Robotic Arm based Industrial Automation System

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بسم الله الرحمن الرحيم

Abstract

The idea of automation always gets importance in the market in terms of its value and use. It is a Robotic arm based system which holds the concept of color sensing and automation. Basically an interface has been created between robotic arm and color sensing USB Camera. The famous and most important engineering tool from National instruments Lab View is used for this purpose. Whole system consists of three parts. The parts are Robotic Arm, USB Camera and ball stand. The project has a scope in industry, security system used in airport or any other industrial mechanism like manufacturing plants etc.

Acknowledgement

First of all we would like to thank Allah Almighty for granting us opportunity to work within an environment in which we learned a lot and done with this idea as final year project. We also feel lucky that our teachers gave us support, assistance and valuable suggestions to complete this task. We have achieved our targets under the supervision of out teacher Mr. Muneeb Yaqoob. He has been so kind and helpful for us throughout the project duration. Because of his guidance we kept right track and the right direction. His effort granted us resources and environment to work and discover ourselves. From the project approving till the last day we could not complete at the required time without his support.

We are also thankful to the lab engineer Mr. Kashif and Mr. Imran who handed over the very costly resources of the university to us. Also thanks to the Guard of Machine Lab for his patience and support.

Dedication

Our Humble effort is dedicated to our parents who sacrificed their comfort and created opportunity to study and learn in this world class institution.

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CHAPTER 1

INTRODUCTION

In this chapter we will have a brief introduction to the theme and concept of this project. In any industrial application idea of automation is always important. That is why we got inspiration to work on this project. We have designed such an efficient mechanism which is able to differentiate things automatically. The system we have designed is having a robotic arm which has been controlled by the board Trinamic TMCM-610. It also has a color sensing module. This is able to detect the colors by the idea of reflection using light dependent resister (LDR). Another major part is the conveyor belt which is being controlled by the circuitry of stepper motor. The major and most important part of this mechanism is the interface which is controlling all this system. A famous engineering tool from the "National Instruments" is the software named as NI Lab View is having that interface. As much you go through this chapter you would be able to understand the whole story.

1.1 Robot:

A robot is a combination of electrical and mechanical mechanism which has been designed to perform the tasks repeatedly which is being programmed to do.

The robotic arm we are using is provided us by the university manufactured by "Elettronica Veneta" Model # MRB-4/EV. This robotic arm consists of 4-wire stepper motors. The details would be given in next chapter.

1.2 Stepper Motor:

Stepper motor is a type of motor which rotates its shaft in steps. It does not rotate smoothly as any other dc or conventional motor. It is also called pulse motor because it works when powered by electrical impulses. The main reason of using this instrument is

that it can be controlled precisely. It has precise positioning and repeatability of moment. Unlike DC motor it acts quickly.

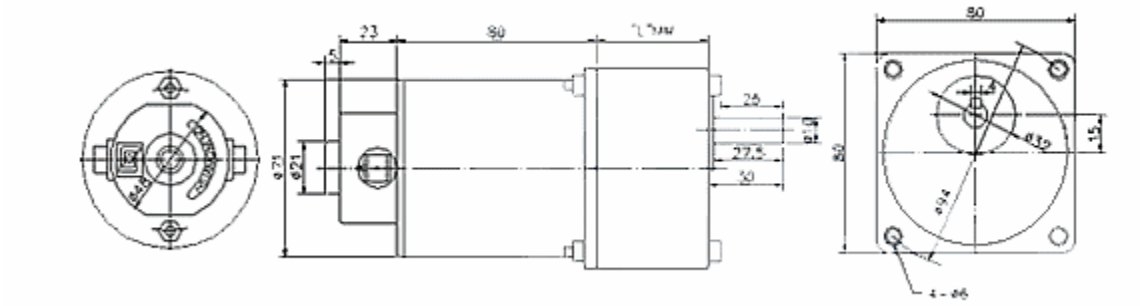
1.2.1 Types of stepper motor:

There are three major types of stepper motor.

- VR (Variable Reluctant Motor)
- PM (Permanent Magnet Motor)
- Hybrid Motor (mixture of VR & PM)

1.3 DC Gear Motor:

A DC motor is an electric motor that runs on direct current (DC) electricity. These motors are used to run machinery. It is obvious from the name that DC motors can operate directly from rechargeable batteries. These are usually small in size and that's



why today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Modern DC motors are always operated in conjunction with power electronic devices.

The normal DC motor used in market is carrying very high rpm. To reduce the rpm of the motor normally pulleys are attached. But the gear motor is a kind of DC motor which has very low rpm with respect to conventional dc motor. That's why according to the

need simple dc motors are being replaced by dc gear motors. We also used dc gear motor because we need a bit slower rotating camera to detect the colors.

1.4 Color Sensing:

Color sensing as obvious from the name it is a technique to recognize and differentiate through different colors. Two major techniques of color detection are

- Color detection through image processing.
- Color detection through LDR or photo transistor.

1.4.1 Image Processing:

Image processing is any form of signal processing where the input is an image and we need to get the output by analyzing it graphically. Output of image processing may be either an image or a set of characteristics or parameters related to the image. Most of the times it deals with the image as a two dimensional signal and applies standard image processing techniques to it. In the start of this project we decided to use compact camera vision for color recognition using image processing technique. We spend time and started knowing about that instrument. Unfortunately because of the unavailability of compact camera vision we were advised to switch the color sensing technique from compact camera vision to USB Camera.

1.4.2 LDR or Photo Transistor:

Color detection can also be done by using photo transistor of LDR light dependent resistor. This works with the concept of reflection of light. We have design a color sensing module which has an LDR, LED and microcontroller in which we have programmed the working of this circuit. LDR is a type of variable resistor whose value changes with the change in the intensity of light.

An LDR is made of a high resistance semiconductor. As the intensity of light changes, then the circuitry of the color sensing module will create a relevant output analog signal. We have made in such a way that we can get digital signal through this also.

1.4.3 USB Camera:

A simple USB camera which is easily available in the market has different properties. It is a video camera that takes images and videos from real time and places them in a computer controlled environment. Webcams are known because of their low manufacturing cost. Their flexibility makes them the lowest cost form of video telephony. Another important usage of these cameras are as a source of security and privacy issues, as some built-in webcams can be remotely activated via spyware.

1.5 Lab View:

Electrical Engineers are often using different engineering tools to design their systems. The most common tools so far are Multisim, Proteous, MATLAB, LabView etc. LabView is the latest tool from NATIONAL INSTRUMENTS which is creating reasonable space among users. Like MATLAB it is a complete solution for engineers. It is time efficient and it has unique graphical programming environment. LabView can easily handle through software functions, hardware interfaces, visualization and data analysis. One of its functions is to control the mechanical equipments by introducing virtual interfaces in a graphical form. This software is using sort of visual programming language. That's why we use to place some virtual equipment on the software. The window which is being shown on the computer is called block diagram. We put visual equipments by picking them from the large libraries of LabView. A different window called front panel shows the user interface and it allows the user to run the program which has been set on the block diagram by connecting different virtual equipments with virtual wires. The thing which makes this program very much interesting is its ability to interface with the hardware. Its large libraries make it more flexible to deal with every problem.

1.6 Goals and Objectives:

We can categories our goals and objectives into following bullets:

- The USB camera must sense the color and generate the signal quickly.
- Robotic arm must pick the color balls by getting command from LabView Interface and then place them into respective baskets.
- The moment of camera gear motor must be accurate and in time.
- All this procedure must have to be self controlled without any human intervention.

1.7 Purpose of the Project:

Purpose of this project is to make such a user friendly automated system which can do the assigned task in less time and with less human effort. 21st century is the age of competition. So any production plant manager will look for more effective system which helps his industry to stay in the market and grow with maximizing the profitability.

The working of our project is very much interesting. The robotic arm picks up a color ball from a conveyor belt and puts it into relevant basket. The thing which makes our robotic arm intelligent enough to perform these tasks is the robotic arm interface which is getting signal from color sensor that senses the color of the ball.

1.8 Practical Applications:

Robot and automated system are largely used in assembly line works. They can easily perform a job for which industry needs to hire two or more persons.

- In any manufacturing plant this idea can be easily implemented like pharmaceutical companies, heavy industry etc.
- At Airports when luggage move on a belt and passes through scanner. After that suspected bags which are being collected manually can be separated automatically.

- In cargo service, this system can be easily converted to differentiate the luggage with respect to the area of delivery by putting some sort of code on them.

CHAPTER 2

Components

This chapter is about to briefly explaining each component of this system. We will discuss that how these components have been manufactured and why they are beneficial for us. You will also know about the structure and working of the components. Physical Appearance of the components, circuit diagrams, individual properties of every circuit components. When we work to design a system for the industry we must keep one thing in mind that our system must be flexible so that it can be used for more than one task. We have to use those components which are easily available in the market and we are managing them in such a way that end user feel himself comfortable by using it.

Following are the main components of our project.

- Robotic Arm
- Camera Stand Module
- USB Camera
- DAQ Card (Data Acquisition Card)
- DC Gear Motor

2.1 Robotic Arm:

The robotic arm we are using has been provided us by the university. It is the state of the art production of the internationally recognized company “Elettronica Veneta”. This unit is manufactured in such a way that it can fulfill educational needs efficiently because of its contained size and performance. It is the machine which has maximum interaction with

the user. Six stepper motors helps this machine to move freely in 6 degrees. We can control the robot with the key board because of its programmed control box. We can create a sequence of motion and can record it to use repeatedly.

2.1: Robotic Arm with Control Box

2.1.1: Technical Specifications:

Manufacturer: "Elletronica Veneta"
Model: MRB-4/EV
Robot Weight: 8 kg
Controller Weight: 3 kg

It is interfaced with its control box with a 26 pin connecter. Its details would be given in control box section. Total six motions can be observed in which five are on different axis and one is for gripper to hold the object. All these motions are controlling these parts of the robot.

2.2: 26 pin Connector

BASE: The base can be rotated up to 300° on both sides.

SHOULDER: Vertical moment can be observed on base, this motion supports to lift the object upward or downward. It can lift up to 90°.
ARM: it is the part which is attached to the shoulder and gripper is attached to its end. Its working is almost same as shoulder but it help gripper to get access through object.

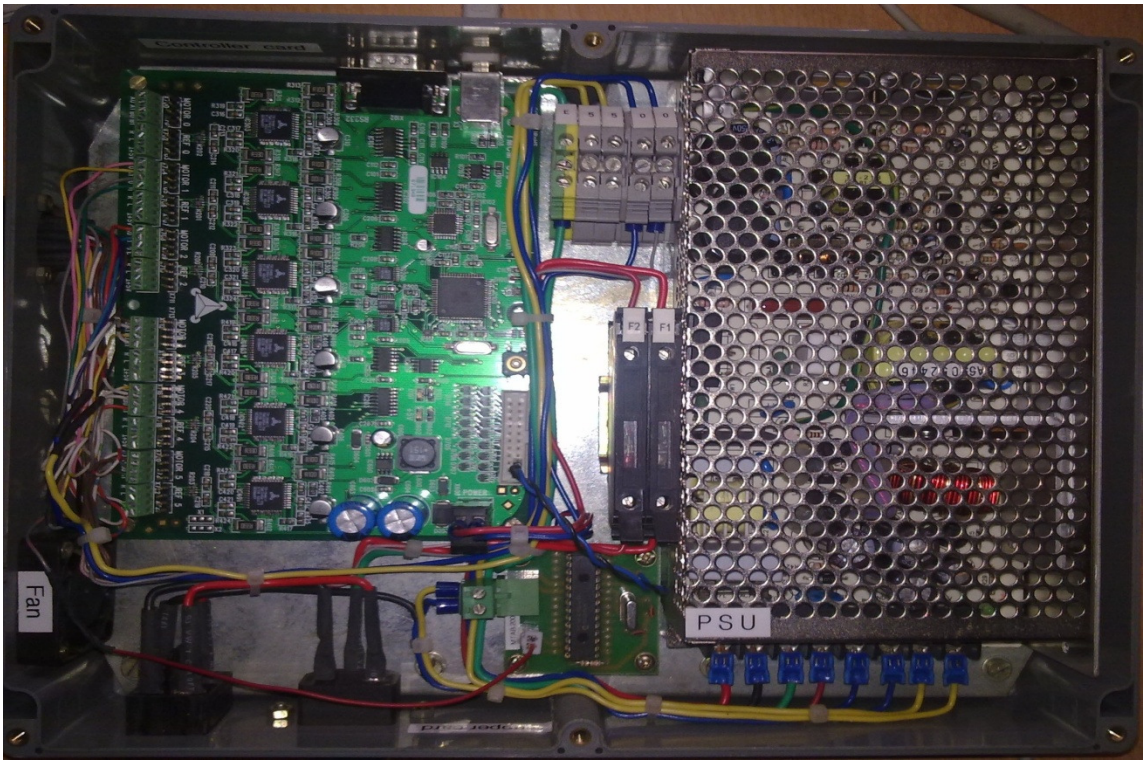
WRIST/LIFTING: The motor attached to arm and gripper helps gripper to adjust as the requirement of the destination. Its angle of rotation is 180°.

WRIST/ROTATION: Base of grip can rotate up to 120°.
GRIP: it has open close motion to grip the object.

Other characteristics of the equipment are:

- Resolution of moment is 1 mm.
- It can handle up to 250 grams of load.

- Its repeatability is 1mm.
- The gripper is parallel.
- Gripper is controlled by a DC motor.

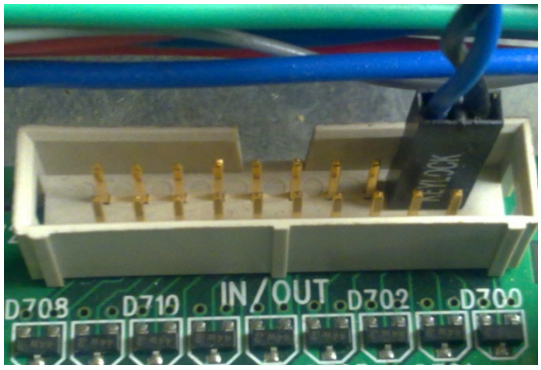


2.2 Control Box:

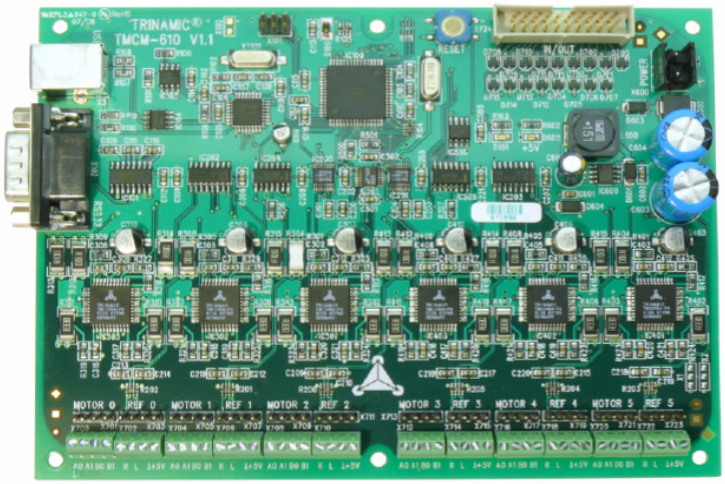
The key element which can help the robotic arm to perform the tasks which are discussed in previous section is the control box. This is programmed very much efficiently. Before going inside this box if we observe its physical appearance we can find 26 pin adopter port, a USB cable port, power cable terminal and an ON/OFF button. It also has provision to attach RS-232 cable with it.

2.3: Inside Control Box

Inside this box a mother board is fixed which is manufactured by TRINAMIC, model # TMCM610. There is a power supply which is able to have 7-34V for the board. Before we proceed we must now about this board.



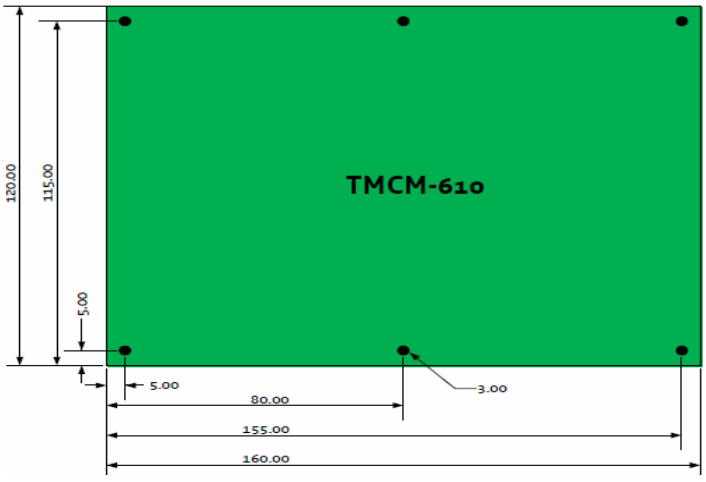
2.2.1 Trinamic TMCM 610:



The TMCM-610 is a six axis 2-phase stepper motor controller. It is helpful for single board motion control at a very low cost. It is also helpful to integrate additional I/Os to create complete system control applications. It has screw terminals to connect motors and switches easily. Dual-line pin connector can be used to connect the multipurpose I/Os.

2.4: I/O Ports

TMCL (Trinamic Motion Control Language) which is a PC based software environment with high level commands makes sure the fast development of motion control application. TMCM-610 comes with this software. If we need to update the firmware of module we can do it using serial interface. Here we have the dimensional view of this board.



To know the purpose of using

this board we have to look at the main characteristics of Trinamic TMCM 610. If we look at the electrical requirement of this board we came to know that it requires up to 1.1A coil current and 7V to34V of supply voltage. It supports two phase bipolar motors which are placed at the robotic arm. Those motors required 0.3A to 1.1A coil current.

If we look at the diagram we will find that how can we interface with this board? For this purpose the board has RS232 and USB interface. It takes inputs for the sake of reference and to stop the switches. We can also give digital or analog input because it has general purpose analog and digital me /Os. If we look at the special features of this board we came to know that it is programmed by TMCL commands and it can store 2048 TMCL commands. This board has an eligibility of altering the motion parameters. We can change the position, velocity and acceleration of the hardware. Size of this board is 160 x 120 mm. We will be controlling this board using its RS-232 port because in LabView integrated environment it needs a USB wrapper program to operate it through USB. The programming of this wrapper is unnecessary and time consuming because we already have RS-232 port that doesn't need to have any additional program. Now a question arises how can we control this board through LabView? There is a huge discussion upon it later on in the chapter of interfacing.

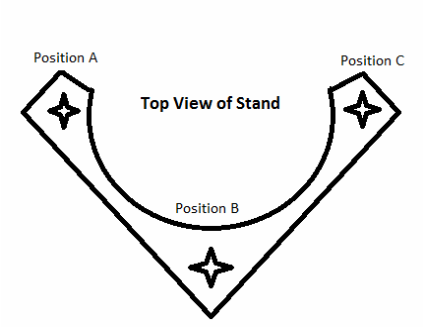
2.3: USB Camera:

Short introduction about USB camera and its usage is been given in the previous chapter. Now we will let you know the reason of using USB Camera. In the start we have decided to use the compact camera vision system. And we approached a compact camera vision available in university. But unfortunately it was black and white camera and that was the basic contradiction with our concept. After making search about that we decided to go for webcam because it is easier to control in LabView. The vi regarding camera can be seen in VI section.

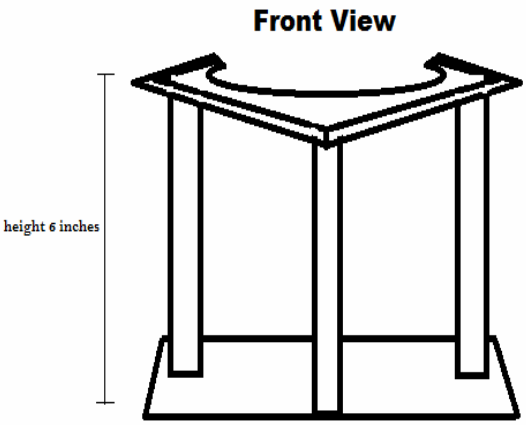
2.4: DC Gear motor:

In the previous chapter we discussed the definition and working of the gear motor but now we will discuss the using of motor in our project. We actually needed a motor with very low rpm and the conventional dc motors have very high rpm. It has required level of rpm. We do not need to attach any other pulleys. Our requirement is to rotate camera so we have made a small box regarding that.

2.5: Camera Stand:



According to the requirement of the project we need a rotating camera module we needed to have a gear motor which has been discussed above. We made a box having gear motor attached inside and camera has been attached with its rotating terminal. The images regarding our camera stand can be seen. Gear motor box is 4 inches high. And it rotates on both sides according to the requirement. As far as the rotating feature is concerned there is a circuitry containing two arrays and voltage sources. We are using a DAQ card to control this motor. Actually the DAQ card we are using only sends +5V DC. But we also need -5V DC also because of rotating the gear motor on both sides. The circuitry of gear motor controller has been made in such a way that only one array is ON at a time and rotates the motor for the required time interval. The Circuit diagram is attached below.

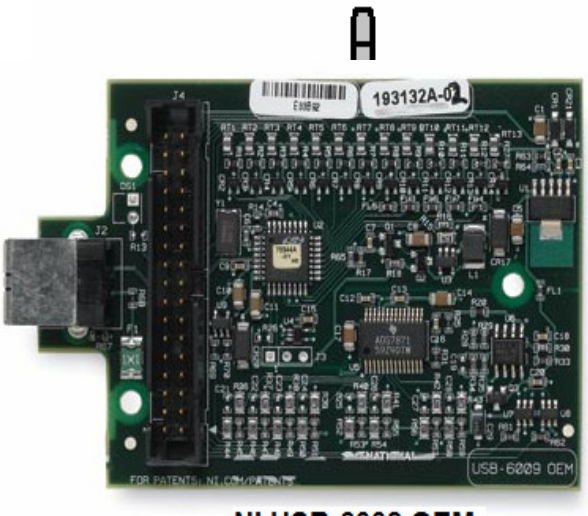


Another part of the stand is where we will put our color balls in front of camera for that we have a small stand having three positions position A, B and C. Camera has to move through these positions. And send command to LabView after detecting colors.

2.6: DAQ Card (Data Acquisition Card):

Specifications:

- Model # NI USB-6008 OEM
- 8 analog inputs (12-bit, 10 K S/s)
- 2 analog outputs (12-bit, 150 S/s), 12 digital I/O; 32-bit counter



NI USB-6008 OEM

- Bus-powered design for convenience; 34-pin connector for easy integration
- Driver software for Windows, Mac OS X, Linux®, and PDA

2.6.1: Pin Configuration of DAQ Card:

+5 V	34	33	PFI 0
D GND	32	31	P1.3
P1.2	30	29	P1.1
P1.0	28	27	P0.7
P0.6	26	25	P0.5
P0.4	24	23	P0.3
P0.2	22	21	P0.1
P0.0	20	19	D GND
LED	18	17	D+
VBUS	16	15	D–
AI GND	14	13	AI GND
AI 4 (AI 0–)	12	11	AI 0 (AI 0+)
AI 5 (AI 1–)	10	9	AI 1 (AI 1+)
AI 6 (AI 2–)	8	7	AI 2 (AI 2+)
AI 7 (AI 3–)	6	5	AI 3 (AI 3+)
AI GND	4	3	AI GND
AO 1	2	1	AO 0

USB-6008/6009 OEM Terminal Assignments

We are getting input of gripper motor from the pins #28 & 30.

2.6.2: Reasons of using DAQ Card:

We have I/O Ports available inside control box on TMCM-610 board. In the default software of robotic arm gripper is being controlled by these ports. But if we need to control these ports with LabView we are required to know the hexadecimal code to activate the port. We were unable to access the hex code. So to control two dc motor in our project we decided to avail this data acquisition.

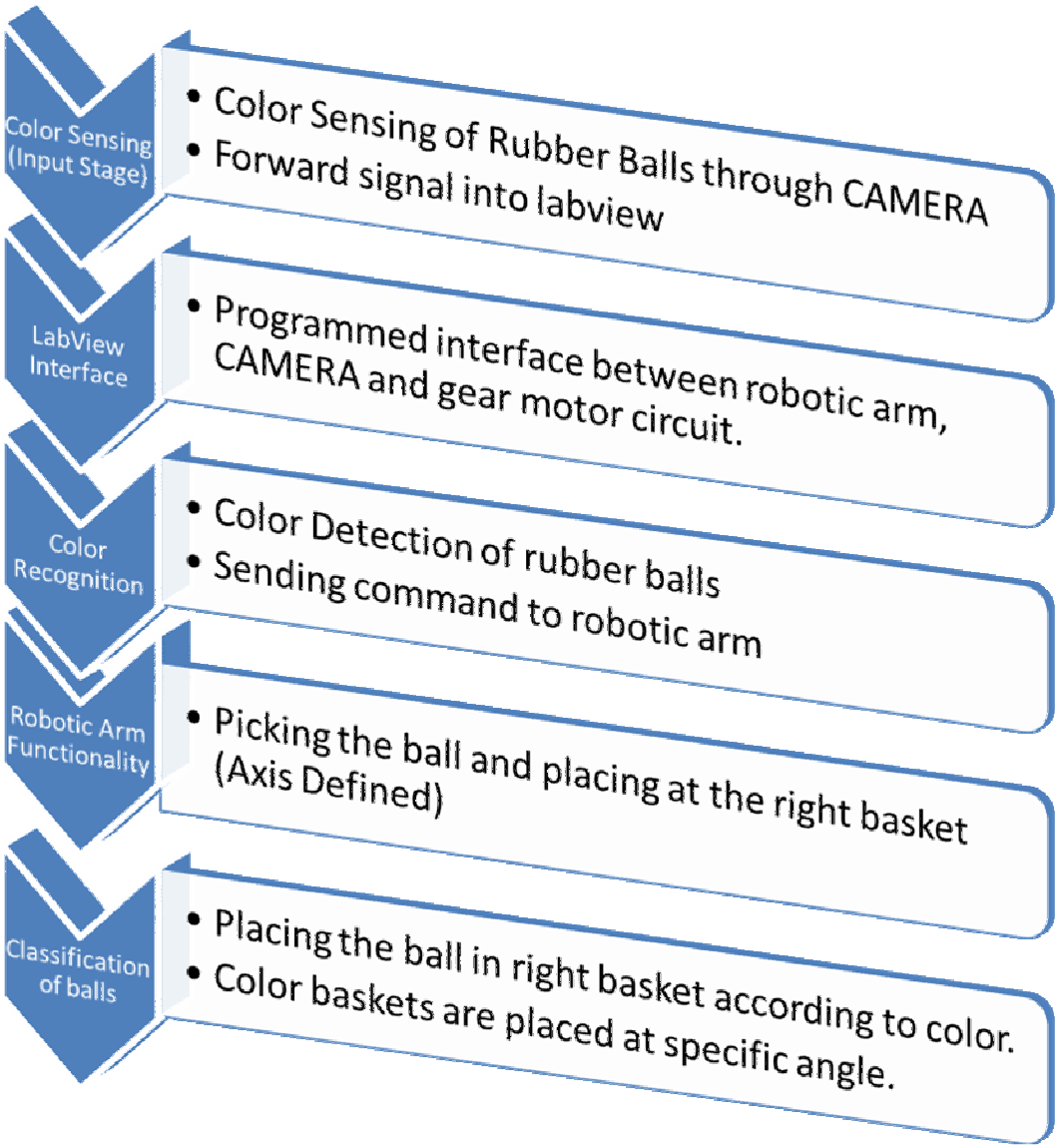
CHAPTER 3

Interfacing

Till this chapter we have slightly given the introduction a working of this project and properties of the components. But in this chapter we will explain the interfacing of all these components. So this chapter is said to the core of this project. As the LabView is being used to control this system that's why there would be a complex programming of LabView. We designed the LabView environment to operate the robotic arm and the other mechanism. It is a bit challenging task to keep every component in a row that everything is working on time and automatically. Every hardware which is programmed to work automatically is definitely having a sequence of commands in it. There is always a DLL (Dynamic Link Library) in which all the code is stored. Once a ".dll" file is generated and locked all the code inside is unchangeable now. To control such a mechanism we need to access the ".dll" file. As we know from the previous section in introduction of TMCM-610 that this board has a TMCL programming in it and the entire program is also locked in a ".dll" file. We were required to access it and extract what is useful for us. For that purpose we have designed a comprehensive Dynamic link library call function. The board also has a provision to tackle with other digital or analog signals through its general I/O ports. So we decided to control our gear motor circuit through it.

There is a comprehensive block diagram to know how the system will work after a successful interfacing.

3.1 Block Diagram:



3.1: Block Diagram

3.2 VI's:

VI is the program which is compiled in this software it does not contains lines of codes but the equipments as mentioned above. Here is the front panel of the final VI of the project. it is the user interface by which we can control the system. Three color circles can be seen in the front panel when any color ball passes through the camera the respective color circle blows up and robotic arm moves its programmed motion for this color.

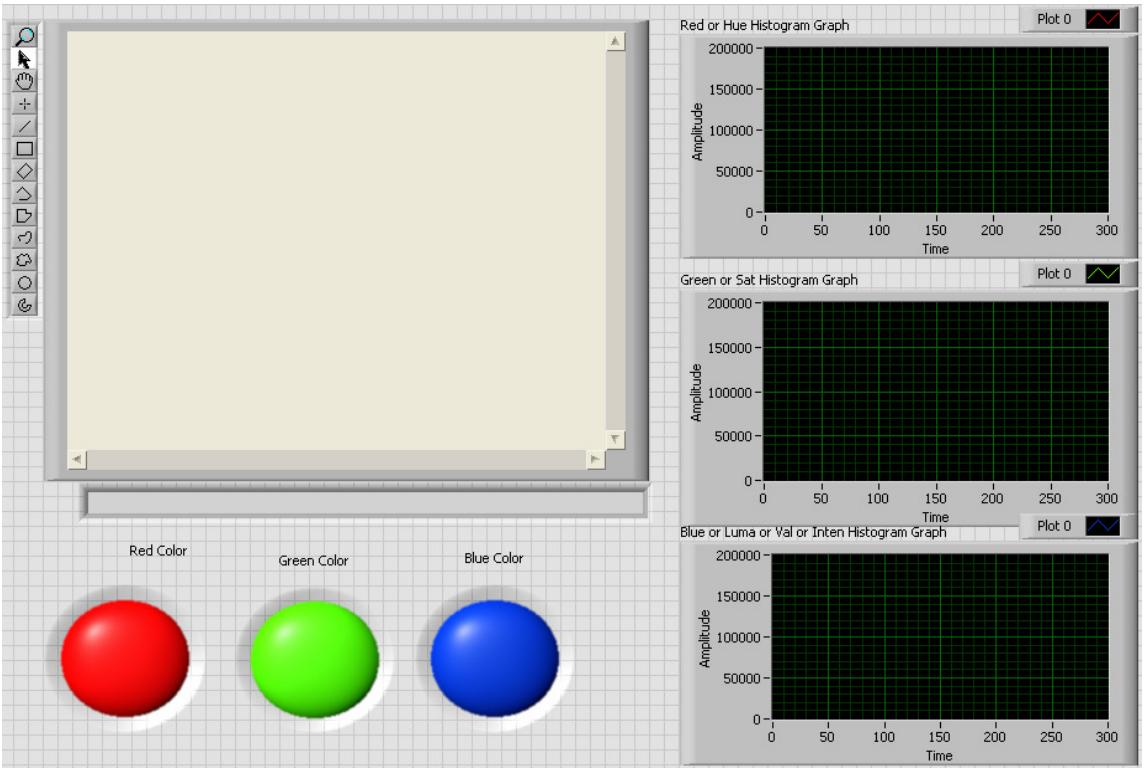
3.3 LabView:

LabView has made this system more interesting. The VI which we have made is off three parts. First one is called VISA part. This part helps the system to interact with the hardware through RS-232 port. In other words VISA part is the driver of our RS-232. It is also called RS-232 wrapper. We use to set the port number, baud rate, etc. All these things generate a hexadecimal number which helps the program to access the required output port.

Second part of this system is motor part. We discussed about the hexadecimal address that controls the output ports. We have motors connected at the ports and the ports are named as MOTOR1, MOTOR2 etc. there is a controlled program of motor section in which adders are used. For example if we need to control the motor 1. Our program will add the bit in such a way to get "1" at the end which is subjected to motor one. We will have to get "2" "3" at the end to control the motor 2 and motor 3 respectively.

3.4 User Interface:

In the LabView how our system will look like? There is affront panel from where we are controlling our system. There are some knobs related comport connection some ports are related to the speed and direction of motors and some ON/OFF switches. Following is the User interface of our project. This is the front panel of the final VI of the project. It is the user interface by which we can control the system. Three color circles can be seen in the front panel when any color ball passes through the camera the respective color circle blows up and robotic arm moves its programmed motion for this color.



Control Panel

3.5 working of DAQ (Data Acquisition Card):

Third part of our VI is the programming of our Gripper of robotic arm and gear motor. If we recall the previous details of the robotic arm we will know that there are four to five stepper motors in the robotic arm but our gripper has a dc motor which cannot be connected by stepper ports of the card and same is the case of dc gear motor. For that purpose there is a gripper card having a microcontroller on it and it is programmed to move that dc motor of

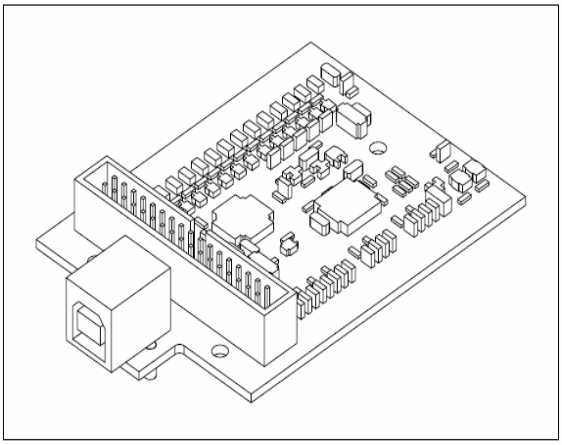
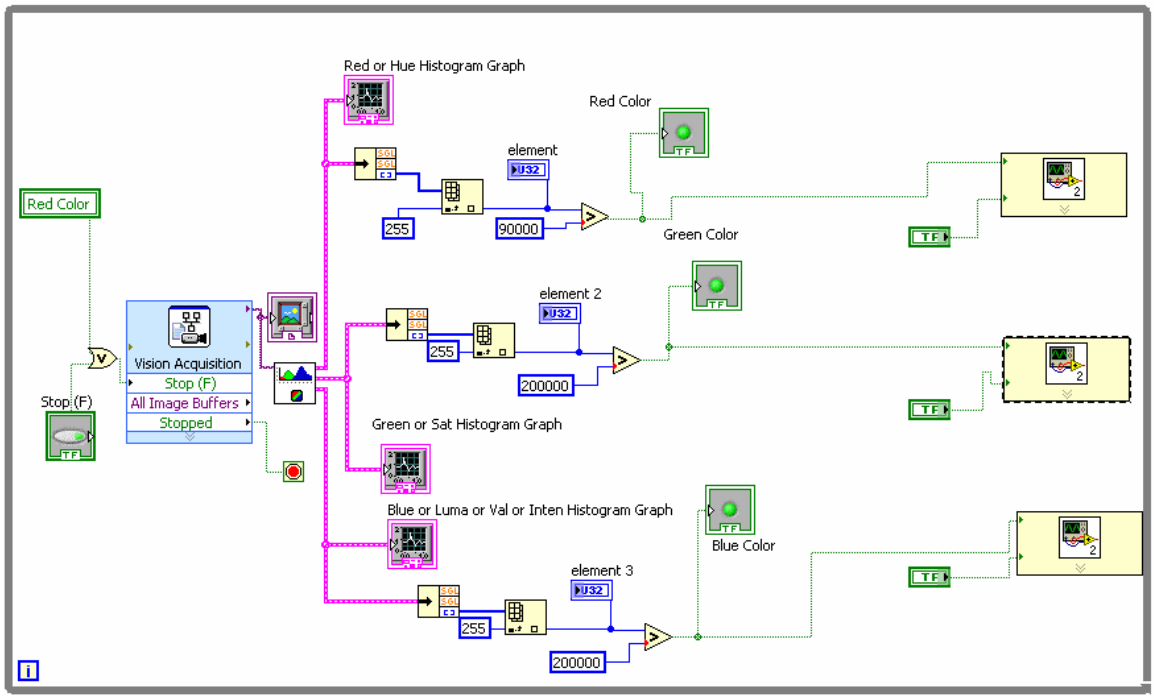


Figure 1. USB-6008/6009 OEM Device

gripper in two directions. Primary task was to integrate it with TMCM-610 the I/O ports of the card are used. The same I/O ports were supposed to use to integrate the gear motor. But unfortunately our I/O ports on TMCM-610 are controlled by a specific hexadecimal number but we were unable to know hexadecimal numbers of the I/O ports. That's why we decided to introduce a DAQ card manufactured by NATIONAL INSTRUMENTS. This card already has an integrated VI function for LabView. We accessed the defined I/O ports of this card. After that we connected gripper and gear motor through these ports. Ports configuration of DAQ card is attached.

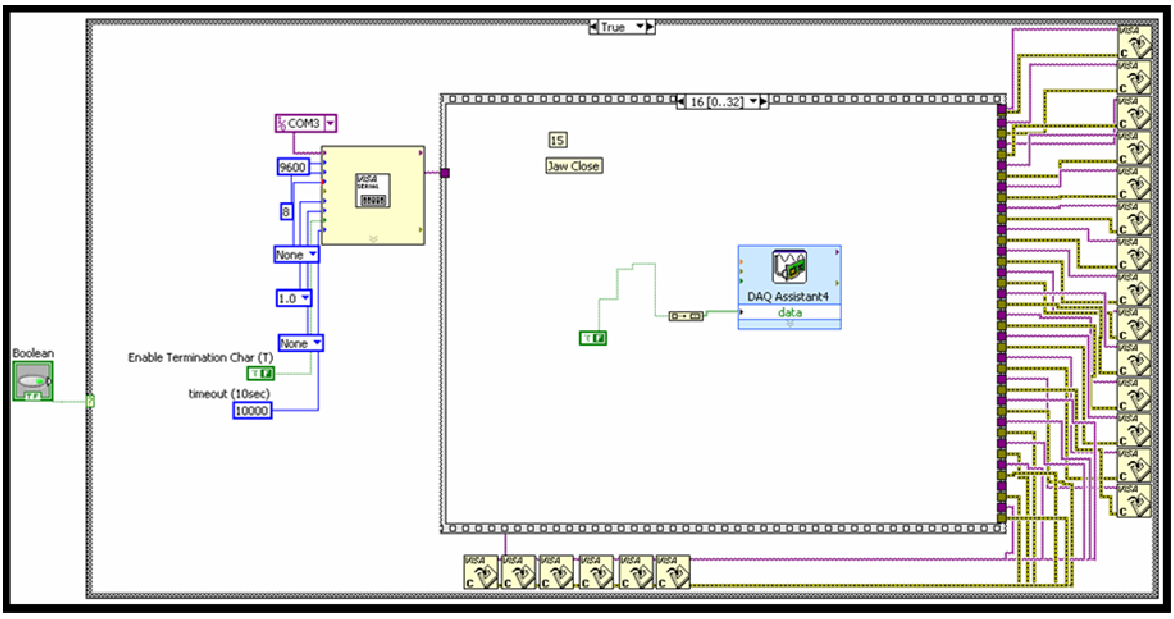
3.6: VI's of the Project:

Control Panel has been shown above in user interface section. Following is the main VI of the project. it shows what really going behind the scene.



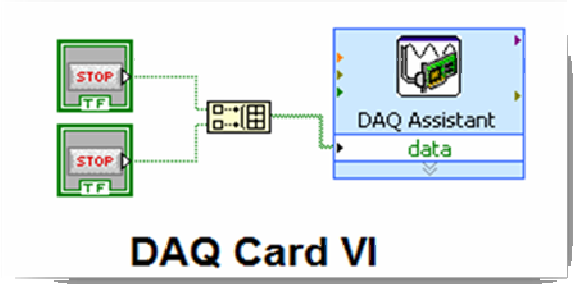
Yellow boxes in the right most are the sub VI s. each box is integrated for different color RED, GREEN and BLUE respectively. There is a complex sequence of command is

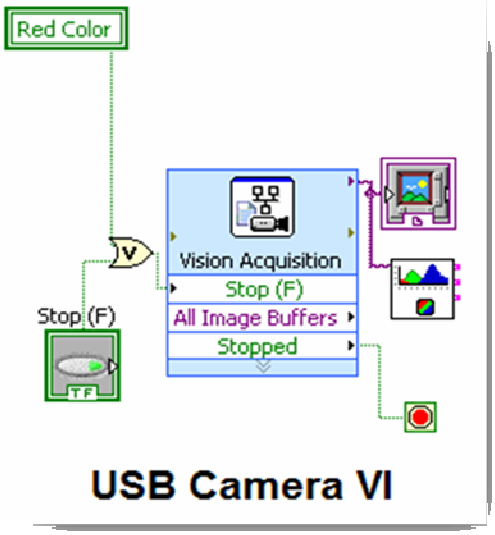
being running inside every sub VI. Following is the image of internal sequence of a VI.



There are more than thirty command sequences inside each sub VI.

Now, following are the VI of vision acquisition and data acquisition for accessing camera and DAQ Card respectively.





CHAPTER 4

Conclusion

Here are some important conclusions and recommendations about the project. We have made this system for educational purpose. It has some limitations. But when it is going to be used for industrial purposes there must have some changes. We are recommending that changes for the most precious experience. That project will urge our new engineers to learn about the world of LabView. This program has the ability to solve the problems very much efficiently. Our new industry leader will get the ideas and they will continue the research in this field.

4.1 Conclusions:

The aim of the project was to build the industrial automation system with the ability of color sensing USB camera through Lab View programming. It has been implemented successfully. The basic functionalities as per requirements, for example Color sensing USB Camera, interfacing with lab view, picking color balls from the ball stand and placing them into their respected color baskets have been achieved. The main points are given below to describe the achieved goals.

- The fundamental functionality of the Automation system was interfacing of Robotic arm with the Lab View has been effectively achieved.
- Every motor of robotic arm is now can be controlled by Lab View.
- The DC Gear motor which is holding USB camera. It's timing controlled by the Lab View is effectively achieved.
- Interfacing of the Lab View with the camera is achieved successfully.

- The movement of the robotic arm according to the programmed has been successfully achieved.

4.2 Future Enhancements:

This project has been completed using USB Camera as color sensor and following are the recommendation for future use.

- This project can be used manually and automatically as well, Through Joystick or completely automated programmed.
- The USB camera which is used in this project is easily available in the market. We can also sense the color through LDR or with more consistent sensors to acquire the exact value.
- We can use conveyor belt instead of moving camera. That would make this project more attractive and practical.
- Image processing can also be performed by the lab View with the help of Compact Camera Vision.
- This project can be used in automobile and manufacturing industries for assemble machineries, Load Bricks, clean parts, paint, chemical handling and spot welding work.