

B.Sc. in Computer Science and Engineering Thesis

# **Vision Based Navigation of an Autonomous Robot**

Submitted by

Zakia Al Kadri  
201014028

Talha Bin Omar  
200914035

Sumaia Jahan Brinti  
201014048

Supervised by

Lieutenant Colonel Md. Mahboob Karim  
Instructor class 'A', MIST.

Fahim Hasan Khan  
Assistant Professor, MIST



**Department of Computer Science and Engineering  
Military Institute of Science and Technology**

# CERTIFICATION

This thesis paper titled “**A Paper on Vision Based Navigation of an Autonomous Robot**”, submitted by the group as mentioned below has been accepted as satisfactory in partial fulfillment of the requirements for the degree B.Sc. in Computer Science and Engineering on December 2010.

## **Group Members:**

Zakia Al Kadri  
Talha Bin Omar  
Sumaia Jahan Brinti

## **Supervisor:**

---

Lieutenant Colonel MD. MAHBOOB KARIM  
Instructor class 'A'  
Fahim Hasan Khan  
Assistant Professor  
Military Institute of Science and Technology (MIST)

## CANDIDATES' DECLARATION

This is to certify that the work presented in this thesis paper is the outcome of the investigation and research carried out by the following students under the supervision of Lieutenant Colonel MD. MAHBOOB KARIM, Instructor class 'A' and Fahim Hasan Khan, Assistant Professor Military Institute of Science and Technology (MIST), Dhaka, Bangladesh.

It is also declared that neither this thesis paper nor any part there of has been submitted anywhere else for the award of any degree, diploma or other qualifications.

---

Zakia Al Kadri  
201014028

---

Talha Bin Omar  
200914035

---

Sumaia Jahan Brinti  
201014048

# ACKNOWLEDGEMENT

We are thankful to Almighty for his blessings for the successful completion of our thesis. Our heartiest gratitude, profound indebtedness and deep respect go to our supervisor Lieutenant Colonel MD. MAHBOOB KARIM, Instructor class 'A' and Fahim Hasan Khan, Assistant Professor, Military Institute of Science and Technology (MIST), Dhaka, Bangladesh, for their constant supervision, affectionate guidance and great encouragement and motivation. Their keen interest on the topic and valuable advices throughout the study was of great help in completing thesis.

We are especially grateful to the Department of Computer Science and Engineering (CSE) of Military Institute of Science and Technology (MIST) for providing their all out support during the thesis work.

Finally, we would like to thank our families and our course mates for their appreciable assistance, patience and suggestions during the course of our thesis.

Dhaka  
December 2013

Zakia Al Kadri  
Talha Bin Omar  
Sumaia Jahan Brinti

# ABSTRACT

Machine vision is a powerful tool for process automation and control. This paper describes the development of Robot System capable of capturing image through roof-mounted cameras and by detecting that image the robot can make decision to navigate.

The image detection part is the machine vision part which was done in NI LabVIEW, a graphical program development environment from National Instruments (NI). Basic theoretical background on machine vision is presented at the beginning of this thesis; this is followed by a description of the vision development module in LabVIEW, and a method to communicate between a PLC and LabVIEW.

The communications network uses a combination of router and microcontrollers serial communication. Router is used for the distance ( $d < 1\text{m}$ ), transmitting data between the robot system and the PC.

# TABLE OF CONTENT

<i>CERTIFICATION</i>	ii
<i>CANDIDATE'S DECLARATION</i>	iii
<i>ACKNOWLEDGEMENT</i>	iv
<i>ABSTRACT</i>	i
<b>List of Figures</b>	vi
<b>List of Tables</b>	vii
<b>List of Abbreviation</b>	viii
<b>List of Symbols</b>	viii
<b>1 Introduction</b>	<b>1</b>
1.1 Background of Thesis . . . . .	1
1.2 Our Proposed System . . . . .	2
<b>2 Literature Review</b>	<b>4</b>
2.1 Robotics and Robots . . . . .	4
2.1.1 History of Robotics and Robots . . . . .	5
2.1.2 Laws of Robotics . . . . .	6

2.1.3	Types of Robots . . . . .	7
2.1.4	Branches of Robots . . . . .	9
2.1.5	Component of Robotics . . . . .	9
2.2	Robotic Vision . . . . .	11
2.2.1	Computer Vision . . . . .	11
2.2.2	A Brief History . . . . .	12
2.2.3	Digital Image . . . . .	12
2.2.4	Digital Image Acquisition . . . . .	13
2.2.5	Image Processing Using Transformation . . . . .	14
2.2.6	Pattern Recognition . . . . .	15
2.3	Some robotics terminology . . . . .	16
2.3.1	Mobile Robot . . . . .	16
2.3.2	Autonomous Robot . . . . .	16
2.3.3	Navigation by Vision . . . . .	17
2.3.4	Driving Mechanism (Differential Drive) . . . . .	18
<b>3</b>	<b>Technology Used</b>	<b>20</b>
3.1	Software Technologies . . . . .	20
3.2	Hardware Technologies . . . . .	21
3.2.1	Microcontroller: Arduino . . . . .	21
3.2.2	Arduino Shields . . . . .	23
3.2.3	Router:wireless 150n access point . . . . .	23

3.2.4	Motor . . . . .	24
3.2.5	Others . . . . .	26
<b>4</b>	<b>Design of the System</b>	<b>29</b>
4.1	System Architecture . . . . .	29
4.2	System Design . . . . .	30
<b>5</b>	<b>Implementation</b>	<b>34</b>
5.1	LABVIEW Implementation . . . . .	34
5.2	Working Procedure of The Robot . . . . .	36
5.2.1	Arduino UNO . . . . .	36
5.2.2	Ethernet sheild . . . . .	36
5.2.3	Network Settings . . . . .	37
<b>6</b>	<b>Conclusion</b>	<b>40</b>

**References**

**Appendix-A Java Code for Setup**

**Appendix-B Code for Aurdino**



# LIST OF FIGURES

1.1	Basic flow of the System . . . . .	3
2.1	Articulated welding robots used in a factory, a type of industrial robot. . . . .	5
2.2	An intelligent AGV drops-off goods without needing lines or beacons in the workspace . . . . .	8
2.3	Neighborhood of a pixel . . . . .	13
2.4	The autonomous Urbie is designed for various urban operations, including military reconnaissance and rescue operations.Photo courtesy NASA . . . . .	17
2.5	Differential drive method . . . . .	19
3.1	Arduino Uno . . . . .	22
3.2	Ethernet shield . . . . .	23
3.3	wireless 150n access point . . . . .	24
3.4	Motor Driver(L293D) . . . . .	26
3.5	Geared-Motor . . . . .	26
3.6	Breadboard . . . . .	27
3.7	4 AA batteries i.e. 6V for motors and servo . . . . .	27
3.8	Gauge wires or male to male jumper wires . . . . .	28
4.1	Basic flow of the System . . . . .	29
4.2	Video Acquisition using IMAQ Vision Acquisition Express. . . . .	30

4.3	Grayscale image acquisition using IMAQ Vision Acquisition Express. . . .	31
4.4	Pinout diagram of Aurdino ATMEGA328 . . . . .	32
5.1	Flow diagram of Labview . . . . .	35
5.2	The output directs to move left . . . . .	35
5.3	Circuit powering the motor with 9V . . . . .	38
5.4	Internal circuitry of the Robot . . . . .	39
5.5	Final view of our designed Robot . . . . .	39

# LIST OF TABLES

2.1	History of Robotics and Robots . . . . .	6
2.2	Component of robotics . . . . .	10
2.3	Operation table for robot movement . . . . .	19
5.1	Circuit Connection . . . . .	37

# LIST OF ABBREVIATION

<b>ADC</b>	: Analog To Digital Converter
<b>AGVs</b>	: Automated Guided Vehicles
<b>CCD</b>	: Charge-Coupled Device
<b>CMOS</b>	: Complementary metaloxidesemiconductor
<b>DC</b>	: Direct Current
<b>DHCP</b>	: Dynamic Host Configuration Protocol
<b>IDE</b>	: Integrated Development Environment
<b>LabVIEW</b>	: Laboratory Virtual Instrument Engineering Workbench
<b>LED</b>	: Light Emitting Diode
<b>MAC</b>	: Media Access Control
<b>NI</b>	: National Instruments
<b>PC</b>	: Personal Computer
<b>PCB</b>	: Printed Circuit Board
<b>PIC</b>	: Programmable Computer
<b>RX/TX</b>	: Receiver Transmitter
<b>RPM</b>	: Revolution Per Minute
<b>TCP/IP</b>	: Transmission Control Protocol/Internet Protocol
<b>USB</b>	: Universal Serial Bus

# CHAPTER 1

## INTRODUCTION

### 1.1 Background of Thesis

In today's world robots have become a replacement to humans because jobs that are harmful to the human, repetitive jobs that are boring, stressful etc. are done by the robots. The industry wants to get more and more automated in order to reduce production times, increase productivity, improve quality production, at a cheaper cost, to be less wasteful, with less need to have a skilled operative, to be more flexible meaning easy to implement changes and possible to leave the automated process working with little supervision around the clock. Vision in Robotics helps controlling production in a relatively simple form, avoiding a skilled operative to spend his time watching the machine doing his job. Moreover, the automatic inspection process does things faster and with improved quality than a human.

Robotics Vision and Image Processing tools are the most desired tools for quality control in industry. An initial investment is needed to buy all the necessary Vision Hardware, but software can be built by using a few existing tools.

Robots can be wired or wireless, both having a controller device. So robot systems need to be managed, either by themselves (autonomous) or by a user (remote control), depending on the objective and situation of the robot. If the system is complex, and the robot task is not straightforward, in the sense that it needs human consideration, then the system must be managed with a remote control otherwise autonomous system is preferred.

Because of the large development of communication technologies many wireless products are available. Mobile robotics is no stranger to this fact; the benefits of joining the wireless communication technologies with the developments in mobile robots are clear.

Object detection is defined as the determination of whether a given direction is right for safe travel by an autonomous vehicle. Object detection is one of the most renowned problems

within the sub field of computer vision in terms of the amount of research it has attracted and the number of uses it has. Together with research into other sub fields of artificial intelligence, object detection is crucial in order to perform many basic operations for mobile robots such as avoidance and navigation.

A good object detection system must be capable of the following :

- to detect objects on a given space in good time
- to detect and identify correct objects

Previous work into this field has made use of digital cameras, laser scanners, sonar, odometry etc. to perform object detection. Snap shots are taken of the real scene using these input devices and the data is processed by a computer which ultimately performs object detection. Since most of these devices can only take a limited number of shots of a scene in a given time and since an enormous amount of data needs to be processed, object detection can often be quite slow for some real time applications, e.g. navigation of high-speed vehicles. Very sophisticated sensors and processors used to perform object detection so far have been able to accommodate navigation at speeds of only a few meters per second.

## **1.2 Our Proposed System**

We propose a system, using which the user can navigate the wireless robot in the environment using various commands.

The basic concept of this project is to design a robot which can move forward and backward, left and right without human guidance or control. Although several other methods such as odometry, infrared and laser have been used to achieve object detection, this project uses vision. In this system, Micro controller Aurdino will be used as the brain of this robot as it controls the systems of the robot. The robot we make has a camera mounted on it. This camera is used to capture real time video stream of our specified direction to generate commands for the robot. The robot can move in all possible directions in the environment using four possible types of commands which are Forward, Backward, Right and Left. Image frame is

taken as an input and processed using Image Processing. Processed image is then used to extract the command.

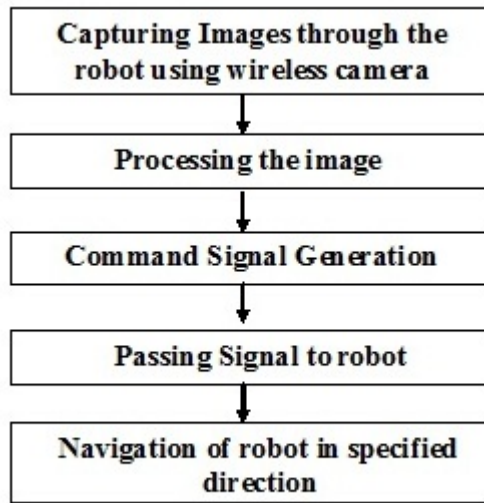


Figure 1.1: Basic flow of the System

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 Robotics and Robots

**Robotics** is the branch of technology that deals with the design, construction, operation, and application of robots[1] as well as computer systems for their control, sensory feedback, and information processing. In Webster's New World Dictionary, robotics is defined as the science or technology of robots, their design, manufacture, application, use etc. But in Europe, robotics is defined as the science of robotology and robotology is defined as the means by which robot machines are put together and made to work. The design of a given robotic system will often incorporate principles of Mechanical engineering, Electronic engineering and Computer science particularly Artificial intelligence. The study of biological systems often plays a key role in the Systems engineering of a project and also forms the field of Bionics. The mathematical expression of a biological system may give rise to control algorithms for example, or by observing how a process is handled by nature, for example the bifocal vision system, an analogous system may be formed using electronics.

The concept of creating machines that can operate autonomously dates back to classical times, but research into the functionality and potential uses of robots did not grow substantially until the 20th century. Throughout history, robotics has been often seen to mimic human behavior, and often manage tasks in a similar fashion. Today, robotics is a rapidly growing field, as technological advances continue, research, design, and building new robots serve various practical purposes, whether domestically, commercially, or militarily. Many robots do jobs that are hazardous to people such as defusing bombs, mines and exploring shipwrecks.

A **robot** is a mechanical or virtual agent, usually an electro-mechanical machine that is guided by a computer program or electronic circuitry. Robots can be autonomous or semi-





Figure 2.1: Articulated welding robots used in a factory, a type of industrial robot.

autonomous and range from humanoids such as Honda's Advanced Step in Innovative Mobility (ASIMO) and TOSY's TOSY Ping Pong Playing Robot (TOPIO) to industrial robots, collectively programmed 'swarm' robots, and even microscopic nano robots. By mimicking a lifelike appearance or automating movements, a robot may convey a sense of intelligence or thought of its own. In fact, the first use of the word "robot" occurred in a play about mechanical men that are built to work on factory assembly lines and that rebel against their human masters. The word "robotics" was also coined by a writer. These machines in R.U.R. (Rossum's Universal Robots), written by Czech playwright Karl Capek in 1921, got their name from the Czech word for slave. The word "robotics" was also coined by a writer. Russian-born American science-fiction writer Isaac Asimov first used the word in 1942 in his short story "Runabout."

### **2.1.1 History of Robotics and Robots**

The idea of a Robot has transcended from the world of fiction to modern day reality. The term itself has been coined by Karel Capek, a playwright who invented fictional robotic monsters. It is a Czech word that literally means 'forced labor'. Robotics is a branch of technology that deals with Robots. Robot Institute of Technology, 1979 has defined a robot as 'a re-programmable, multi functional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks'.

A person involved with robotic technology needs to acquire knowledge of electronics, engineering, mechanics, and software to perform activities such as construction, operation, manufacture and structural disposition upon any robot.

Table 2.1: History of Robotics and Robots

Year	Evolution	Inventor
1890s	First remote control vehicles. Invention of the radio, induction motors, Tesla coils	Nikola Tesla
1892	Motorized crane with gripper to remove ingots from a furnace. First reference to the word robot in the play 'Rossum's Universal Robots'. It described robots as tools doing simple, repetitive tasks.	Seward Babbitt
1921	However, when the robots in the story were used in battle, the story shows them turning against their human owners and taking over the world.	Karel Capek , writer
1938	A programmable paint-spraying mechanism for the DeVilbiss Company	Willard Pollard and Harold Roselund
1940	Early robot called Elsie the tortoise, or Machina speculatrix.	Grey Walters
1941	First time the word 'robotics' is used to describe the technology of robots and predict the rise of a powerful robot industry.	Isaac Asimov , writer

### 2.1.2 Laws of Robotics

The Three Laws of Robotics (often shortened to The Three Laws or Three Laws) are a set of rules devised by the science fiction author Isaac Asimov. The rules were introduced in his 1942 short story "Runaround", although they had been foreshadowed in a few earlier stories. The Three Laws are:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

### **2.1.3 Types of Robots**

Nowadays, robots do a lot of different tasks in many fields and the number of jobs entrusted to robots is growing steadily.

#### **Industrial robots**

##### **Car production**

Over the last three decades, automobile factories have become dominated by robots. A typical factory contains hundreds of industrial robots working on fully automated production lines, with one robot for every ten human workers. On an automated production line, a vehicle chassis on a conveyor is welded, glued, painted and finally assembled at a sequence of robot stations.

##### **Packaging**

Industrial robots are also used extensively for palletizing and packaging of manufactured goods, for example for rapidly taking drink cartons from the end of a conveyor belt and placing them into boxes, or for loading and unloading machining centers.

##### **Electronics**

Mass-produced printed circuit boards (PCBs) are almost exclusively manufactured by pick-and-place robots, typically with SCARA manipulators, which remove tiny electronic components from strips or trays, and place them on to PCBs with great accuracy. Such robots can place hundreds of thousands of components per hour, far out-performing a human in speed, accuracy, and reliability.

##### **Automated guided vehicles (AGVs)**

An intelligent AGV drops-off goods without needing lines or beacons in the workspace. Mobile robots, following markers or wires in the floor, or using vision or lasers, are used to transport goods around large facilities, such as warehouses, container ports, or hospitals.

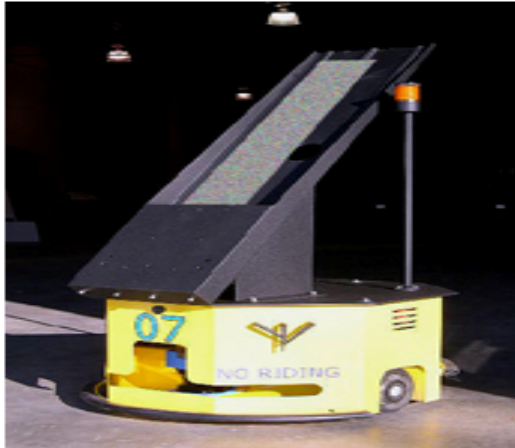


Figure 2.2: An intelligent AGV drops-off goods without needing lines or beacons in the workspace

### **Domestic or household robots**

Robots used at home. This type of robots includes many quite different devices such as robotic vacuum cleaners, robotic pool cleaners, sweepers, gutter cleaners and other robots that can do different chores. Also, some surveillance and telepresence robots could be regarded as household robots if used in that environment.

### **Medical robots**

Robots used in medicine and medical institutions. First and foremost - surgery robots. Also, some automated guided vehicles and maybe lifting aides.

### **Service robots**

Robots that dont fall into other types by usage. These could be different data gathering robots, robots made to show off technologies, robots used for research, etc.

### **Military robots**

Robots used in military. This type of robots includes bomb disposal robots, different transportation robots, reconnaissance drones. Often robots initially created for military purposes can be used in law enforcement, search and rescue and other related fields.

### **Entertainment robots**

These are robots used for entertainment. This is a very broad category. It starts with toy robots such as robosapien or the running alarm clock and ends with real heavyweights such as articulated robot arms used as motion simulators.

## **Space robots**

Id like to single out robots used in space as a separate type. This type would include robots used on the International Space Station, Canadarm that was used in Shuttles, as well as Mars rovers and other robots used in space.

## **Hobby and competition robots**

Robots that you create. Line followers, sumo-bots, robots made just for fun and robots made for competition.

### **2.1.4 Branches of Robots**

Robotics is divided into three main branches, which share the same origin, namely:

#### **1. Industrial**

Performs repetitive manufacturing tasks that are considered unsafe or unpleasant for human workers. They do the mechanical function of repeating a work over and over again. Modern industrial robots can easily be programmed to perform new applications.

#### **2. Research/service**

They assist in exploring and gathering data, and are often used in space applications, surgeries, and household chores. They interact with the environment and react appropriately according to the situation. This function is termed as 'artificial intelligence'.

#### **3. Educational**

At times, they are considered as toys or kits and hence provide an educational experience. They are also used in competitions and for learning experience. They come with the ability to that simulates learned behavior.

### **2.1.5 Component of Robotics**

Today, machines have succeeded in mimicking certain simple human thought processes, but they still can't match the human brain and its intelligence. Equipping robots with AI requires complex programming.

Table 2.2: Component of robotics

<b>Part</b>	<b>Function</b>
Mechanical devices	Also known as a hardware base, it interacts with its environment. For example a wheeled platform, arm, fixed frame or other construction.
Sensor Systems	They are special features that provide judgment abilities to the controller. They give out relevant information regarding the environment and also provide feedback to the robot. They usually are placed on or around a robot.
Joints	They are not just points that link various parts of the robot. Rather, they help in making it more versatile through actions such as flexing, rotating, revolving and translating.
Controller	It acts as the brain of the robot. These are run with the help of a set of instructions written in a code language. Basically, it commands the robot memory and logic, enabling it to work automatically, with least further dependence.
Power Source	It is the robot's source of energy. A robot may "derive" energy directly through a battery, or alternately from a power plant, solar energy, hydraulics or gas.
Artificial intelligence	It provides robots the ability to think for themselves, like human beings.

## **2.2 Robotic Vision**

### **2.2.1 Computer Vision**

Computer vision is the science and technology of machines that see. As a scientific discipline, computer vision is concerned with the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences and views from cameras.

In most practical computer vision applications, the computers are pre-programmed to solve a particular task, but methods based on learning are now becoming increasingly common.

Computer vision systems rely on image sensors which detect electromagnetic radiation which is typically in the form of either visible light or infra-red light. The sensors are designed using solid-state physics. The process by which light propagates and reflects off surfaces is explained using optics. Sophisticated image sensors even require quantum mechanics to provide a complete understanding of the image formation process. Robots can also be equipped with multiple vision sensors to be better able to compute the sense of depth in the environment. Like human eyes, robots' "eyes" must also be able to focus on a particular area of interest, and also adjust to variations in light intensities.

There is a sub field within computer vision where artificial systems are designed to mimic the processing and behavior of biological system, at different levels of complexity. Also, some of the learning-based methods developed within computer vision have their background in biology.

Computer vision problems can be subdivided into low-level ones and high level ones. The former refers to the initial stages of image processing with very little other knowledge of the environment and includes operations such as edge detection, boundary drawing etc whereas the latter refers to highly task-specific operations performed on presumably perfect data from low-level processes with some or no additional data and includes operations such as obstacle detection, face recognition etc.

### **2.2.2 A Brief History**

Researchers have taken a bottom up approach in computer vision for decades starting with algorithms that performed very simple analysis of raw input images direct from cameras [8]. Roberts [9] is well known for his work in the blocks world, which is basically the concept that artificial environments only consist of regular geometric shapes. His work mainly consisted of algorithms that converted the input image into a large number of line drawings and then analysed sets of lines to identify and differentiate among pre-defined geometric shapes. Image segmentation, i.e. the division of an input image into several distinguishable segments with common characteristics is another low-level process vital to computer vision. The decade after that most contributions to computer vision came from the application of physics and geometry [10]. Information on shapes within the scene such as convexity, concavity, slopes and smoothness would in turn provide information on the scene itself. In 1970 Horn [11] incorporated the analysis of texture and shading to help represent the scene into a 3D form within the machine. Scene analysis i.e. the reconstruction of a representation of the image from a simple description of the scene (usually by identifying geometric properties of objects present). Other than geometric features, texture, markings and colour also contributed to the representation of the scene with the computer which was then used in a variety of applications such as obstacle detection and avoidance, navigation, planning etc.

### **2.2.3 Digital Image**

An image is treated as a matrix of  $M \times N$  elements. Each element of the digitized image (pixel) has a value that corresponds to the brightness of the point in the captured scene. An image whose resolution in intensity is of 8 bits, can take values from 0 to 255. In the case of a black and white image images it can take 0 and 1 values. In general, an image is represented in a bidimensional matrix .

Since most of the devices acquire the images with a depth of 8 bits, the typical range of levels of gray for an image is from 0 to 255. At this point it is convenient to say that even if the images are acquired at RGB format, it is frequently transformed in a gray scale matrix and for achieving the transformation from RGB type to gray Grassman level (Wyszecki



Stiles,1982)is employed[12]:

$$I_{gray} = I_{Red}(0.299) + I_{Green}(0.587) + I_{Blue}(0.114)$$

Another important characteristic in the image definition is the neighbourhood of pixels, that could be classified in 3 groups :

If the neighbourhood is limited at the our adjacent pixels is named call 4-neighbourhood

If the one conformed by the diagonal pixels is the D- neighbourhood and

If the 8 surrounding pixels is the 8-neighbourhood, the last one includes the 4- and the D-neighbourhood of pixel.

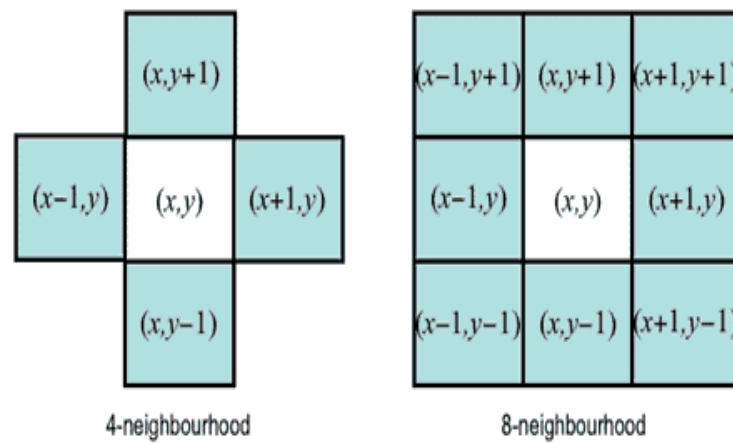


Figure 2.3: Neighborhood of a pixel

#### 2.2.4 Digital Image Acquisition

In the case of the digital images, the acquisition systems require in the first place a light sensitive element, which is usually constituted by a photosensitive matrix arrangement obtained by the image sensor (CCD, CMOS, etc.). These physical devices give an electrical output proportional to the luminous intensity that receives in their input. The number of elements of the photosensitive system of the matrix determines the spatial resolution of the captured image. Moreover, the electric signal generated by the photosensitive elements is sampled and discretized to be stored in a memory slot; this requires the usage of an analog to- digital converter (ADC). The number of bits used to store the information of the image determines the resolution at intensity of the image.

A colour mask is generally used (RGB Filter) for acquisition of colour images. This filter

allows decomposing the light in three bands, Red, Green and Blue. The three matrixes are generated and each one of them stores the light intensity of each RGB channe.

### **2.2.5 Image Processing Using Transformation**

The images processing can be seen like a transformation of an image in another, in other words, it obtains a modified image starting from an input image, for improving human perception, or for extraction of information in computer vision. Two kinds of operations can be identified for them:

- A. Punctual operations.
- B. Grouped operations.

#### **A. Punctual operations**

The punctual operations transform an input image  $I$ , in a new output image  $I'$  modifying a pixel at the same time without take in account the neighbours pixels value, applying a function  $f$  to each one of the pixels of the image, so that:

$$I' = f(I)$$

The  $f$  functions most commonly used are, the identity, the negative, the threshold or binarization and the combinations of these. For all operations the pixels  $q$  of the new image  $I'$  depends of value of pixels  $p$  at the original  $I$  images.

#### **The identity function**

This is the most basic function and generates an output image that is a copy of the input image, this function this defined as:

$$q = p$$

#### **The negative function**

This function creates a new image that is the inverse of the input image, like the negative of a photo, this function is useful with images generates by absorption of radiation, that is the case of medical image processing. For a gray scale image with values from 0 to 255, this function is defined as:

$$q = 255 - p$$

#### **The threshold function**

This function generates a binary output image from a gray scale input image; the transition

level is given by the threshold value  $t$ , this function is defined as:

$$q=0 \text{ if } p \leq t$$

$$q = 255 \text{ if } p > t$$

## **B. Grouped operations**

The grouped operations correspond to operations that take in consideration a group of points. In the punctual operations, a pixel  $q$  of the output image, depends only of a pixel  $p$  of the input image, however in grouped operations, the result of each pixel  $q$  in the image  $I'$  depends on a group of values in the image  $I$ , usually given by a neighborhood. So, if an 8-neighbourhood is considered, a weighted sum must be done with the 8 neighbors of the corresponding pixel  $p$  and the result will be assigned to the pixel  $q$ . To define the values of weight, different masks or kernels are generally used with constant values; the values of these masks determine the final result of the output image.

### **2.2.6 Pattern Recognition**

Pattern recognition is a common technique that can be applied for the detection and recognition of objects. The idea is really simple and consists into find an image according a template image. The algorithm not only searches the exact apparition of the image but also finds a certain grade of variation respect to the pattern.

In the literature are found different projects using the template matching technique to solve different problems. Goshtasby presented an invariant template matching using normalized invariant moments, the technique is based on the idea of two-stage template matching [7]. Denning studied a model for a real-time intrusion-detection expert system capable of detecting break-ins, penetrations, and other forms of computer [13]. Seong-Min presents a paper about the development of vision based automatic inspection system of welded nuts on support hinge used to support the trunk lid of a car[2]. Izk introduces an application in image analysis of biomedical images using matching template [3].

## **2.3 Some robotics terminology**

### **2.3.1 Mobile Robot**

Mobile robotics is a relatively new research area that deals with the control of autonomous and semi autonomous vehicles. Mobile robots have the capability to move around in their environment and are not fixed to one physical location. An example of a mobile robot that is in common use today is the automated guided vehicle or automatic guided vehicle (AGV). An AGV is a mobile robot that follows markers or wires in the floor, or uses vision or lasers. AGVs are discussed later in this article.

Mobile robots are also found in industry, military and security environments. They also appear as consumer products, for entertainment or to perform certain tasks like vacuum cleaning. Mobile robots are the focus of a great deal of current research and almost every major university has one or more labs that focus on mobile robot research.

Mobile robots are usually used in tightly controlled environments such as on assembly lines because they have difficulty responding to unexpected interference. Because of this most humans rarely encounter robots. However domestic robots for cleaning and maintenance are increasingly common in and around homes in developed countries. Robots can also be found in military applications.

### **2.3.2 Autonomous Robot**

Autonomous robots can act on their own, independent of any controller. The basic idea is to program the robot to respond a certain way to outside stimuli. They can perform with a high degree of autonomy, which is particularly desirable in fields such as space exploration, cleaning floors, mowing lawns, and waste water treatment.

Some modern factory robots are "autonomous" within the strict confines of their direct environment. It may not be that every degree of freedom exists in their surrounding environment, but the factory robot's workplace is challenging and can often contain chaotic, unpredicted variables. The exact orientation and position of the next object of work and (in the more advanced factories) even the type of object and the required task must be determined. This can vary unpredictable (at least from the robot's point of view).

Simpler mobile robots use **infrared or ultrasound sensors** to see obstacles. These sensors work the same way as animal echolocation: The robot sends out a sound signal or a beam of infrared light and detects the signal's reflection. The robot locates the distance to obstacles based on how long it takes the signal to bounce back.

More advanced robots use **stereo vision** to see the world around them. Two cameras give these robots depth perception, and image-recognition software gives them the ability to locate and classify various objects. Robots might also use microphones and smell sensors to analyze the world around them[4].

Meanwhile, an autonomous robot in the real world must have the ability to:

- Gain information about the environment.
- Work for months or years without human intervention.
- Travel from point A to point B, without human navigation assistance.
- Avoid situations that are harmful to people, property or itself
- Repair itself without outside assistance

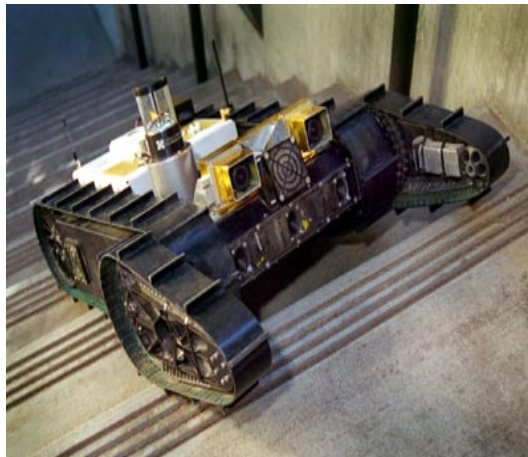


Figure 2.4: The autonomous Urbie is designed for various urban operations, including military reconnaissance and rescue operations. Photo courtesy NASA

### 2.3.3 Navigation by Vision

Though a significant percentage of robots in commission today are either human controlled, or operate in a static environment, there is an increasing interest in robots that can operate

autonomously in a dynamic environment.

A vision system perceives the light of the environment using a two-dimensional field of receptors. Although higher resolutions are possible (photo cameras that can yield about 10 million pixels already exist), the primary restriction is the data bandwidth that is necessary to transfer video information at 25 to 30 Hertz for real-time vision.

Such information is valuable for recognizing objects, understanding situations and controlling dynamic processes in real-time. When a human drives a vehicle, he mostly relies on his eyes. He uses his sense of vision not only for finding the path on which to drive and for estimating its condition, but also for detecting and classifying external objects such as other vehicles and obstacles, and for estimating their state of motion. Entire situations may thus be recognized, and expectations as to their further development in the near future may be formed.

In the late 1970s the idea of motion recognition and vehicle control by computer vision emerged in the context of planetary rover vehicles [5]. Typically, the required computers needed a quarter of an hour for image analysis. The vehicles moved a little and had to wait, standing still as long as the image was analyzed. Each image was interpreted from scratch. At that time, a different approach was taken by Dickmanns, coming from the field of control engineering. His approach emphasized the importance of a high image frequency (larger than 10Hz) to exploit temporal and visual continuity in the scene. Modeling the change in camera location would allow prediction of the feature positions in the images and search space would be reduced drastically. Extending the well-established methods of the 1960s for recursive estimation of incomplete measurement data, he put forth the "4-D approach", the full state reconstruction in 3-D space and time, which was finally widely accepted in the community dealing with autonomous vehicles[6].

#### **2.3.4 Driving Mechanism (Differential Drive)**

The differential drive method describes how a robot will move. This driving mechanism is very common among hobbyists because it requires only two wheels, and the control algorithm is very simple. The turning speed of the robot is determined by the difference in speed of the two motors.

- If both motor rotate in a same direction at equal speeds the robot will move forwards or backwards based on the rotation of the wheel.
- If the speed of one motor is faster than the other, the robot will turn in the direction of the slower motor.
- If both motors rotate in opposite directions, the robot will spin in its place.

Table 2.3: Operation table for robot movement

A	B	C	Function
1	0	1	Forward
1	1	0	Right(Clockwise)
0	1	1	Left(Anti-Clockwise)
0	0	0	Error
1	1	1	No Line Detected
0	1	0	White Track

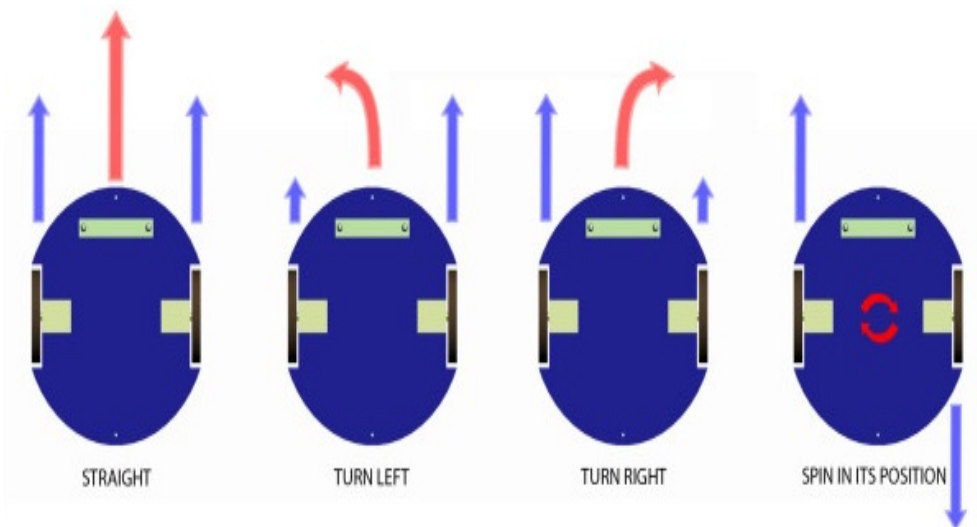


Figure 2.5: Differential drive method

# CHAPTER 3

## TECHNOLOGY USED

### 3.1 Software Technologies

#### LabVIEW

LabVIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment . LabVIEW is a system design platform and development environment for a visual programming language.It includes IMAQ Vision, a library of powerful functions for vision processing, and Vision Assistant, an interactive environment for developers who need to prototype LabVIEW applications quickly without programming, or who need off-line inspection. It is used for recognition of direction for the robot.

#### Why using LabVIEW?

##### 1. Software Benefits:

LabVIEW provides the flexibility of a powerful programming language without the complexity of traditional development environments[16].

- Easy to Learn and Use
- Complete Functionality
- Integrated I/O Capabilities

##### 2. Instructor Benefits:

- Exploration of Concepts
- Improved Learning Experience



- Seamless Integration with Hardware to Design Experiments

### 3. Student Benefits:

- Accelerated Learning
- Industry Standard

## 3.2 Hardware Technologies

The Arduino board is a microcontroller board, which is a small circuit (the board) that contains a whole computer on a small chip (the microcontroller).

### 3.2.1 Microcontroller: Arduino

The Arduino Uno is a microcontroller board based on the ATmega328. It is inexpensive, cross-platform (Arduino software runs on Windows, Linux) and easy to program. Consisting of a simple hardware platform and a free source code editor with an easy one-click compile/upload feature, it is designed to be really easy to use without being an expert programmer.

#### Why using Arduino?

There are many hardware prototyping platforms available but Arduino is a good choice as:

- Inexpensive - Arduino boards are relatively inexpensive compared to other microcontroller platforms. The least expensive version of the Arduino module can be assembled by hand, and even the pre-assembled Arduino modules cost less than \$50
- Cross-platform - The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows.
- Simple, clear programming environment - The Arduino programming environment is easy-to-use for beginners, yet flexible enough for advanced users to take advantage of

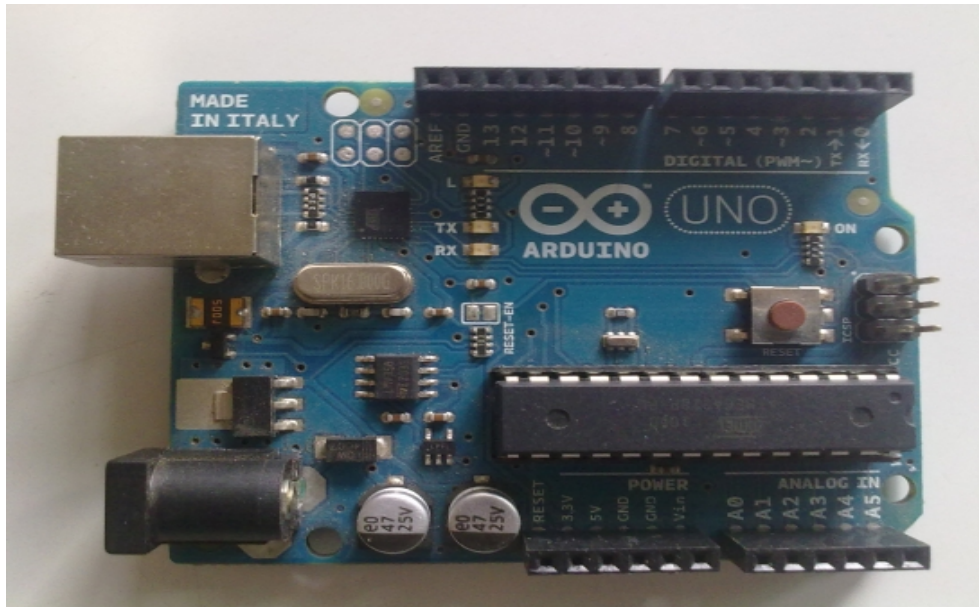


Figure 3.1: Arduino Uno

as well. For teachers, it's conveniently based on the Processing programming environment, so students learning to program in that environment will be familiar with the look and feel of Arduino.

- Open source and extensible software- The Arduino software is published as open source tools, available for extension by experienced programmers. The language can be expanded through C++ libraries, and people wanting to understand the technical details can make the leap from Arduino to the AVR C programming language on which it's based. Similarly, you can add AVR-C code directly into your Arduino programs if you want to.
- Open source and extensible hardware - The Arduino is based on Atmel's ATMEGA8 and ATMEGA168 microcontrollers. The plans for the modules are published under a Creative Commons license, so experienced circuit designers can make their own version of the module, extending it and improving it. Even relatively inexperienced users can build the breadboard version of the module in order to understand how it works and save money.

### 3.2.2 Arduino Shields

Arduino boards functionalities can be extended by using shields. There are shields for Motor controlling and Ethernet communication. The idea is that using a shield is possible to add a specific feature to Arduino without the hassle of developing an ad hoc circuit or PCB trying to implement such feature.

#### Arduino Ethernet Shields

The Arduino Ethernet Shield enables the Arduino to send and receive data from anywhere in the world with an internet connection. In three steps can be built a powerful communication system by plugging the Ethernet module into the Arduino board, create network connections, and building the application for data transfer. In this case, we make an overview of Ethernet shields Arduino compatible with different features including here standard shield, WiFi module already integrated in the shield or a combo pack with an Arduino board and Ethernet shield.

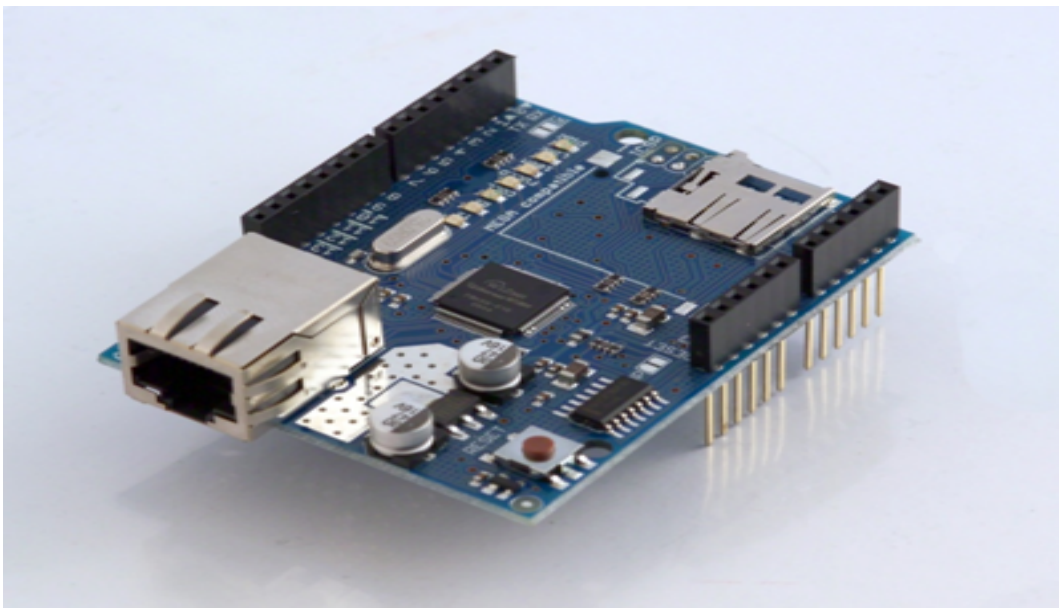


Figure 3.2: Ethernet shield

### 3.2.3 Router: wireless 150n access point

A router is a device that forwards data packets between computer networks, creating an overlay internetwork. A router is connected to two or more data lines from different networks. When a data packet comes in one of the lines, the router reads the address



Figure 3.3: wireless 150n access point

information in the packet to determine its ultimate destination. Then, using information in its routing table or routing policy, it directs the packet to the next network on its journey. Routers perform the "traffic directing" functions on the Internet. A data packet is typically forwarded from one router to another through the networks that constitute the internetwork until it reaches its destination node. Using TCP/IP which provides end-to-end connectivity specifying how data should be formatted, addressed, transmitted, routed and received at the destination. This functionality has been organized into four abstraction layers which are used to sort all related protocols according to the scope of networking involved. From lowest to highest, the layers are the link layer, containing communication technologies for a single network segment (link), the internet layer, connecting independent networks, thus establishing internetworking, the transport layer handling process-to-process communication, and the application layer, which interfaces to the user and provides support services.

### 3.2.4 Motor

**DC Motor** The direct current (DC) motor is one of the first machines devised to convert electrical power into mechanical power. Permanent magnet (PM) direct current converts electrical energy into mechanical energy through the interaction of two magnetic fields. One field is produced by a permanent magnet assembly; the other field is produced by an electrical current flowing in the motor windings. These two fields re-

sult in a torque which rotates the rotor. As the rotor turns, the current in the windings is commutated to produce a continuous torque output. The stationary electromagnetic field of the motor can also be wire-wound like the armature (called a wound-field motor) or can be made up of permanent magnets (called a permanent magnet motor)The speed of a DC motor can be controlled by changing the field current [15].

Some of the advantages are:

- i. Easy to understand design
- ii. Easy to control speed
- iii. Easy to control torque
- iv. Simple, cheap drive design

Some of the disadvantages are:

- i. Can't reliably control at lowest speeds
- ii. Physically larger
- iii. High maintenance

### **L293D: Motor Driver**

The L293D is a monolithic, integrated, high voltage, high current and has 4 channel drivers. It has four input pins two on each side of the PIC. All these four pins are connected to the digital pins of an Arduino and four output pins are connected to DC motors of the Robot. Enable pins are used to enable input/output pins on both the sides of PIC and Vcc is used for supplying external power to the DC motors. Both the motors on the same side of the robot move in the same direction at a time. So positive ends of both motors are put in output pin 1 of PIC and negative ends of same motors are put into output pin 2, same thing is done for other side of PIC too. Vcc pin is be used to provide external power supply to the DC motors. control for a range of speeds above and below the rated speeds. The speed of a DC motor can be controlled by changing the field current [14].Figure 3.5 shows L293D PIC.

### **Gear Motors**

Gear motors are complete motive force systems consisting of an electric motor and a reduction gear train integrated into one easy-to-mount and -configure package. This greatly reduces the complexity and cost of designing and constructing power tools,

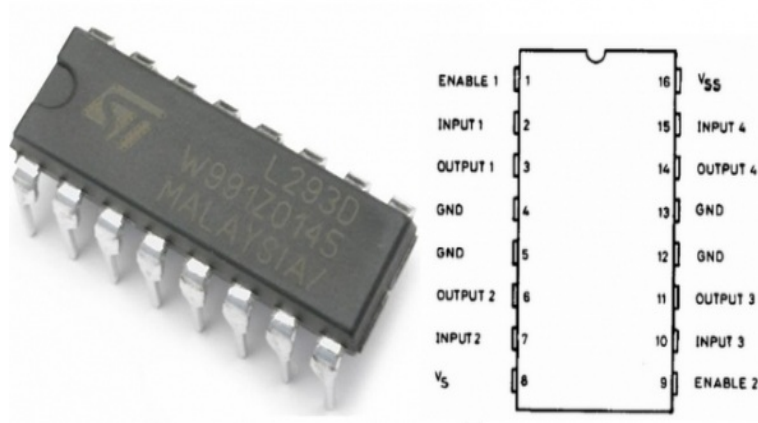


Figure 3.4: Motor Driver(L293D)

machines and appliances calling for high torque at relatively low shaft speed or RPM. Gear motors allow the use of economical low-horsepower motors to provide great motive force at low speed such as in lifts, winches, medical tables, jacks and robotics. The main component of a servomotor is a DC motor. Two servomotors were used in the model of the robot; they receive information for movement (forward, backward, left, right) through the controller board (Arduino Uno connected to the L293D).



Figure 3.5: Geared-Motor

### 3.2.5 Others

#### Chassis

A robot needs a chassis to attach all the electronics to. Most robots is made out of plastic or aluminum. We used aluminum for ours.

## 1 x Breadboard

Half sized breadboard is used for this robot.

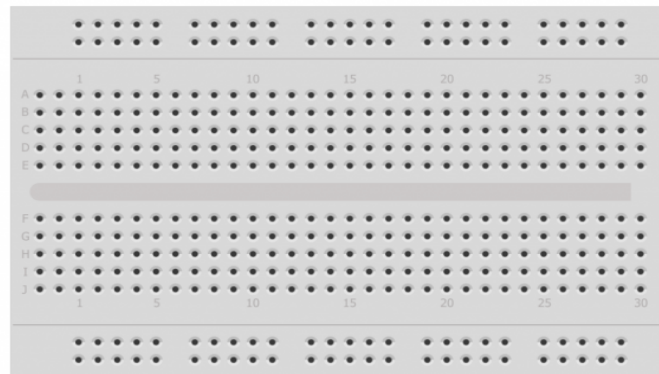


Figure 3.6: Breadboard

## Batteries

Arduino itself needs 9V(recommended).So it is better to use two different battery packs.1 x 9V PP3 battery for arduino and 4 AA batteries i.e. 6V for motors and servo.



Figure 3.7: 4 AA batteries i.e. 6V for motors and servo

## Wheels

Big wheels will let robot move faster. Small wheels for slower. But bigger wheels means robot has less torque to carry a heavy payload, and bigger wheels generally mean fine position control is harder too. Also, the sensors often cannot keep up with fast changes in position.

### **Gauge wires or male to male jumper wires**

For making connections on the breadboard you will need either gauge wire or male to male jumper wires.



Figure 3.8: Gauge wires or male to male jumper wires



# CHAPTER 4

## DESIGN OF THE SYSTEM

### 4.1 System Architecture

Figure 3.1 shows the architecture of the designed system and then it is described each of its components.

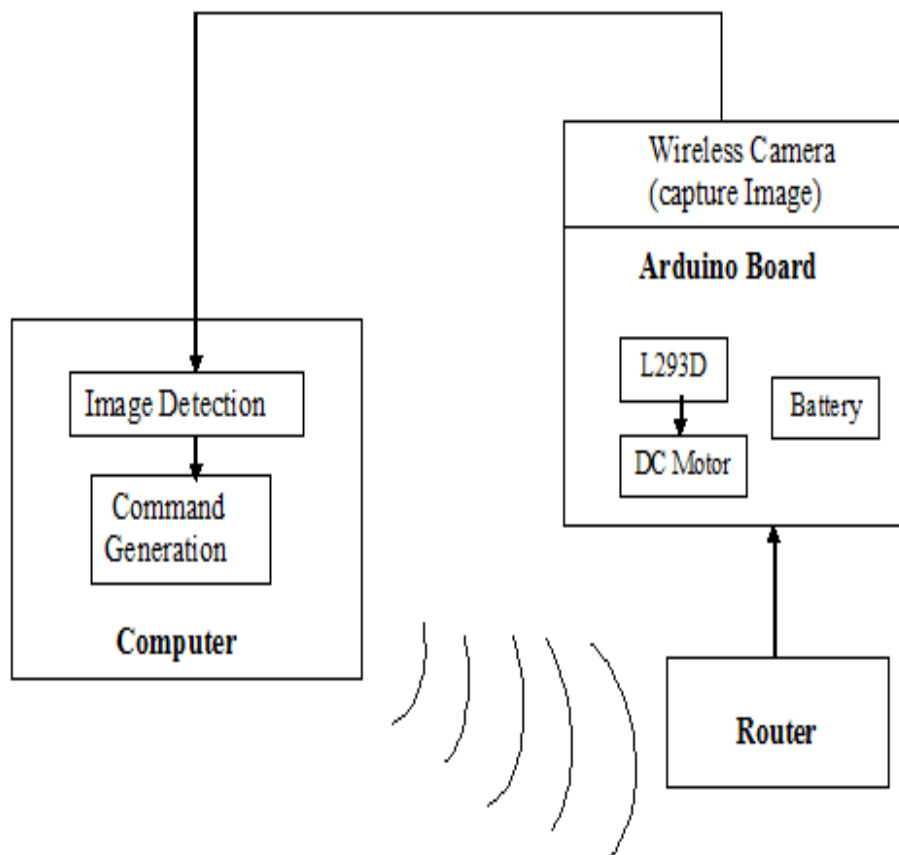


Figure 4.1: Basic flow of the System

## 4.2 System Design

Our design primarily focuses on symbol Recognition. Command is generated at the PC and sent to the robot through router within the routers range. The robot moves in the specified direction according to the specified command. The following section illustrates the steps carried out in the design.

### A. Image Acquisition

We acquire video from a camera using the NI Vision Acquisition Express. This block is located in Vision/Vision Express toolbox and it is the easiest way to configure all the characteristics in the camera. Inside this block there are four sections: the first one corresponds to the option of select acquisition source which shows all the cameras connected in the computer.

The next option is called select acquisition type which determines the mode to display the image and there are four modes: single acquisition with processing, continuous acquisition with inline processing, finite acquisition with inline processing, and finite acquisition with post processing. The third section corresponds to the configure acquisition settings which represents the size, brightness, contrast, gamma, saturation, etc. of the image and finally in the last option it is possible to select controls and indicators to control different parameters of the last section during the process.

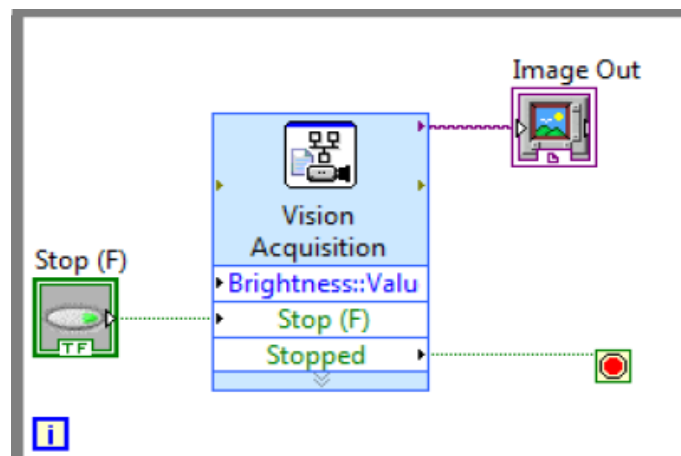


Figure 4.2: Video Acquisition using IMAQ Vision Acquisition Express.

### B. Acquiring digital image in gray scale format

We have to acquire a digital image in gray scale format using the IMAQ toolbox. In this case there are two important blocks: The first one is the IMAQ Create block

located in Vision and Motion/Vision Utilities/Image Management, this block creates a new image with a specified image type (RGB, Grayscale, HSL, etc.), the second block is the IMAQ Read Image which is located in Vision and Motion/Vision Utilities/Files/, the function of this block is to open an image file which is specified previously in the file path of the block and put all the information of this opened image in the new image created by IMAQ Create. It is very simple to modify the image type of the system to Grayscale (U8) and the image is placed in imageGray.

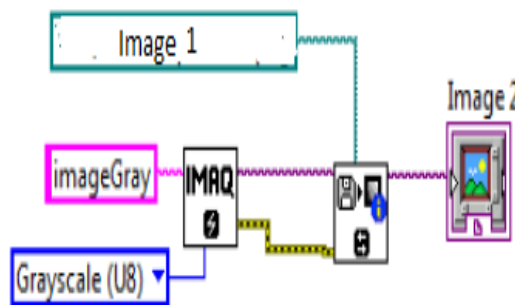


Figure 4.3: Grayscale image acquisition using IMAQ Vision Acquisition Express.

### C. Symbol Recognition

A continuous acquisition from the camera with inline processing was used; therefore there is a while loop inside the blocks of video acquisition and pattern recognition system. One important parameter is to transform the format of the image in the acquired video into intensity values. One of the methodologies to change RGB values to intensity values is through IMAQ extract single color plane located in vision utilities/color utilities/. Once the image has been converted into intensity, this image will be the input for the pattern recognition function.

The vision Assistant was used for the pattern recognition section. It carries out the pattern matching algorithm and identifies the desired object. Finally when the program is executed in real-time, each frame of the camera identifies the desired object.

### D. Generate Specific Signal

This is done using LabView library. To make robot move in forward, backward, right and left direction simple values are written as 1, 2, 3 and 4 respectively. For example, Forward command is represented as 1.

## E. Micro-Controller: Arduino Uno

Arduino gets command signal from the PC. Depending on this command, signal is sent to L293D motor driver through the digital pins of the Arduino. Four digital pins of the Arduino is set as input to the L293D PIC, two pins on both sides. It has four possible methods as forward(), backward(), right(), left(). Depending on the command signal, a particular method is called for every iteration. Each method is defined with a specified command to make each digital pin HIGH or LOW.

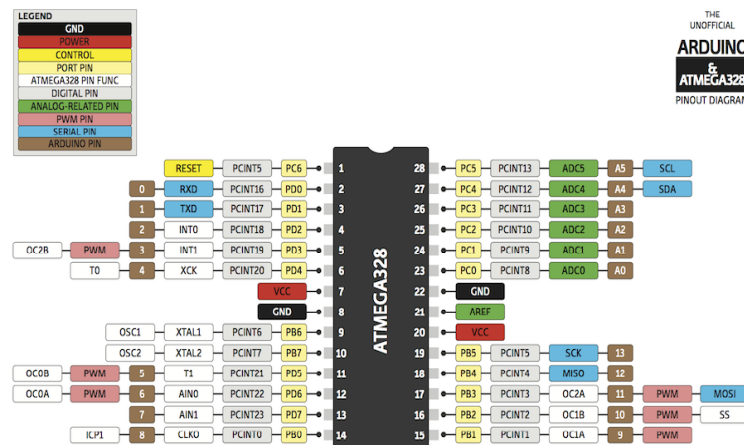


Figure 4.4: Pinout diagram of Aurdino ATMEGA328

## F. Wi-Fi

WiFly works on HTTP port 80 for provided library. WiFly on the robot connects itself with the Wi-Fi Hotspot. Then it continuously pings this web page on the PC.

## G. Motor Driver: L293D Circuit

It has four input pins two on each side of the PIC. All these four pins are connected to the digital pins of an Arduino and four output pins are connected to DC motors of the Robot. Enable pins are used to enable input/output pins on both the sides of PIC and Vcc is used for supplying external power to the DC motors. Both the motors on the same side of the robot move in the same direction at a time. So positive ends of both motors are put in output pin 1 of PIC and negative ends of same motors are put into output pin 2, same thing is done for other side of PIC too. Vcc pin is be used to provide external power supply to the DC motors.

## **H. DC Motors**

A DC motor is mechanically commutated electric motor powered from direct motor (DC). The stator is stationary in space by definition and therefore so is its current. The current in the rotor is switched by the commutator. DC motors better suited for equipment ranging from 12V DC systems in automobiles to conveyor motors, both which require fine speed control for a range of speeds above and below the rated speeds. The speed of a DC motor can be controlled by changing the field current [10].

# CHAPTER 5

## IMPLEMENTATION

### 5.1 LABVIEW Implementation

Lab view is a vast software used for many purposes in many field. How ever here we used the lab view softwares LABVIEW 2011 platform along with its LABVIEW 2011 REAL TIME MODULE and NI Vision Acquisition Software, NI Development Module 2011 and NI Vision Development Module Run Time 2011 for detecting the pattern by a camera and making the decision to which object or sign it matches and subsequently send the associated decision to the arduino module in response to direct the car to do the accordingly and previously specified operation.

If we use a high resolution camera then the image resolution would be good and the output of the lab views image detection module would be fine therefore: the car or the autonomous system can make a good decision in real time regarding the object or sign it just recognized.

The vision acquisition module captures the image via the specified camera, then according to the images you want to match or the object you want to match you set the minimum match score accordingly. Then using the vision assistant the details of the image matching or pattern recognition process is fixed via rotation angle, match offset, match mode etc. then when you run the project the camera captures the image or stream the video to get the required frame and show the output on screen like go left, go right and also send the associated signal to the autonomous system (here the car) to take appropriate decision.



Once connected the data cables, the robot was programmed. The movements performed were left, right, forward, backward, pause and exit, by making coincide the keys left, right, forward and backward respectively.

## **5.2 Working Procedure of The Robot**

### **5.2.1 Arduino UNO**

We begin with our basic setup() method, adding only our WiFly setup functions to it. We are using this WiFly library by jrcrouchley. We download it and put it in our Arduino IDEs libraries directory. Once that is done, we start it off. This code is mostly self-documenting, however the one area that confused us starting out was that we needed to open a Serial port in order to use the WiFly module. This is due to the wiring of the Wireless SD Shield it uses the Arduino RX/TX ports which are normally used for native Serial connections to instead communicate with the RN-XV (which is configured via commands sent over Serial). Because of this, we have to tell the WiFly library to explicitly use the native Serial object at 9600 baud.

The one possible issue to note is that we cannot use the Serial monitor or the Serial.print commands because the WiFly has taken over the usual port. With that sketch, we should be able to establish a WiFi connection and open a TCP socket to an arbitrary Node.js server. From there we can go ahead and add some code to our loop() to make the Arduino turn on its LED when it is connected to the Node.js server and to accept a TCP reply from the server.

In short, we implemented TCP/IP in arduino board which acts as a client. In arduino uno we gave power 9v. Using java we made computer as our host. Data is passed to Arduino uno. Those data determines in which way motor will rotate.

### **5.2.2 Ethernet shield**

We used the shield, mount it on top of an Arduino board (e.g. the Uno). To upload sketches to the board, we connected it to our computer with a USB cable as we normally would. Once the sketch has been uploaded, we disconnected the board from our computer and powered it with an external power supply.



Connecting the shield to our computer or a network hub or router using a standard ethernet cable (CAT5 or CAT6 with RJ45 connectors). Connecting to a computer may require the use of a cross-over cable (although many computers, including all recent Macs can do the cross-over internally).

### 5.2.3 Network Settings

The shield must be assigned a MAC address and a fixed IP address using the Ethernet.begin() function. A MAC address is a globally unique identifier for a particular device. Current Ethernet shields come with a sticker indicating the MAC address you should use with them. Valid IP addresses depend on the configuration of network. It is possible to use DHCP to dynamically assign an IP to the shield. DC gear motor using L293D with Arduino : First we made ground and Vcc connections on the breadboard from arduino. Before proceeding further we understand the pin diagram of L293D

#### Connections

Table 5.1: Circuit Connection

L293D	Arduino
Enable 1	5V
Input 1	Digital output pin.Pin no is upto you (We have used 3)
Output 1	motor wire 1
GND	Ground
Input 2	Digital output pin.Pin no is upto you(We have used 4)
Output 2	Motor wire 2
Vs	Power supply for motors
Vss	5V

The image above shows SN754410 H-bridge which is compatible with L293D and it is the pin to pin replacement. So that means we can use L293D in the circuit made using SN754410 and vice versa Now make connections for driving the motor as shown in below figure.

In this method we are using external power supply for the arduino board and the same

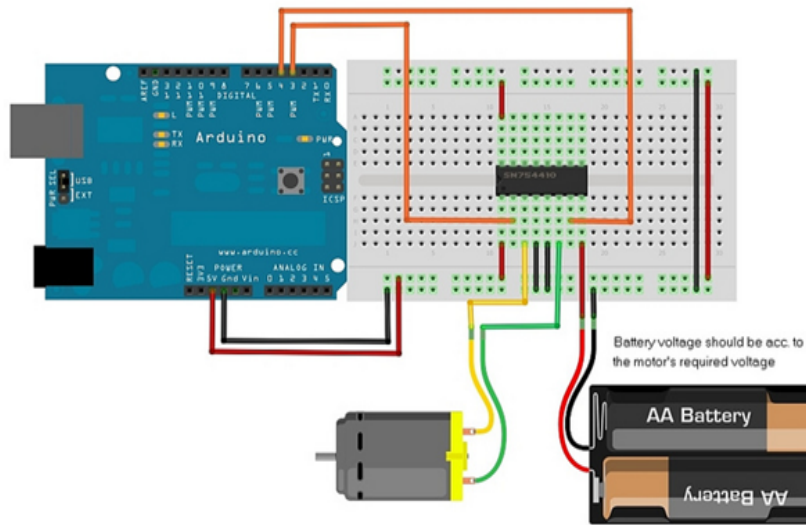


Figure 5.3: Circuit powering the motor with 9V

power supply is being used by the motors.i.e we are powering the motors from Vin on arduino.

This is the final end product of robot consisting of all the hardware WiFly, Arduino and L293D motor Driver circuit on the robot chassis having power supply provided by the rechargeable batteries.

Two DC motors are connected to this robot chassis as shown in Figure 5.3.

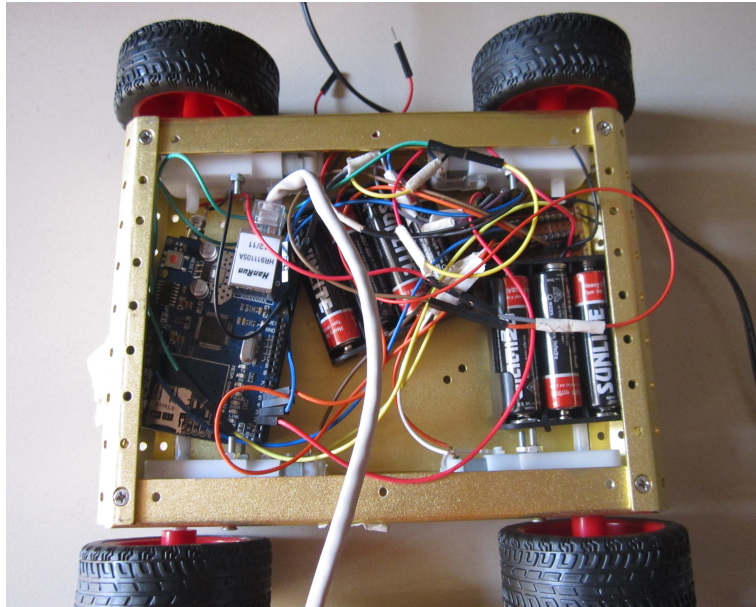


Figure 5.4: Internal circuitry of the Robot

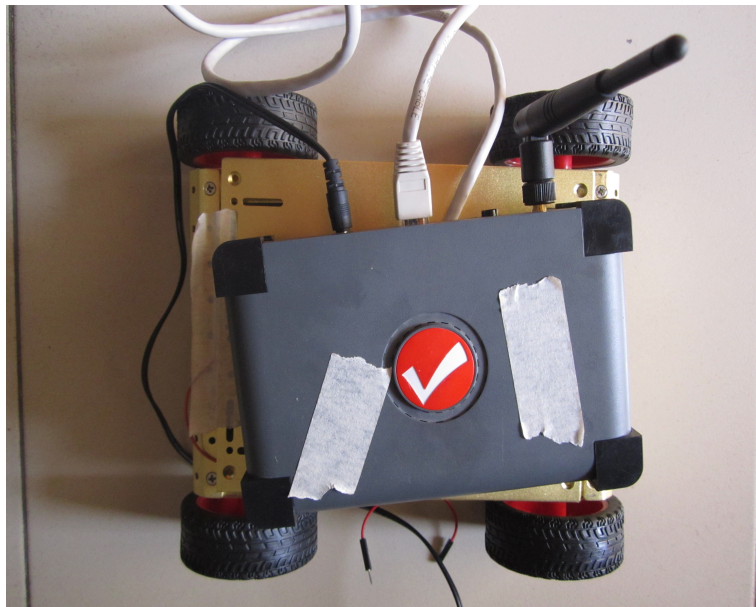


Figure 5.5: Final view of our designed Robot

# CHAPTER 6

## CONCLUSION

We have implemented a system that enables a mobile service robot to detect target and follow it correctly. This system has been implemented with different type of images. Firstly, the color images were captured by cameras. For matching purpose, the images were converted into grayscale since the images are easy to match with the system stored database images.

Images with better resolution could be used to get better estimates but for resource management we could not use the high definition camera which very perfectly captures images independent of the fact that how far the image is, how angular the image is and if it is perpendicular to the projection plane or not. We used to capture only the still pictures for the same reason, we hope our thesis work will be carried through further by making an entire autonomous car on industrial level in our country. It is possible to use four cameras and integrate them if somebody wants, for the integration of that system much more sophisticated hardware and software is need.

### **Future Expansion: phase one**

We have two plans in future:to make the robot fully autonomous with a processing system on board or in the control station which is currently under processing due to the resource management issue.

The Arduino board used in the car presently has no USB slots available for connecting to any sort of camera or video capturing device or any other type of slots available,and there is no Arduino board available which has this facility to connect any sort of camera.

But yes, there is Ardu-Cam available and IP cam available, we are currently working on the concept of connecting any one of this camera to the arduino for making the processing system not on board and in the central control station.

Then due to resource management issue,we cant use any of these two only available

options and we are currently working on it.

**Future Expansion: phase two**

What we are doing now, is connecting a robot in a wireless network with the help of on board situated wireless router with the Laptop or the control station.

We are working on making a web portal to control the robot from thousands of miles away while able to see its movement or observing the robots maneuver if it is autonomous from that portal.

In a word we are trying to get the robot on the internet controlling system via the pico net or without it Mean we are trying to setup a connection to the robot via an middle accesspoint or directly establishing the connection between the control station and the robots

## REFERENCES

- [1] “robotics”. Oxford Dictionaries. Retrieved February, 2011 .
- [2] Seong-Min, K., Young-Choon, L., Lee, S.-C. (18. October 2006). SICE-ICASE , 1508-1512.
- [3] Izak, P., Hrianka, M. (kein Datum). Biomedical Image Analysis by Program ”Vision Assistan” and “LabView”. Advances in Electrical and Electronic Engineering , 233-236, 2001.
- [4] <http://www.howstuffworks.com/robot4.htm>, 15/11/2013.
- [5] A. M. Thompson. “The navigation system of the jpl robot”. In *Proc. IJCAI* , pp 749-757, 1977.
- [6] M. Bertozzi, A. Conti, and A. Fascioli. Obstacle and lane detection on ARGO. In *Proc. IEEE - Conference on Intelligent Transportation Systems*, Boston, 1997.
- [7] Goshtasby, A. (27. Enero ). Pattern Analysis and Machine Intelligence. *IEEE transactions on* , pp 338-344, 2009.
- [8] L. Zollei: “Place Recognition Using Colour Region Analysis”, Mount Holyoke College, 1999.
- [9] L. Roberts: “Machine perception of three-dimensional solids” “Optical and electrooptical information processing, Massachusetts, MIT Press, 1965.
- [10] A. Guzman: “Computer Recognition of three-dimensional objects in a visual scene”, Tech. Rep. MAC-TR-59, AI Laboratory, MIT, 1968.
- [11] B.K.P. Horn: “Obtaining Shape from Shading, The Psychology of Computer Vision”, McGraw Hill, 1970.
- [12] R. P.Gmez, Oscar Osvaldo Sandoval-Gonzlez, Albino Martnez Sibaja, Otniel Portillo-Rodrguez and Giner Alor-Hernndez: “Digital Image Processing Using LabView”, Instituto Tecnolgico de Orizaba, Departamento de Postgrado e Investigacin, Mxico, 1995.
- [13] Denning, D. (2006). Software Engineering. *IEEE Transaction on* , SE-13, pp 222-232. 2001.

- [14] L293D Motor Driver, <http://luckylarry.co.uk/arduino-projects/control-a-dc-motor-with-arduino-and-l293d-chip>, 22/05/2013
- [15] DC Motors, [http://www.globalspec.com/learnmore/motion\\_controls/motors/dc-motors](http://www.globalspec.com/learnmore/motion_controls/motors/dc-motors), 20/04/2013