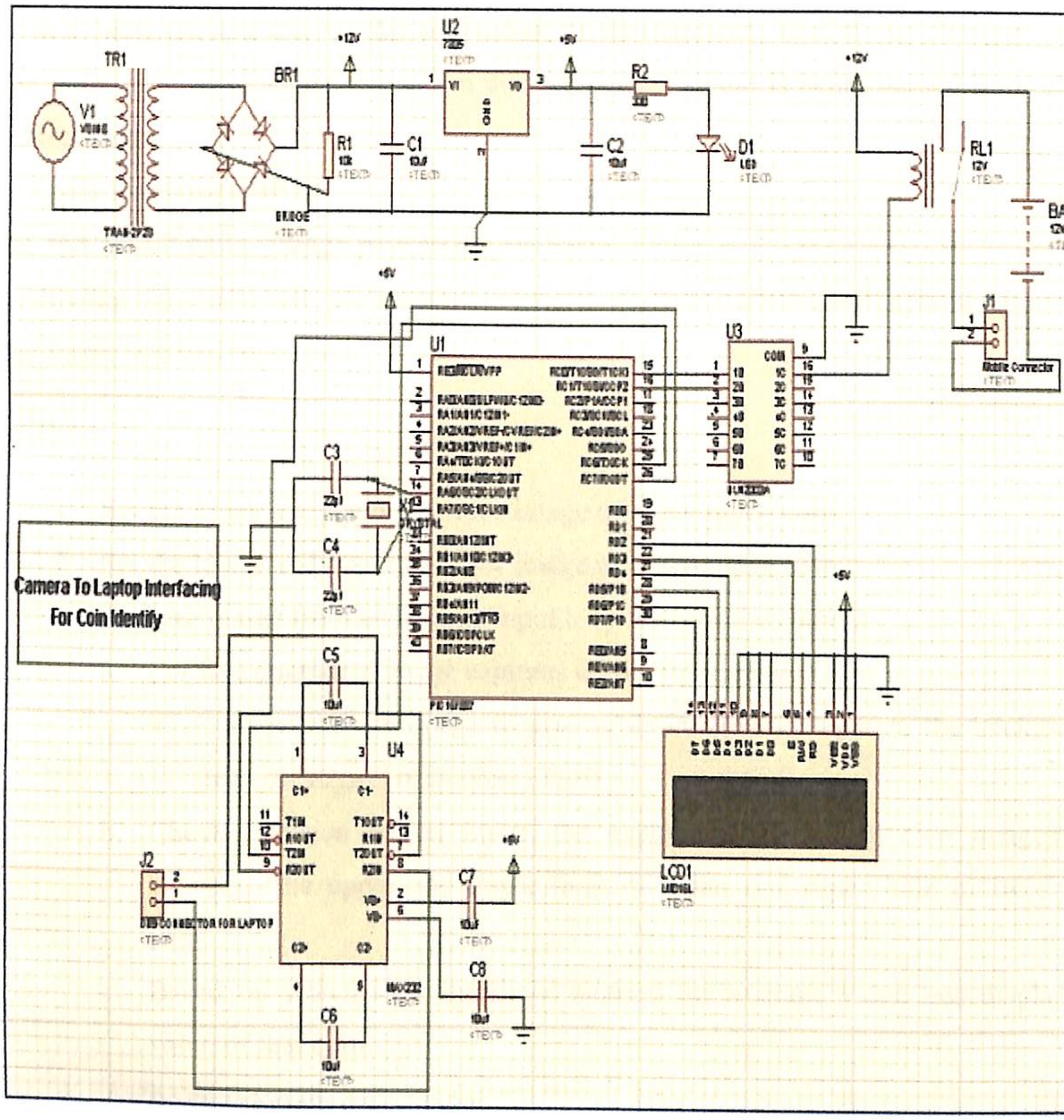

Figure 4-1: Circuit design of the system

4.2.2 Assembling

- After completing implementation of stage 1, next is to assemble all the components according to the circuit and PCB design. Hardware components used for this project is cheap in cost and with not much of best quality, initially, but the system can be upgraded later on.
- Every assembled unit tested individually and also after integrating each unit together. Testing was required because the simulated circuit is in ideal condition, but this is not possible when the circuit works actually in a non-simulated (physical) environment.
- After the assembling of the circuit and testing, if all the components were in perfect working order, then the assembly level program is loaded onto the microcontroller.
- Once the program is loaded, the microcontroller is taken for a test run where the integration of the software and the hardware is teats out. This helps in removing any

minor bugs present due to the calibration of the hardware and minor changes in the program need to be made to confirm that the correct signal is being passed through the correct port.

4.2.3 Code Implementation

4.2.3.1 MATLAB code (Image processing toolbox)

The following algorithm (**set_parameter**) is used to set and confirm the threshold parameters for one rupee and two rupee coin.

Algorithm:

1. Set the lower and upper limit for image of a one rupee coin.
2. Set the lower and upper limit for image of a two rupee coin
3. Capture image from an infinite input loop through the camera
   a. For five continues image captures do the following:
      i. Convert the rgb image to gray scale image and separate the background from the region of interest (ROI).
   b. Check between which limits the average value of all five images lies between- the upper and lower limit of either one rupee coin or two rupee coin.
   c. Based on which ever threshold interval the average value lies display the value of that coin.
4. At the end stop the video input.

The following algorithm (**run_coin_detection**) is used to identify the coin in the image captured and provide appropriate information to the microcontroller.

Algorithm:

1. Start a serial communication between the computing device and the microcontroller.
2. The port used for this communication can be set by the user and is constantly open.
3. Capture image from an infinite input loop through the camera
   a. For five continues image captures do the following:
      i. Convert the rgb image to gray scale image and separate the background from the region of interest (ROI).

b. Check between which limits the average value of all five images lies between- the upper and lower limit of either one rupee coin or two rupee coin.

c. Based on which ever threshold interval the average value lies send the appropriate information through the open serial communication port and display the value of the coin recognized.

4. At the end stop the video and close the opened serial COM port.

4.2.3.2 C language code (PICkit2 tool)

The following algorithm is used to control the overall circuit working by the microcontroller according to the information gained by the MATLAB code

Algorithm:

```
Initiate USART communication
While (1) →infinite loop
{
        Check if a coin is detected through IR
        {
        On odd count valued of a counter, call servo () with a delay and set
coin indicator as true.
        }
If coin indicator is true
{
        Check if USART is data ready
        Receive pattern from the serial communication port
        {
        If no pattern detected, call servo reverse ()
        If pattern for Re. 1 is detected, call servofell (), delay 4000ms,
servoreverse ()
        If pattern for Rs. 2 coin is detected servofell (), delay 8000ms,
servoreverse ()
        }
}
}
```

4.2.3.3 Flowchart for hardware working via microcontroller

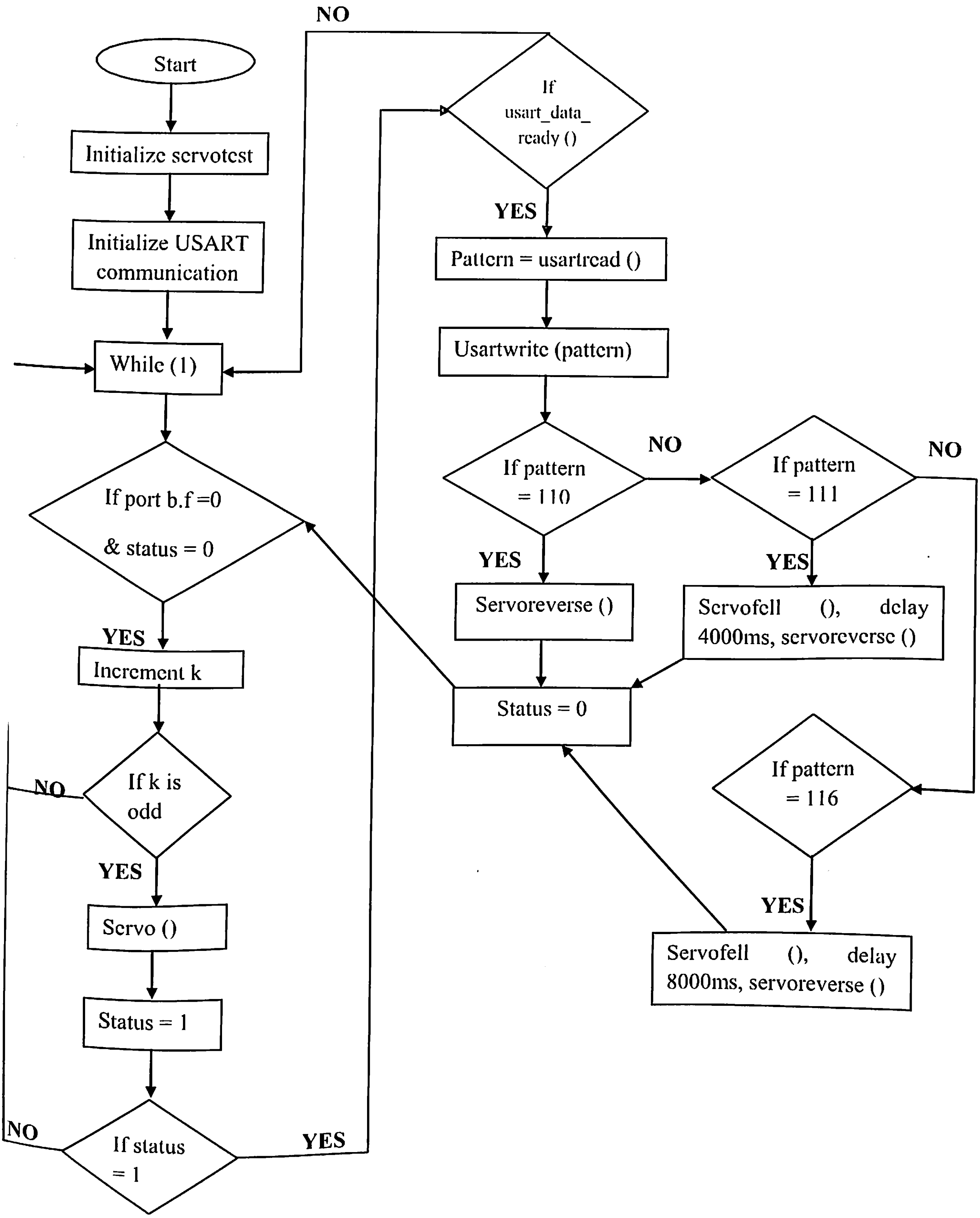

Figure 4-2: Flowchart of the microcontroller

4.2.4 Calculating the value of coin and power supply

After the implementation of all three stages mentioned above, the final run of the project is being performed. At this final stage generated code was run and hence the value of the coin, which is inserted by the user, is being identified by the MATLAB code. This information is transmitted to the microcontroller and controller switches on the power supply accordingly.

Power supply depends on the value of the coin, i.e. if the value of coin Re. 1 then the supply will be on for 5 seconds and for Rs.2, supply will be on for 10 seconds (according to the current algorithm, it can be modified according to the requirement).

The power supply will be provided by the battery connected in the system and this battery will be charged continuously by the solar panel appended to the system.

4.3 Validation

There are numerous points to watch out in the implementation. Lets us discuss one by one.

Firstly, the hardware and software used for the development of this project is of lower cost and of good quality which reduces the implementation cost of the overall system. Also the size of the system is too compact therefore one can easily take the system from one place to another.

Secondly, a proper threshold range is specified for the detection of value of coin inserted by the user and bridging of MATLAB and microcontroller (and other hardware) is working as required. Lastly, the solar energy is used for the working of this system, hence providing the emergency power supply to the user without much requirement of conventional sources of energy.

Chapter 5

TESTING

- Introduction
- Test Plan
- Discussion of the test result

5. TESTING

5.1 Introduction

In this chapter, we will discuss the testing of the program and hardware that implemented in chapter 4. We will only use black box testing, because during the implementation stage, the insides of each function had been tested. So the test plan was divided by four steps, the initial setting up for the hardware, Working of MATLAB code to find the value of the coin, Response of a microcontroller for power supply and Working of Solar panel.

5.2 Test Plan

The test plan was designed due to the development strategy, we discussed in chapter 3. According to that strategy, the hardware should be assembled together according to the circuit designed and PCB layout and then the same is being integrated with the software/algorithm designed for the working of the complete system. Because of unidentified variables and various physical obstacles (quality, human error, circuit performance and so on) it is quite possible that the performance of the real circuit design may vary as compare to simulated circuit. A similar phenomenon may also happen during the process of hardware & software acclimatization. Hence the working of an algorithm designed, at real time, must be tested along with the hardware. And also according to the working conditions we set for the program in section 3.2.2, a pilot run of the assembly (CBCS) is requisite to check its functionality and performance. So, the test plan was classified by four steps as below.

5.2.1 Initial setup of the system

Complete integration of hardware is done in the assembling stage of the system. The figure given below shows the integrated system.

- First image shows the overall setup of the system. Computational device is connected for the program run and the rest of the images show the front end of the system.
- Second image shows the internal integrated circuit assembled during the implementation of the whole system.

Hence during the testing phase, complete setup of the CBCS is arranged to proceed further.

Figure 5-1: System setup

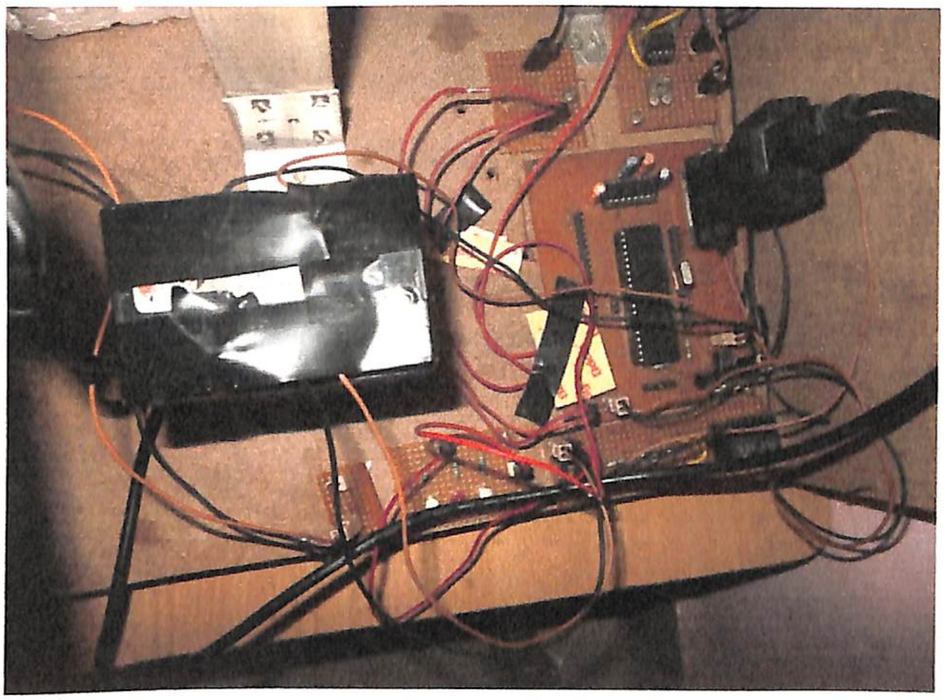

Figure 5-2: Internal circuit of the system

5.2.2 Servomotor control

In this phase of testing, movement of a servo motor is being tested. Working of servo motor is shown in the images below. Programmed functions, i.e. servotest (), servoreverse (), servofell () are used to control the movement of servo motor arms as shown.

- As described earlier, servomotor is being controlled by microcontroller, depending on the working phases of the system. Initially, when no coin is been inserted, servomotor and its connected arm (as shown in image) is at neural position.

Figure 5-3: Initial stage of servomotor and arm

- Image shown below shows the second phase of the servomotor i.e. on the detection of some material inside the coin-holder, IR rays are reflected back and hence arm takes the coin in front of the camera for further processing.

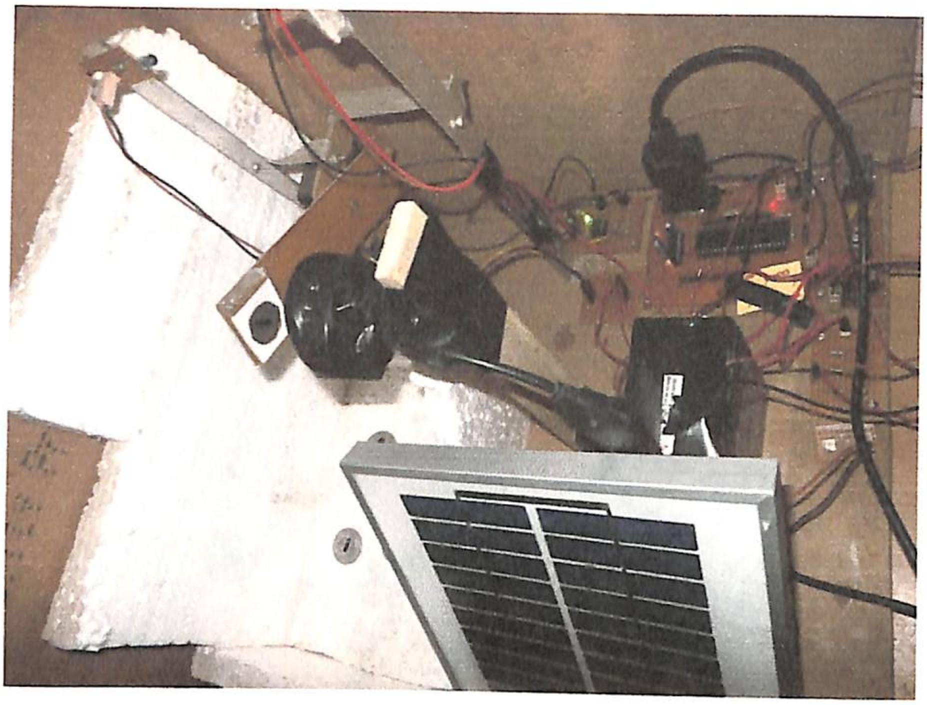

Figure 5-4: Second stage of servomotor and arm after insertion of Coin

- Now, during the second phase of servomotor, if MATLAB code verifies that the object inserted inside the coin-holder is a coin, then it will calculates the value of coin and commands the microcontroller for next step, else controller will call servoreverse(). Image shows below the third and the final phase of the servomotor arm. At this stage, servofell () is being called by the controller and the coin inside the holder will be dropped inside the container, as shown. And finally, the arm will move at the initial position for next process.

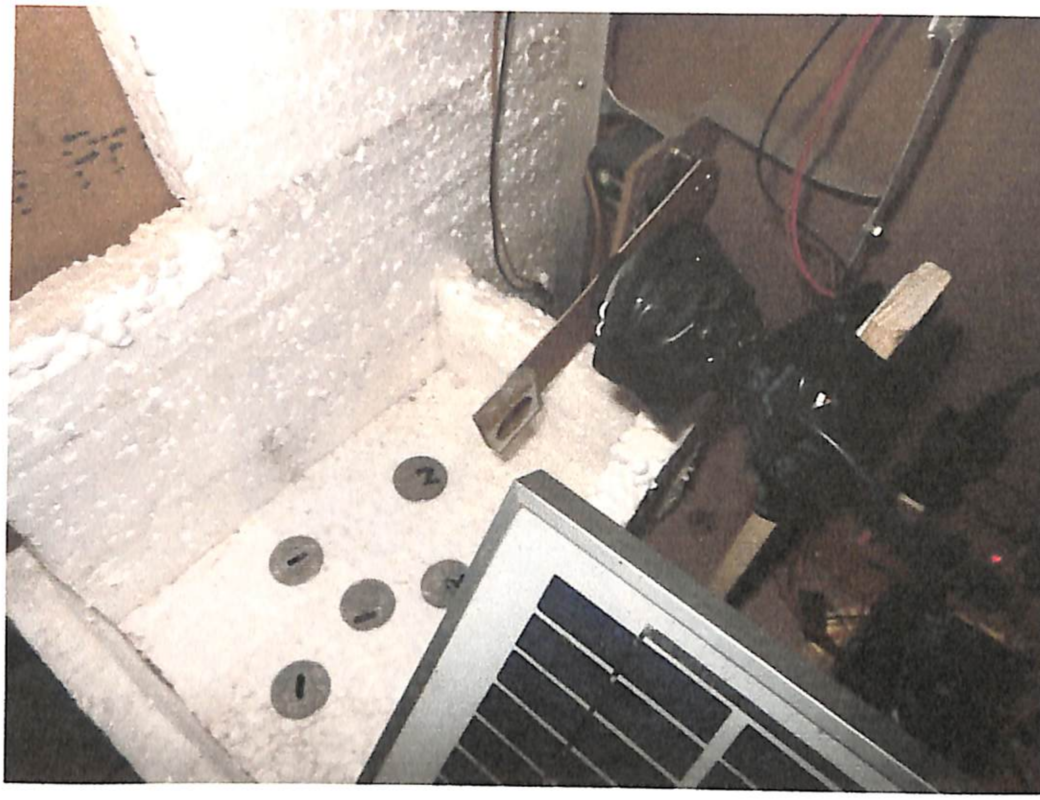

Figure 5-5: Final stage of servomotor and arm

5.2.3 Detecting value of the coin by the camera

MATLAB code is written to detect the value of the coin. This is performed by the image processing technique. Here initially threshold range matching technique is being used. Following figure shows the working of MATLAB code and its output obtained during its run.

Before inserting the coin, the valued portion of the coin is being darkened by the black ink (as mentioned in limitation). Thus the image of the tested coins is shown below.

Figure 5-6: Coins used for testing the system

- First image shows that, while the image captured by the camera at real time, MATLAB code will matches its threshold range, set initially, and hence displays the value of the coin as **two** (as shown) and send command to the microcontroller to work further accordingly.

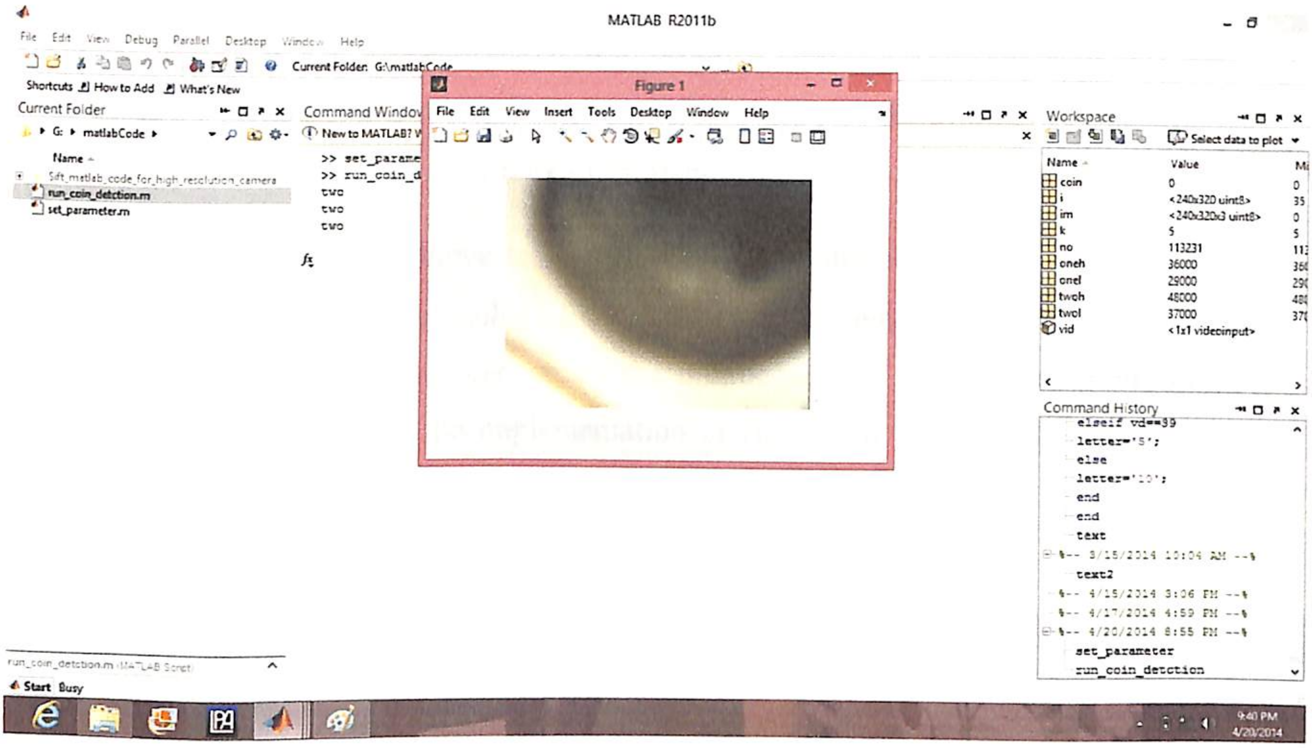

Figure 5-7: Detection of value of the coin via MATLAB for rupees two.

- Image shown below clearly shows that image capture by the camera is of rupee **one** and MATLAB code also displays one on the command screen after matching its threshold value as programmed initially.

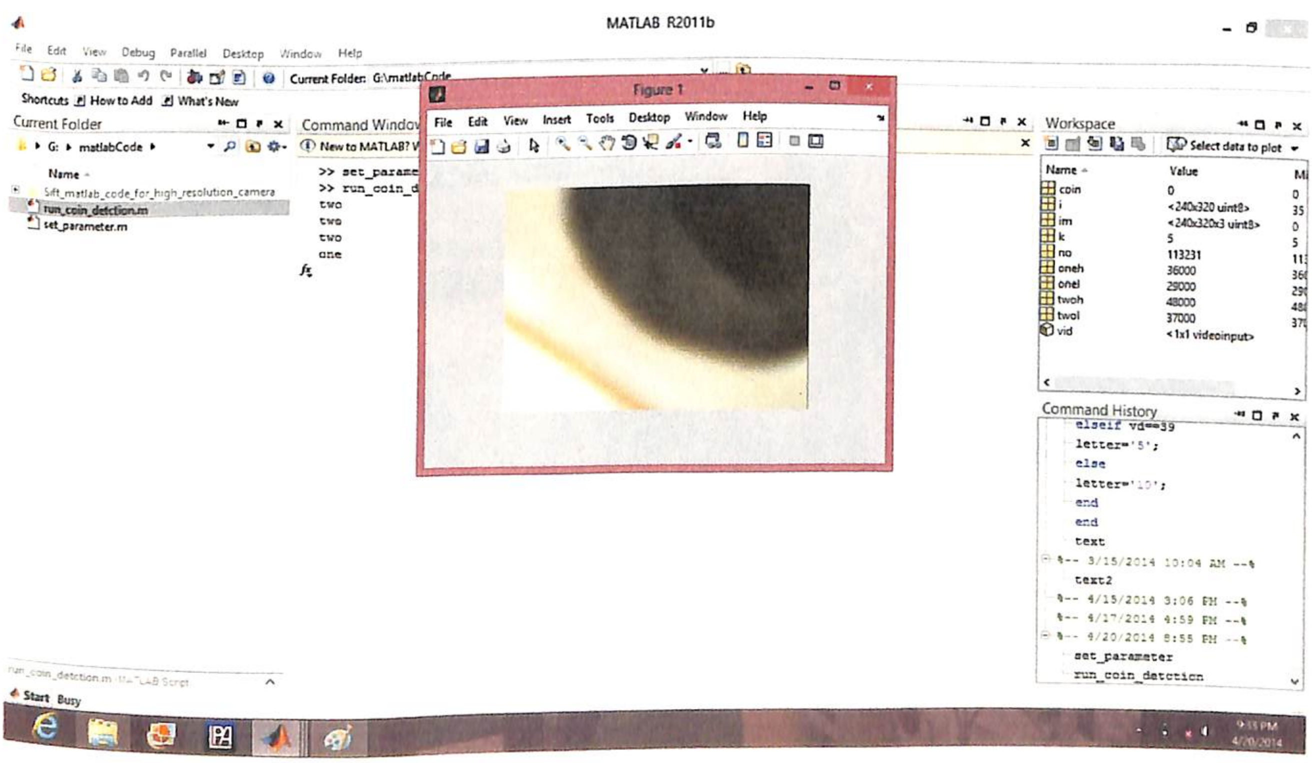

Figure 5-8: Detection of value of the coin via MATLAB for rupee one.

5.2.4 Power supply output

After complete testing of above three stages, the final output of the system is being checked. Hence the result obtained was, according to the plan.

- After the completion above testing phases, the results obtained is as shown in the below images. The violet color LED is blinked which indicates that the output supply via battery is being switched on by the microcontroller every time for the limited period of time (as per the implementation of algorithm) based on the value of coin inserted by the user. Thus, the objective, which is being initially set, is being achieved.

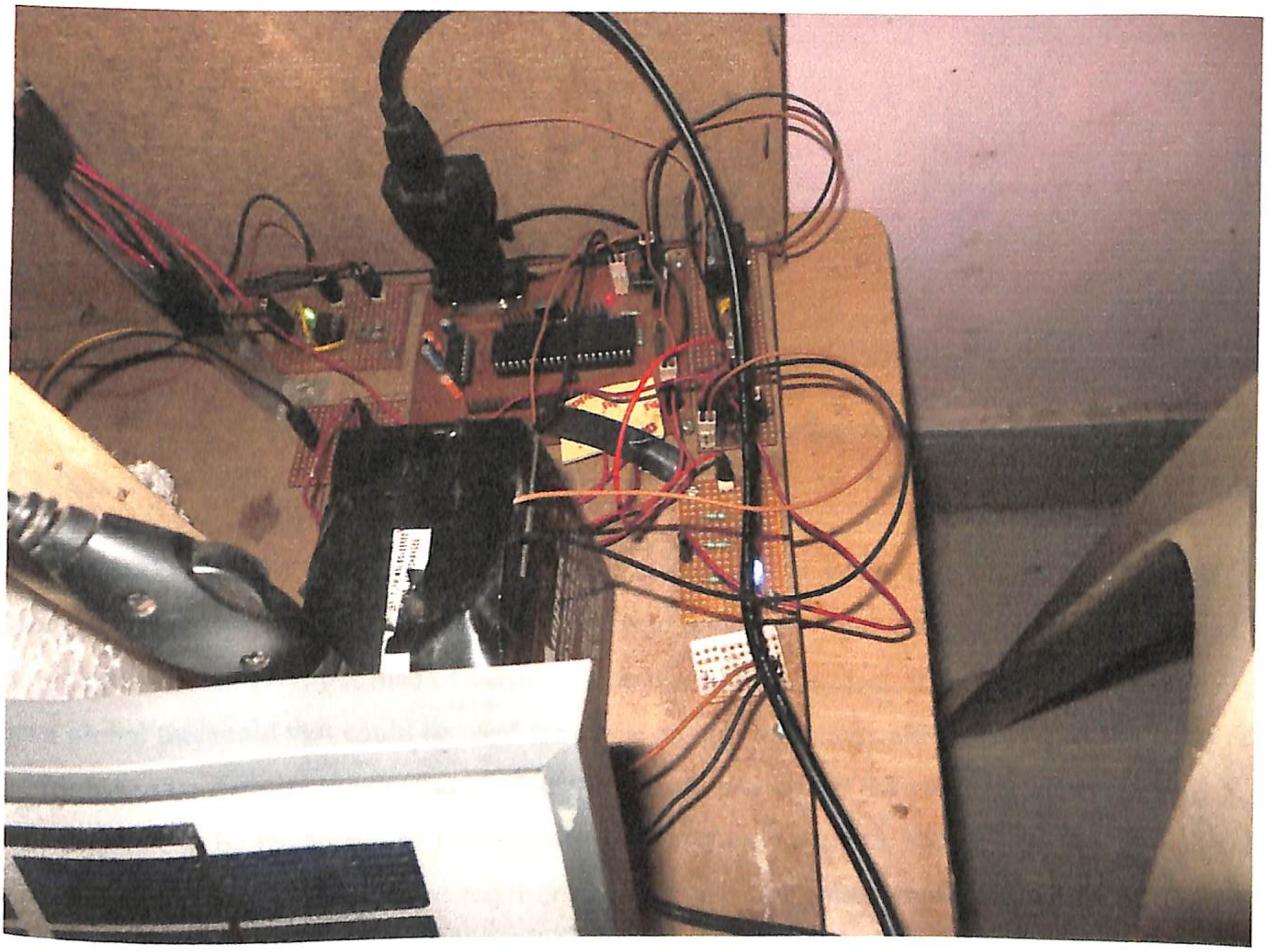

Figure 5-9: Violet LED blinks indicates the output of the system

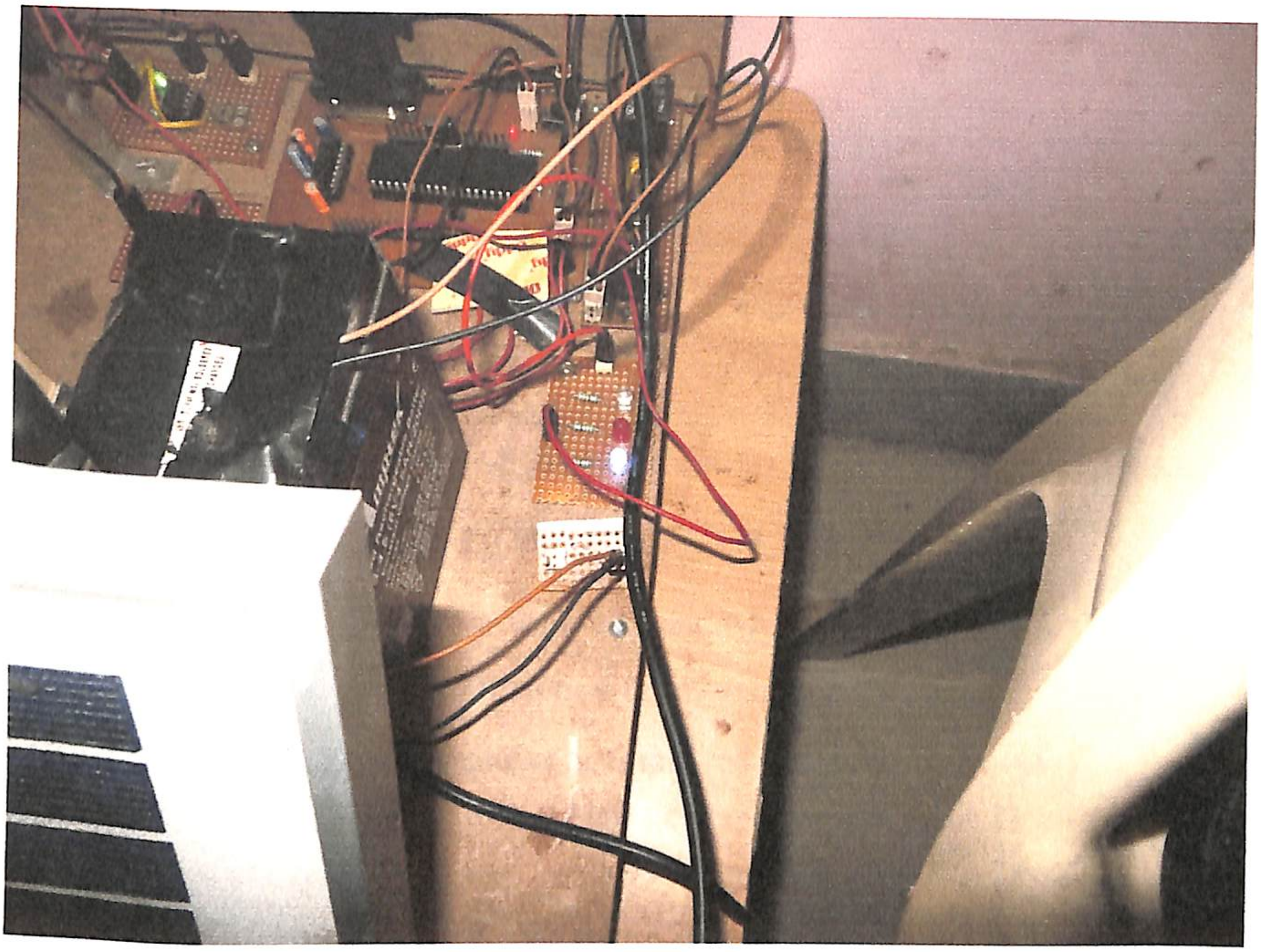

Figure 5-10: Violet LED blinks indicates the output obtained

5.3 Discussion of the test result

The results of the testing phase were satisfying due to the goals that set in the starting sections. Each unit/stage was working as planned and the output obtained was correct as programmed. However, because of various limitations of the project, it could not possible to set a global threshold that could be used for every coin of the same value. Also, initially, coin is needed to be dark by the marker so that the camera can detect the value of the coin more easily. This can be enhanced later by replacing high quality camera. But as per the physical setup conditions decided and other requirement analysis study, the output obtained was quite satisfied and hence the working of the system fulfills the objective of the project.

Chapter 6

REVIEW & RESULTS

- What went well and why?
- Limitation of the system
- What can be improved and how?

6. REVIEW & RESULTS

6.1 What went well & why?

The testing executed as described in the previous section shows that the system has the ability to recognize the value of the coin inserted and it allows power supply for a limited period of time, based upon the value of the coin. Hence, it enables the user to charge their gadget in case of emergency. Also, the system is able to detect whether a coin is inserted or not hence, it can't be fooled by any other metallic object. The main goal of this project was satisfactorily achieved. However, the system works fine for the testing state because working conditions were already being set for both the system and input. The reason for doing so was discussed in chapter 3.

In reality there are a multitude of conditions for the identification of the value of the coin, as the same valued coin has various different types of patterns printed on it, the shape and size of the coin could also vary according to the position of the camera that captures the coins as was mentioned in section 3.2. So the camera that is utilized to capture the coins was fixed. And also because there are relative errors in the assembling of the hardware and designing of the algorithm according to the value of the threshold chosen, and these errors could not be eliminated due to the nature of method used in this project. As the position of the camera was fixed, the threshold range of the coins needs to be set up at the beginning of the program in order to reduce the program running time. The other problem of this project has been discussed in section 5.3, which will not be discussed here again.

As discussed earlier, at the beginning of the section, the performance of the program was really substantial under the conditions discussed above.

6.2 Limitations of the system

Every existing and newly developed system has few limitations as no system can be 100% perfect. Similarly, this developed system has few limitations, among which some of them are discussed as below.

1. **Requirement of a high resolution camera**: Currently, the camera used in this project is a low resolution camera due to which the resultant image captured is less accurate for detection of the coin's pattern.
2. Coin should be inserted in such a manner that value of the coin has to have its front side facing towards the camera.

3. There is a need to darken or mark the value written on the coin so as to enable the camera for easy recognition.

6.3 What can be improved and how?

There are some areas of the current system that can be improved.

- Use of high resolution camera (20 mega pixels or more) can be used to identify the value of the coin.
- Better physical conditions for the system to improve the overall working of the system in its entirety.
- An algorithm needs to be devised which is able to identify the value written upon the coin when either sides of it faces the camera (i.e. either by heads or via tails face).
- Other image processing techniques can be applied to recognize the value of coin under different environmental conditions.
- Instead of a blinking LED as an indicator for the period of charging of the gadget, an LCD can be attached. This LCD would act as a countdown timer letting the customer know how much time of charging is still pending.
- Connection of a buzzer which intimates the user when the charging period is about to finish with enough time left so that in case the user wants to insert another coin to extend the period of charging, he is free to do so.

There are a few more hardware changes that can be implemented to increase the overall system's quality and performance.

Chapter 7

WORKING SCREEN SHOTS

- Hardware screen shots
- Algorithm screen shots

7. WORKING SCREEN SHOTS

Below images shows the overall developed system and the output obtained.

7.1 Hardware screen shots

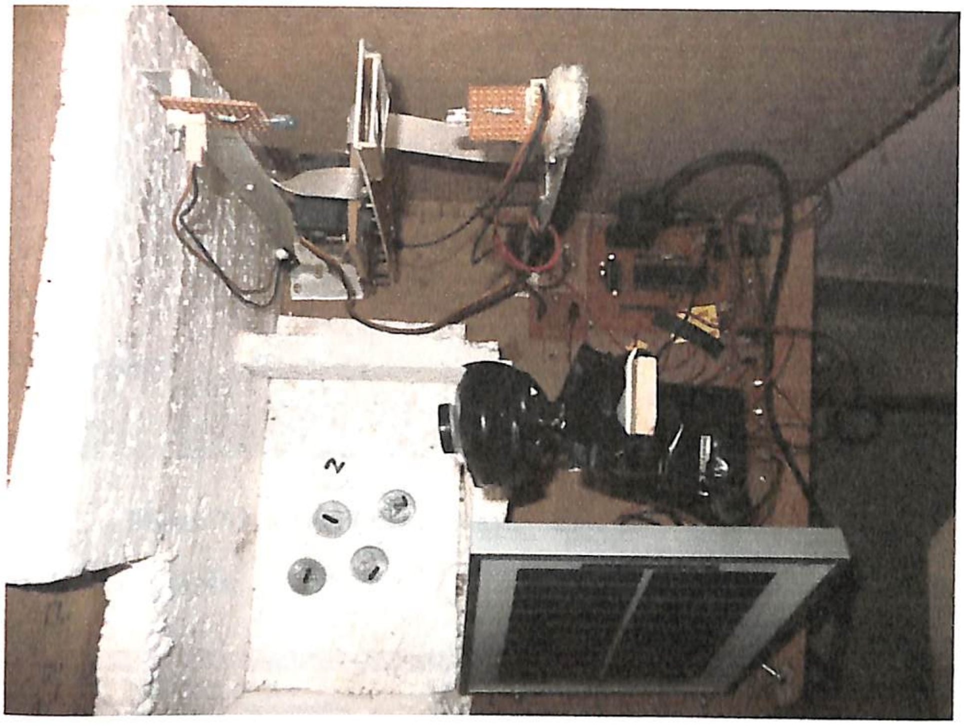

Figure 7-1: Complete Hardware setup (1)

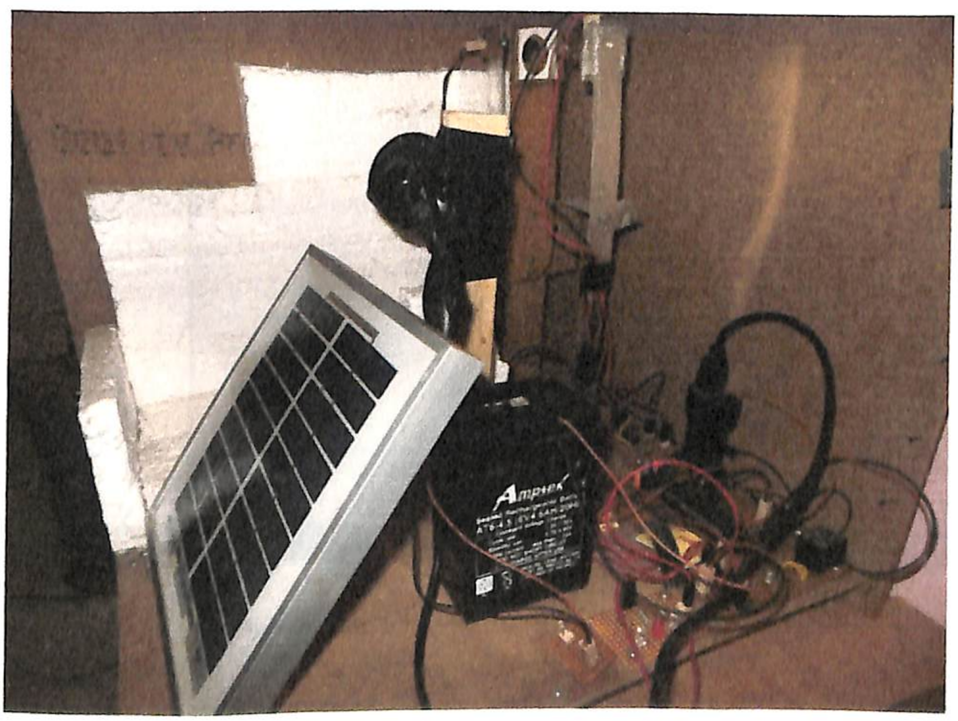

Figure 7-2: Complete Hardware setup (2)

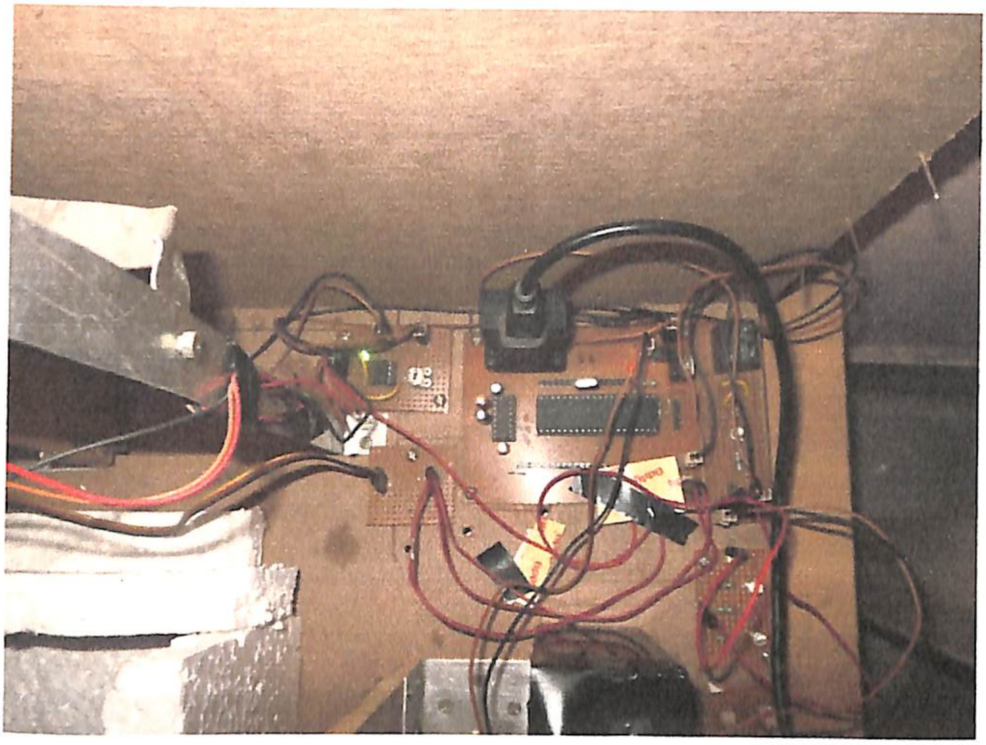

Figure 7-3: Green LED blinks shows system is working fine

7.2 Algorithm screen shots

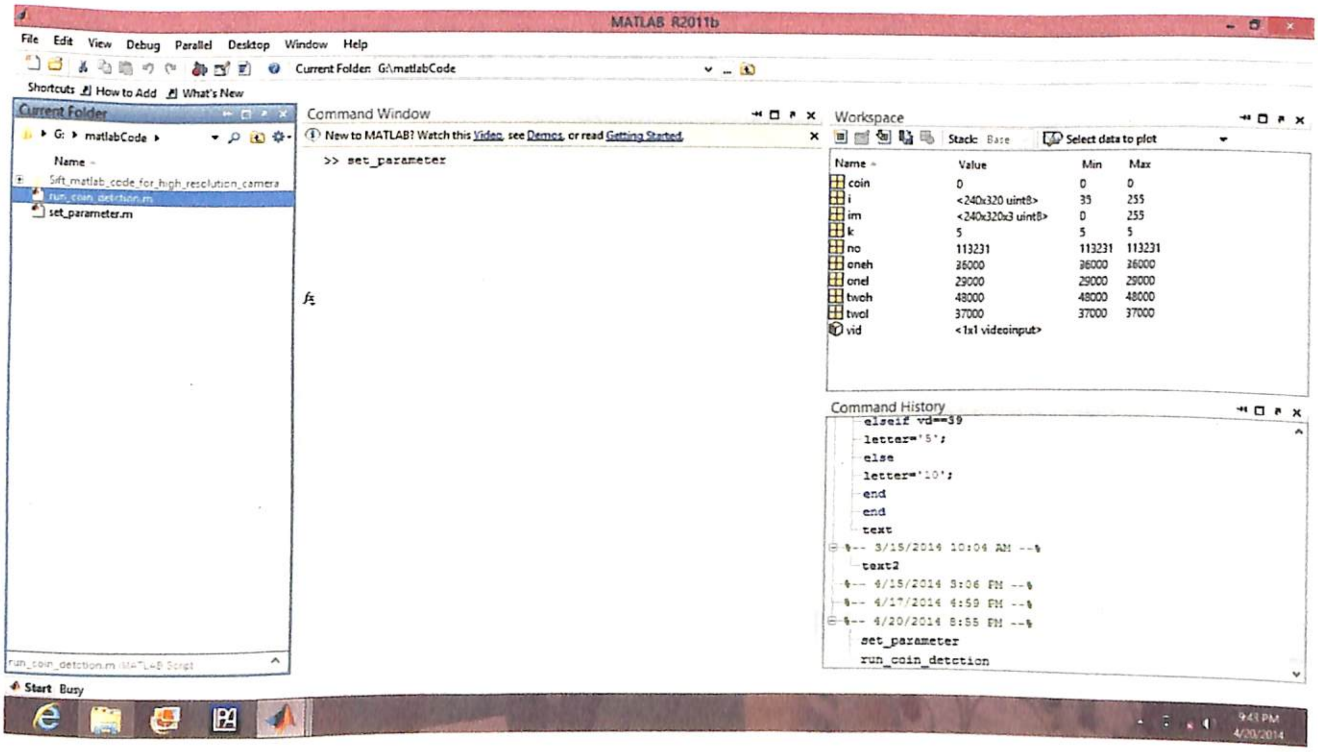

Figure 7-4: Parameter setup in MATLAB

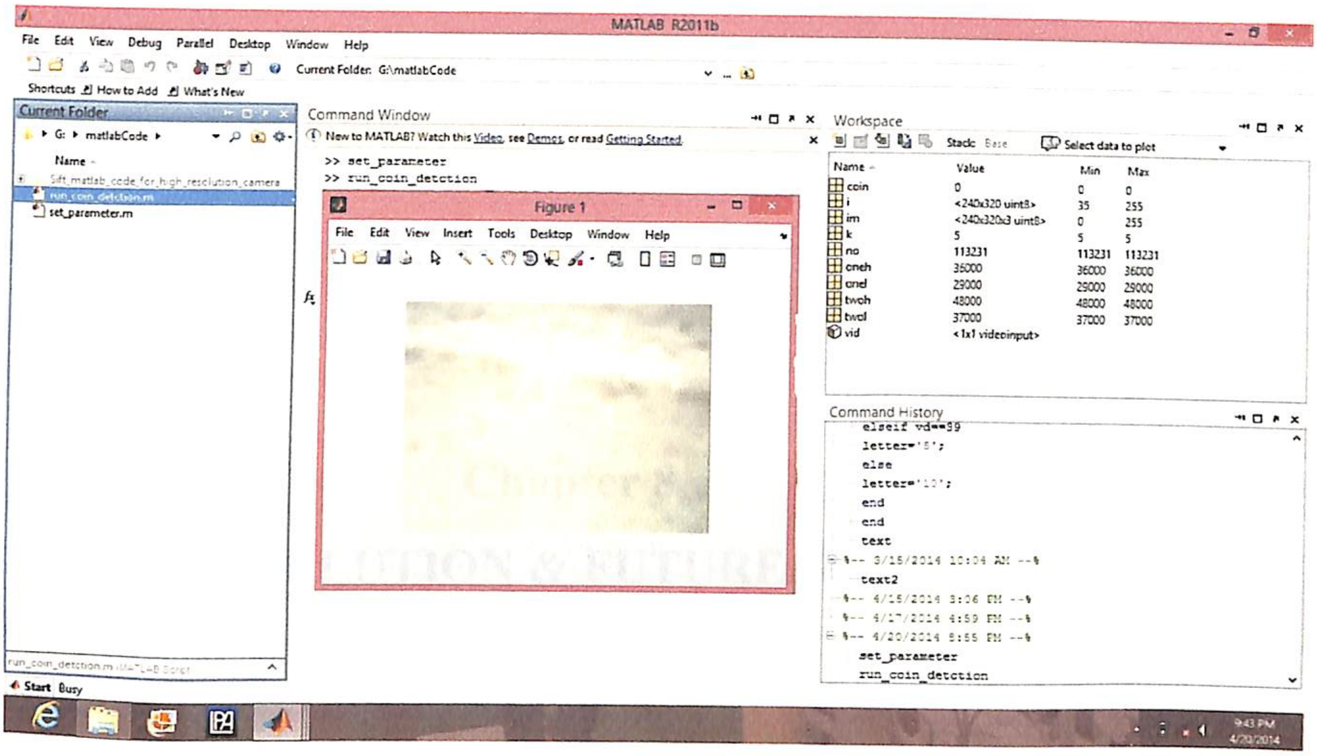

Figure 7-5: Initial startup of the MATLAB code

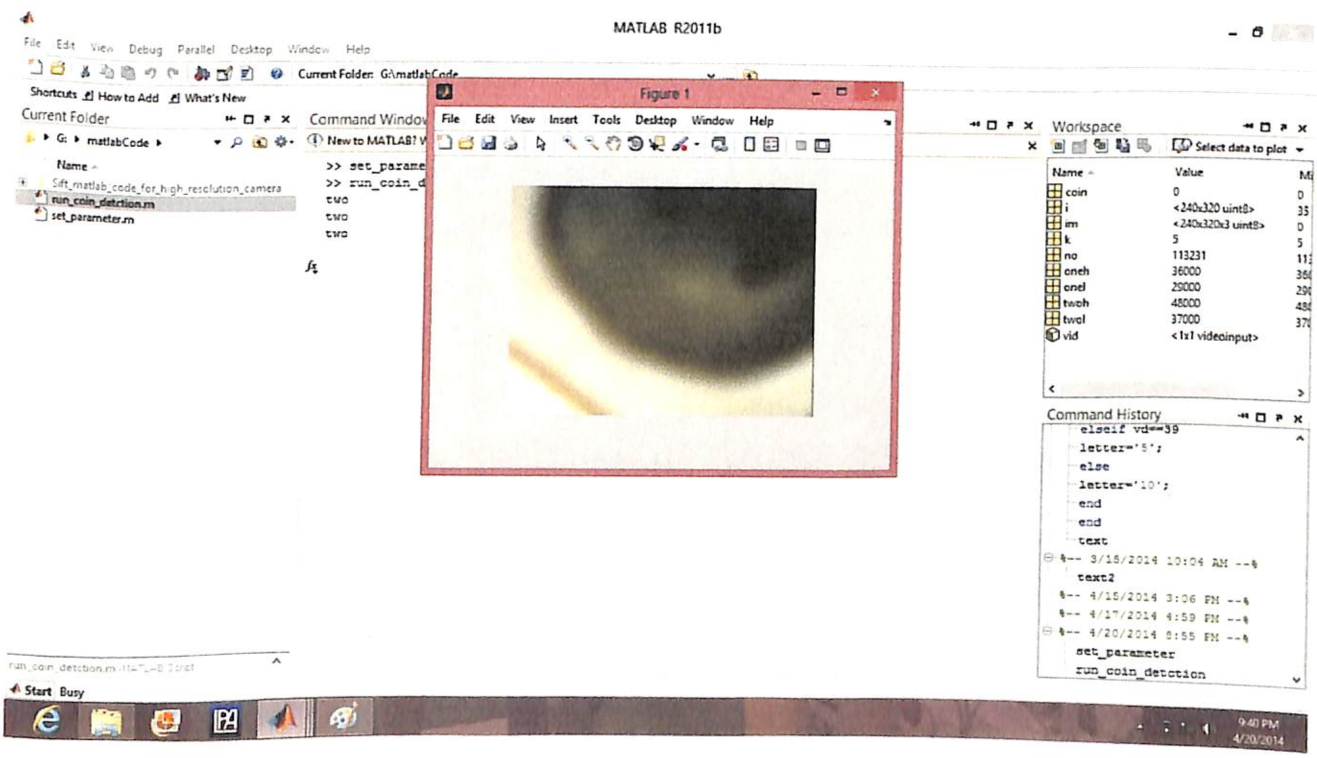

Figure 7-6: Detection of value of coin

Chapter 8

CONCLUTION & FUTURE SCOPE

- Conclusion
- Future Scope

8. CONCLUTION & FUTURE SCOPE

8.1 Conclusion

In entirety it can be said that overall the project developed was able to achieve the main targets that were set in the beginning. Due to the presence of numerous sub goals that needed to be achieved like, detection of the value on the coin, the used of embedded systems, image processing etc, it was difficult to identify the point of origin from where the project could be started off.

After reading the related articles, literatures and analysis of a few similar projects, the current design strategy was chosen. Differentiating the projects that had been implemented in the same field, a new approach to recognize the coin's value was chosen. Bridging of two different areas viz. embedded system and image processing was quite an informative task. Various development stages were planned and finally the whole system was designed and implemented to achieve the final objective as decided initially. Even though the program only worked well under the stated conditions that were set up at the beginning, the running time was quite satisfied.

In this project, a novel method of charging mobile/gadgets batteries of different manufacturers using solar power has been designed for rural and remote areas where the power supply is not available all the time. This project will be extremely helpful in today's life. Because now-a-days, the communication through mobiles and other portable devices (laptops, tablets and so on) is widely in use and their market is currently at the peak. But every time a person cannot carry the entire necessary charger along with him/her. When an individual goes out on long travel or unplanned travel, one may forget to charge or carry the charger along. Under such a scenario, due to dead battery one's work may get interrupted and may suffer a lot. So to overcome this situation, an effective and useful idea was implemented thus, developing this system. This is quite cost effective, portable and easy to install.

While the system is active, it is able to detect when an original coin is placed in the coin holder. It doesn't react when anything other than a coin is placed in the holder. Once the coin is successfully detected, the holder promptly moves the coin towards the mounted camera. The Algorithm successfully identifies the value on the coin based on the image input from the camera and send appropriate information to the microcontroller.

The microcontroller on receipt of the information explicitly jumps over to the correct subroutine and passes on various instructions that relate to the movement of the holder, the blinking of the LED and the active current charge for the charging of the gadget.

8.2 Future Scope

Due to the presence of few limitations, as discussed in previous section, there is need of various enhancements which leads to the future scope of the project. This project leads to study on various image processing and embedded systems techniques which can help in improvement in working conditions of present system. More work is required on coin detection and identification of its value. After the complete improvements in this project one can commercialize it for the public use.

Secondly, this project can be enhanced up to the level of paper note based system. Coins and paper notes are equally in use; hence this project can be enhanced and developed by using identification techniques for paper currency. Various paper note identification and recognition techniques are available using image processing and ANN, which can be applied on this project.

8.2.1 Proposed model for paper currency based system:

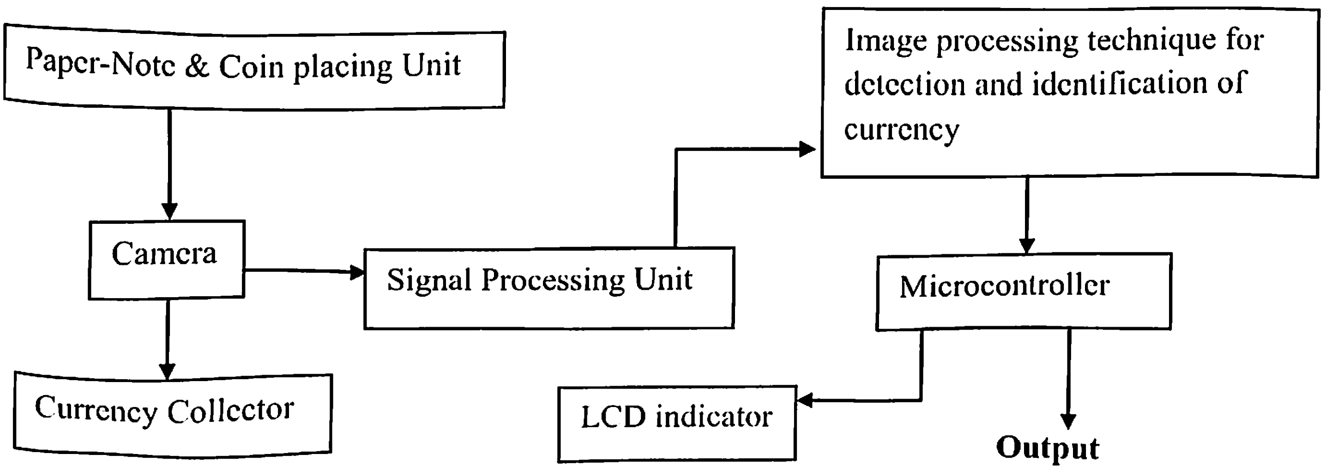

Figure 8-1: Proposed model for future enhancement

The above block diagram indicates how the current system can be upgraded by using coin as well as paper currency.

Chapter 9

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9. REFERENCES

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