M S RAMAIAH INSTITUTE OF TECHNOLOGY

(Autonomous Institute, Affiliated to VTU)

Project Report entitled

REMOTE CONTROLLED ROVER

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ABSTRACT

Security and surveillance systems are widely used in society today. Remote Controlled Rover is a mobile robot integrated with a camera module, attached to an extendable arm to capture live video. The captured live video is streamed through a Wi-Fi medium from the robot to the remote center, which is a laptop in this case. The live video stream fetched at the center is processed and employed for authorization in the restricted-zone. Various applications of such robot include night watch guard, security system, and surveillance and live video streaming.

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INTRODUCTION

Chapter 1
INDRODUCTION

In this technological era the world is changing dynamically with a call for modernization. In the technological field, this modernization can be called with “automation” appellation. The study of automation of mechanical and electrical devices is called robotics. Integration of artificial intelligence in a device to ease human labour is of major concern and is the reason for its advancement over the last decade. From a simple automated washing machine controlled by timers and interrupts to highly precise autopilot systems on air-crafts are all derivatives of robotics.

Surveillance is monitoring of activities, behaviour or other changing information usually of people for the purpose of influencing, directing, managing or protecting them. In other words, continuously scanning of the place is termed as surveillance. In this project the main objective of surveillance is for restricting the entrance of unknown or unauthorized person to the restricted-zone. Surveillance is employed for various purposes by different government organizations and individual to safeguard the materials of their interests. Now a day’s surveillance robot are highly deployed. Surveillance robot works similar to surveillance antennas where the prime function is to amass information of the region and send he collected data to the receiver or control centre.

Robotics is a branch of science that deals with artificial models imitating human behaviours. Robots can be any physical models in form of human beings or a part of their structure designed to perform a task or several integrated tasks. Robotics includes modelling, designing, structuring and programming of robots. Programming can be done using any computer programming languages such as C, C++, and python. However, python is widely used as it is simple and similar to C. In context of this project, robot term is replaced with rover which means space explorer. In simple words, rover indicates a vehicle that transports goods or information from one place to another place.

Automated systems used for surveillance and securities are called surveillance robots. Robots are deployed for surveillance for various benefits that are associated. Few of them are that they are most of the time error free and fool proof. The robots perceive the external world with the help of an important class of electronics components called sensors. Various types of sensors available cover almost all physical factors. Few of physical factors that are sensed

using sensors are motion, temperature, pressure, speed, and liquid. Motion sensors are used to sense motion of objects, temperature sensors sense temperature variations. Similarly, pressure and speed sensors are used to sense pressure applied and speed change respectively. Other sensors such as Infra-red sensors, ultrasound sensors are used to detect obstacles in the path of movement, which is of importance in case of autonomous robots. IR sensors use the variation intensity of the transmitted and received ray of light while ultrasound sensors use the strength of the echoes reflected by opaque objects, like bats.

The data has to be available to the Command centre, irrelevant of its source of origin. To access data or information at any corner of world, various wireless technologies have emerged and used widely. Data is sent from one time-period to another either through wired medium or wireless medium. However, the latter is more used comparatively. To access data through wireless medium various protocols can be designed. Besides, transmission and reception of data though wireless channel for automated systems can also be achieved with the help of readily available Wi-Fi modules such as GSM module, Bluetooth module, Raspberry or Zigbee.

Surveillance robots use this trans-reception capability anti transmit live data and allow the controller make decisions in response to the data. The robot and the controlling device are connected together by a Wi-Fi for limited range of operation. GSM modules are used for global coverage.

In this project, we are going to make a small prototype surveillance robot namely Rover. It has a shape of foldable arm mounted on a chassis and supported by two wheels for movement. Besides, the robot has the features of extendable arm and 3 degree freedom rotation. To facilitate wireless communication channel for connection with control centre, a Wi-Fi module is an intricate part of the robot. The controlling operations are performed at the remote centre which is basically, a personal computer of a laptop. The data sent by the robot Wi-Fi mode is accessed at remote control centre via web browser. Any web browser can be used for this operation except Google Chrome. To do that, the static IP address generated by Wi-Fi module is typed in web-browser where live video is displayed. The fetched data is feed to face detection algorithm followed by face recognition algorithm. Face recognition is employed to verify whether the person is authorized or unauthorized person in the restricted zone. If the person founds to be unauthorized, a signal will be issued to start the siren buzzer placed in the robot. This way the nearest authorized person is informed the presence of intruder. This surveillance system can be used in various applications gearing towards security and nature sightseeing. The robot designed is small and compact which is suitable to

meet the requirement of embedded era. In this era, there is significance of area, power and money. The robot is not bulky at all.

1.1. Objectives

- To design a surveillance robot
- Obtain live video at the Controlled Centre
- Sending alarm signal from Controlled Center to robot
- Process the frames fetched at controlled center

1.2. Literature Survey

Considering the last year "Final Year Project Exhibition" conducted in the college and participated by the year passing students of batch 2010-2014, one of the participants group had modeled a robot that scans the environment and sends the live data to the control center. The control centre is nothing but Google server that is the processing is done online. The robot had an inadequacy of moving forcing it to fix at a place and manual placing if required. Besides, online processing cannot be utilized in practical applications.

In this project we have attempted to overcome above mentioned inadequacies of the robot. In addition, the processing would be offline to ensure that data transmission can take place smoothly irrespective of geographical barriers.

With interest in robotics and information gained on type present trend as the one explained above, we planned to make a surveillance robot as our final year project. In order to get more knowledge about existing technologies in robotics field, we read a myriad number of papers having similar objectives and relevant to our topic.

1.2.1 Autonomous mobile platform for intelligent control of robot

The author puts forward an autonomous mobile platform for intelligent control of the robot. The main objective is to monitor continuously the presence of unauthorized people in a highly secure area and to detect presence of explosives.

To implement duplex communication from robot and PC controller and from PC controller to robot, two Zigbee wireless technology modules are used. The robot communicates to PC through GPS. The inbuilt camera is interfaced to the controller. The location of the robot is traced with camera and zigbee transceiver. An ARM7 microcontroller (LPC2148) is used as the controller which is programed using Keil software.

It works as follows: The robot uses ultrasonic sensor for detecting obstacles found in path. Mine sweeping sensor is used to detect the presence of mines in the surrounding area. After detecting the mine, the controller sends an alarm massage to the monitoring canter using zigbee communication.

1.2.2 The Exploration of Face Recognition Techniques

This paper explores the different techniques of face recognition. The methods examined are PCA, LDA, Independent Component Analysis, Elastic Bunch Graph Matching, 3-D Morphable Model, HMM (Hidden Markov Model) and Neural network. The author also states that various face recognition techniques have proposed each with some preconditions and most of them are not used in real time environment due to performance hindrance. The different hindrances to face recognition systems are pose, presence or absence of structural components, facial expressions, occlusions, facial orientation and facial scaling. Face recognition system is mainly used for two primary tasks namely, face identification and face verification. Face identification is one-to-one comparing process to check if the interest face is same as given face as reference. It is quite difficult process and requires lots of accuracy. Face verification whereas, is a one-to-many procedure where a face taken called test image is compared with a set of per-known images called training images. The face that resembles more with test image is outcome of the recognition system. The decision of matching face is made based on pixel-to-pixel distance measurement. Euclidean distance is the widely used distance for matching.

Generally there are two techniques in face recognition process- holistic technique and feature-based technique. In former method, the whole face is matched with the reference images called template while later method involves extraction of significant features and

using those features for further recognition process. A third method evolved is combination of above two called hybrid method. Briefing out the proposed methods: -

Principal Component Analysis: - PCA is dimensionality reduction technique which extracts principal components. The first principal components are linear combinations of highest variability components while nth principal components are linear combinations of maximum variability among features. This scheme is based on an approach where each face is decomposed in to small sets of significant features called “Eigenfaces”. These are nothing but principal components. Afterwards, eigenvectors are computed and later Euclidean distance and thresholding are used for recognition of faces. PCA is most simple algorithm while highly sensitive to variations.

Linear Discrimination Analysis: - LDA is well-known feature extraction and dimension reduction technique similar to PCA and attempts to draw differences among classes. There is minor difference in their operations. While PCA finds maximum variability among classes LDA computes maximum variability between two individuals.

Independent Component Analysis: - This technique is used to improve PCA algorithm The ICA implementation of face recognition relies on the info max algorithm and represents the input as a dimensional random vector. This random vector is then reduced using PCA, without losing the higher order statistics.

Elastic Bunch Graph Matching: - The EBGM algorithm identifies a person in a new image face by comparing it to other faces stored in a database. The algorithm extracts feature vectors (called Gabor jets) from interest points on the face and then matches those features to corresponding features from the other faces in the database. This technique makes possible to recognize faces up to 22 degrees.

3-D Morphable Model: - The approach is based on a morphable model of 3D faces that captures the class-specific properties of faces. These properties are learned automatically from a data set of 3D scans. The morphable model represents shapes and textures of faces as vectors in a high-dimensional face space, and involves a probability density function of natural faces within face space. The algorithm estimates all 3D scene parameters automatically, including head position and orientation, focal length of the camera, and illumination direction. This is achieved by a new initialization procedure that also increases robustness and reliability of the system considerably. The new initialization uses image coordinates of between six and eight feature points.

Hidden Markov Model (HMM): - Stochastic modeling of nonstationary vector time series based on HMM has been very successful for speech applications. Reference [28] applied this

method to human face recognition. Faces were intuitively divided into regions such as the eyes, nose, mouth, etc., which can be associated with the states of a hidden Markov model. Since HMMs require a one-dimensional observation sequence and images are two-dimensional, the images should be converted into either 1D temporal sequence or 1D spatial sequence.

Neural Network: - Neural networks algorithm is biologically inspired and based on the functionality of neurons. Here neural network is formed for each person in the database. This network usually consists of several layers of neurons. The first layer takes in a dimensionally reduced image from database. An output layer produces a numerical between 1 and -1. The hidden layers in between input and output layers provide a good balance of complexity and accuracy. It is a time consuming and therefore, not suitable for realtime application.

Overall this paper addresses various problems of face recognition along with certain requirements for reliable and efficient face recognition.

1.2.3 2D and 3D Face Recognition: A Survey

This paper presents a survey on existing face recognition techniques. There are five key factors that affect a face recognition system significantly, which are Illumination, Pose, expression, time delay and occlusion. The various existing algorithms are:

Linear/nonlinear projection methods: IN this method recognition is achieved at higher-dimensional space. For example: recognition by template matching where the computation is high if higher the dimension of the space. As the result, the feature dimension is huge. Therefore, such methods are computationally expensive.

To reduce the cost the several other dimensionality reduction techniques are employed such PCA (Principal component analysis), LDA (Linear Discriminant analysis), which is better alternative to the PCA. Overall, these methods are tedious and complex.

The Neural networks: A better nonlinear solution to the face recognition problem is given by neural networks. The basic idea is to consider a net with a neuron for every pixel in the image. It is widely used for pattern recognition and authentication. Neural classifiers provides better classification among the neighbourhood classes compared to other classifiers.

Gabor filters and wavelets: Gabor filters represents a powerful and an excellent tool both in face recognition and face identification due to their capability to capture important visual features, such as spatial localization, scale and orientation selectivity. Gabor filters are used to extract main features from face images. However, Gabor feature vector has large dimension resulting in it to be a computationally expensive technique.

Spectral transforms: Discrete Fourier transform (DFT), discrete wavelet transform (DWT) and discrete cosine transform (DCT) are widely used in spectral techniques for face recognition. These transforms servers feature extractor. DCT helps to eliminate redundant features during extraction thereby, making it an excellent feature extractor. DFT works as DCT except that is extracts imaginary components as well. DFT and DCT works only in frequency domain. DWT is a wavelet transform. It extracts both time and frequency domain information of an image.

1.2.4 Indoor Surveillance Security Robot with A Self-Propelled Patrolling Vehicle

The author proposes a self-patrolling vehicle which can move automatically to a wider range and record the monitored images by IPCAM within a predefined patrolling route.

The position of the vehicle is detected by the RFID reader which is shown on PC screen while the monitored images are transmitted to the server via WIFI system for face tracking and discriminating analysis. The vehicle path is also monitored by the Android smart-phone remote-control model. At the occurrence of some defined event, an inbuilt MSN module is used to notice users by sending messages to PC and smart phone. The modules used in by the author are:

- Wireless IPCAM video capture system
- Face detection system
- RFID position detection system
- Cell phone monitoring and control system

The hardware parts includes:

- Microntroller (DFRduino RoMeo 328)
- 14 sets of digital I/O interface
- 8 sets of emulating analog I/O interface
- 2 pairs of DC motor drives
- 6 input buttons in the Atmega168 based microcontroller

1.2.5 An Autonomous Mobile Robotic System for Surveillance of Indoor Environment

In this paper, the authors suggest an autonomous mobile robotic system for surveillance of Indoor Environment. The system is able to handle autonomously general-purpose tasks and complex surveillance issues simultaneously. An experimental test using multisensory

platform equipped with a monocular camera, a laser scanner and an RFID device, modelling the proposed system, proved successful surveillance scheme. Besides, the robot is able to address a number of basic problems related to environmental mapping, localization and automation navigation. Real world application of the proposed robot include surveillance of wide areas and buildings and monitoring of safety equipment.

The system has three layered architecture developed for surveillance system as shown in figure.

1.3. Functional Block Diagram

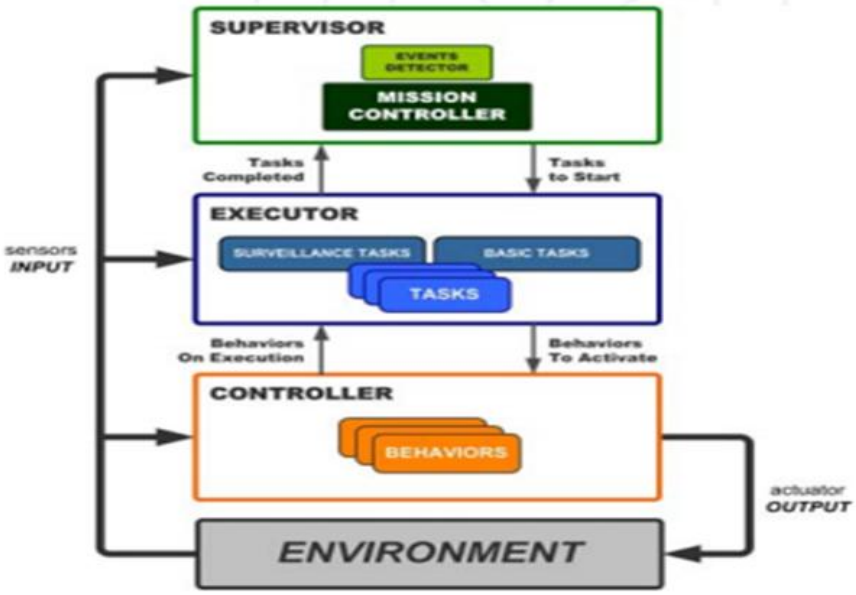

Figure 1.1: Block diagram illustrating system architecture

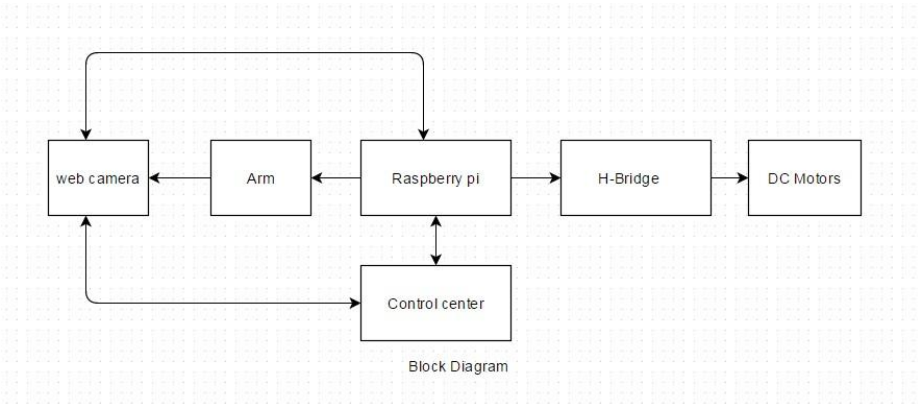

Figure 1.2: Block Diagram

1.4. How it works?

In this project, we are going to make a small prototype surveillance robot namely Rover. It has a shape of foldable arm mounted on a chassis and supported by two wheels for movement. Besides, the robot has the features of extendable arm and 3 degree freedom rotation. To facilitate wireless communication channel for connection with control centre, a Wi-Fi module is an intricate part of the robot. The controlling operations are performed at the remote centre which is basically, a personal computer of a laptop. The data sent by the robot Wi-Fi mode is accessed at remote control centre via web browser. Any web browser can be used for this operation except Google Chrome. To do that, the static IP address generated by Wi-Fi module is typed in web-browser where live video is displayed.

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The block diagram of the proposed system is as shown above. It consists of processing unit, controlling unit, and robot.

Processing Unit: - It is nothing but a laptop or a PC where data are analysed and processed. The data fetched through wireless medium from the robot to the remote centre is obtained via a web browser except Google Chrome. In web browser the data which is video in this case is displayed and snapshot of the image is taken. This snapshot image is used for face recognition. MTLAB is used platform in his project as it has several advantages and easy to learn for anyone. Besides, MATLAB provides a number of in-built functions that can be utilized to achieve the desired task. A collection of different toolboxes forms MATLAB as a whole. MATLAB is first choice for digital image processing and real time tools design for professionals.

Face Detection and Recognition

Object detection is a computer technology related to computer vision and image processing that deals with detecting instances of semantic objects of a certain class in digital images and videos. Well-researched domains of object detection includes face detection and pedestrian detection. Object detection has applications in many areas of computer vision, including image retrieval and video surveillance. Objects can even be recognized when they are partially obstructed from view. This task is still a challenge for computer vision systems. Many approaches to the task have been implemented over multiple decades. Face detection is a computer technology that identifies human faces in digital images. It detects human faces which might then be used for recognizing a particular face. This technology is being used in a variety of applications nowadays. Face detection also refers to the psychological process by which humans locate and attend to faces in a visual scene.

Figure 1.3: Block diagram of Recognition Process

A facial recognition system is a computer application for automatically identifying or verifying a person from a digital image or a video frame from a video source. One of the ways to do this is by comparing selected facial features from the image and a facial database. It is typically used in security systems and can be compared to other biometrics such as fingerprint or eye iris recognition systems. Various techniques and algorithms have been proposed till the date in this field. Few of them are Principal Component Analysis (PCA), Spectral transforms such as Discrete Fourier Transform (DFT), Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT), Gabor Wavelet Transforms etc. In spite of two decades research work carried out in this field, the digital systems get fooled easily with occlusions and complex environmental variations such as pose, illumination and background. Face recognition may also fail with lots of expression variations.

Any face recognition system consists two major modules namely, feature extractor and feature selector. Sometimes both these are combined to a single module termed as feature classifier. Feature extractor reduces number of features required to recognize a person. Similarly, feature selector further reduces feature counts by removing redundancy. The number of features used for recognition purpose is significant as the time taken for processing

of the features is vital for practical applications. The figure above shows a typical recognition system consisting face detector, face recognition, classifier and database modules. A database is collection of a number of images used for training a system prior to testing. Face detection is used to select only face portion of the images and remove most of the background portion. It can be taken as a type of pre-processing.

Pre-processing is preliminary stage of any recognition system. There can be a lots of variations among the images taken for training and testing due to various factors such as variation in camera acquisition timing, lighting conditions, background and so on. These all factors hinders the accuracy of recognition and forces the system to give false result. To minimizes such variations pre-processing plays a vital role in recognition system. It is applied to the input data before actual operations are carried out. Hence, named as pre-processing techniques. Techniques such as histogram equalization, Gaussian filtering, Noise removal, gamma intensity correction (GIC) and median filtering are few pre-processing techniques.

Various detection algorithms are readily available while, widely used algorithm is Viola-John algorithm. Till date there exist no recognition system with the recognition accuracy of 100 %.

A newly emerging trend, claimed to achieve improved accuracies, is three-dimensional face recognition. This technique uses 3D sensors to capture information about the shape of a face. This information is then used to identify distinctive features on the surface of a face, such as the contour of the eye sockets, nose, and chin.

One advantage of 3D facial recognition is that it is not affected by changes in lighting like other techniques. It can also identify a face from a range of viewing angles, including a profile view. Three-dimensional data points from a face vastly improve the precision of facial recognition. 3D research is enhanced by the development of sophisticated sensors that do a better job of capturing 3D face imagery. The sensors work by projecting structured light onto the face. Up to a dozen or more of these image sensors can be placed on the same CMOS chip—each sensor captures a different part of the spectrum.

Even a perfect 3D matching technique could be sensitive to expressions. For that goal a group at the Technion applied tools from metric geometry to treat expressions as isometries. A company called Vision Access created a firm solution for 3D facial recognition. The company was later acquired by the biometric access company bioscrypt Inc. which developed a version known as 3D Fast Pass. The accuracy of recognition system can be judged by various parameters such as recognition rate and success to failure ratio. In this project, we are using success to failure ratio as judging parameter.

HARDWARE

Chapter 2
HARDWARE

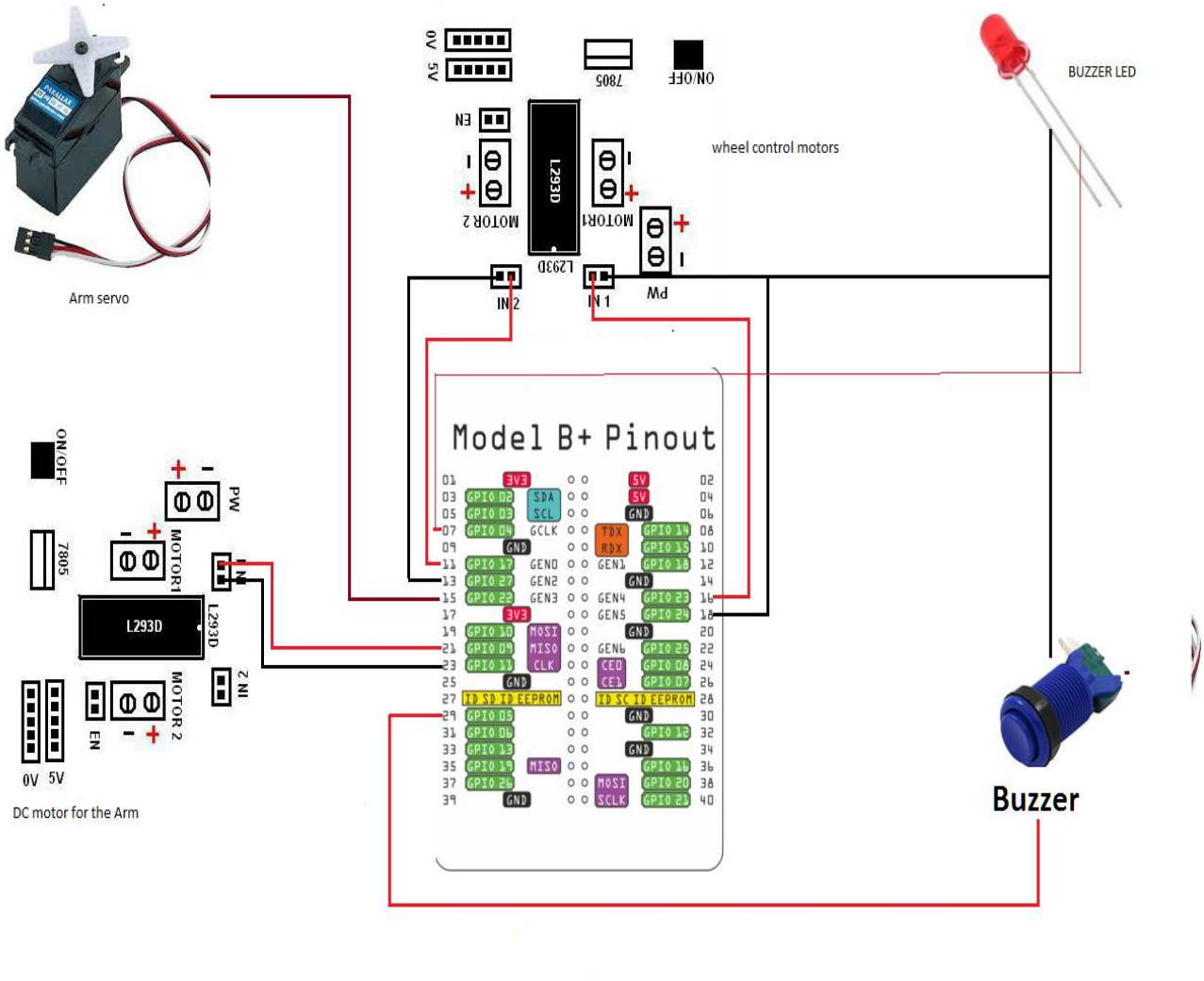


Figure 2.1: Connection Diagram

2.1 Raspberry Pi

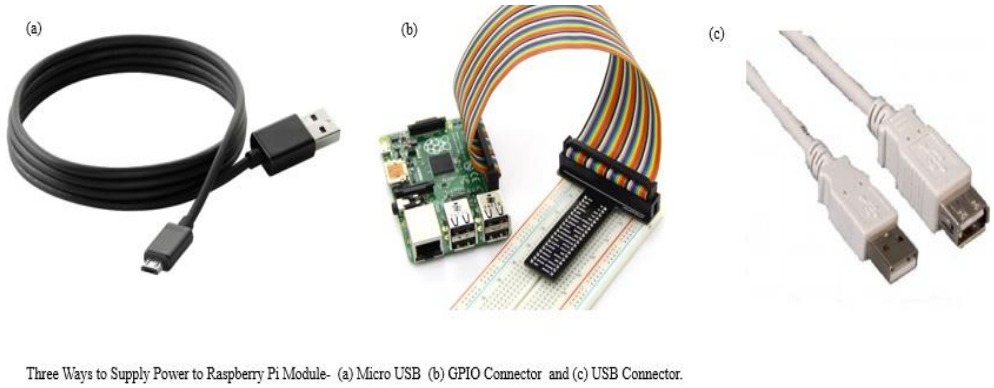
Raspberry Pi is a low-cost, basic computer that was originally intended to help spur interest in computing among school-aged children. The Raspberry Pi is contained on a single circuit board and features ports for:

Figure 2.2: Raspberry Pi

- 1 HDMI
- 4 USB 2.0
- Wi-Fi module
- Analog audio
- Power
- Ethernet
- SD Card

1. *CPU*: This 700Mhz central Processor with ARM V6 architechture, is also known as SoC, System on Chip as the single CHIP is the CPU, 512MB system RAM and GPU, Graphic Processor Unit
2. *Micro-USB power intake*: This powers the RPi. Consider a power supply unit that can supply at least 1AMP. Dedicated PSU can be purchased from RS Components or Farrell's but mobile phone chargers mat work well. An iPhone charger has an output of 1AMP and an iPad 2.5 AMP. Both seems to work well on RPi.
3. *HDMI***:** High definition Multimedia Interface: This can be the output to your TV or Monitor. If your monitor does not have HDMI input then you may be able to obtain and HDMI to VGA or HDMI to DVI connection. These almost certainly will be cheapest purchased online rather than high street stores. The price different can be quite large. Some monitors and TVs may have the composite video connection often used to connect gaming consoles to the TV

4. *10/100 RJ45 Ethernet*: For wired access to the network the 10/100 Ether-net connection exists. This is a single port that can work with 10Mbps or 100 Mbps connections.
5. *USB Ports*: Dual USB ports exist. This could be for a keyboard or mouse or connection through to a USB Hub. This would be a powered USB hub that then could drive external hard disks and the like.
6. *Status LEDS*: yes the pretty lights that flash when there is activity.
7. *Audio Jack*: If you are not using an HDMI to HDMI connection to your TV then audio can be used from this jack
8. *Composite Video*: The yellow connect can be used to plug into some TVs and Monitors.
9. *GPIO*: The General Purpose Input / Output interface that can be used for simple electronics projects.
10. *Wi-Fi*: The board is accompanied with a Wi-Fi module to enable wireless access or communication to or from the control centre. This can also be achieved by using an Ethernet cable for localised movement.
11. *Power*: Raspberry Pi can be powered three different ways namely Micro USB port, SPIO connector and USB device.



Three Ways to Supply Power to Raspberry Pi Module- (a) Micro USB (b) GPIO Connector and (c) USB Connector.

Figure 2.3: Power supply sources

2.2. Bidirectional Motor Control with L293D

Using L298N as the control chip, the module has such characteristics as strong driving ability, low calorific value and strong anti-interference ability. This module can use built-in 78M05 for electric work via a driving power supply part. But to avoid the damage of the voltage-stabilizing chip, we use an external 5V logic supply when using more than 12V

driving voltage. Using large capacity filter capacitor, this module can follow current to protect diodes, and improve the reliability.

The module used in this project has the capacity to drive upto 2 DC motors. The module enables multi drive, i.e., it allows both forward and backward motion of the bot. This is possible because of the switches that are interconnected in the form of a H.

The feature of L298N dual H-bridge are:

- Logical voltage: 5V
- Drive voltage: 5V - 35V
- Logical current: 0mA - 36mA
- Drive current: 2A(MAX single bridge)
- Storage temperature: -20°C to +135°C
- Max power: 25W
- Size: 43 x 43 x 27mm

Using DPDT Switch:

Each DC motor can be controlled by a switch that has three positions for forward, off and reverse. Switches of this type are called Double Pole Double Throw (DPDT) switches with centre-off position.

Connecting Up a DPDT Switch:

The circuit in figure shows how to connections DC motors to a DPDT switch. Connections A, B and C form one pole of the switch and connections D, E and F form the other. Connections B and E are the 'common' connections for their respective poles.

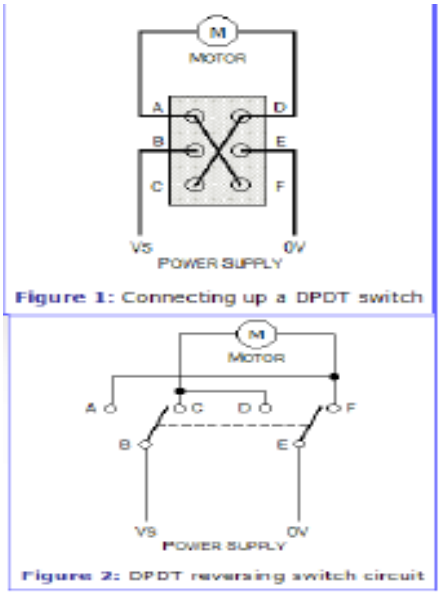


Figure 2.4: a)Connecting up a DPDT switch b) DPPDT reversing switch circuit

Working

If the positive power supply enters at connection B and the switch is Et to the topmost position, connection A becomes positive and the motor will turning one direction. If the switch is set to the lowermost position the power supply is revered and the connection D becomes positive. The motor will turn in the opposite direction. In the center position, the power supply is not connected to the motor and it does not turn. We can use a transistor is order to control the movement of a motor in a single direction. The pictures below depicts the use of a transistor for single direction control of motor.

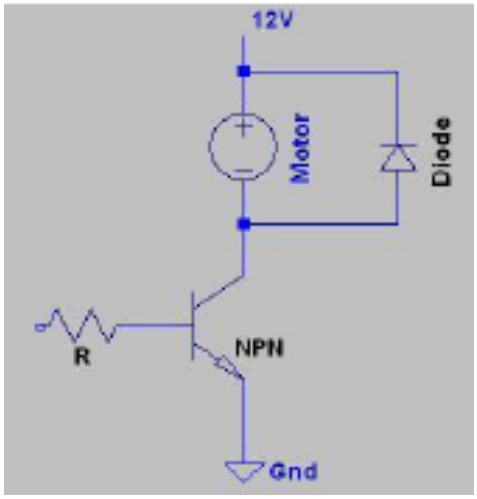


Figure 2.5: Single direction control of motor

Working with Switches

Now let us consider a case where in the motor can be controlled and made to run in either direction. If we consider four switches arranged as shown below, then the motor can be either directions to run forward and backward

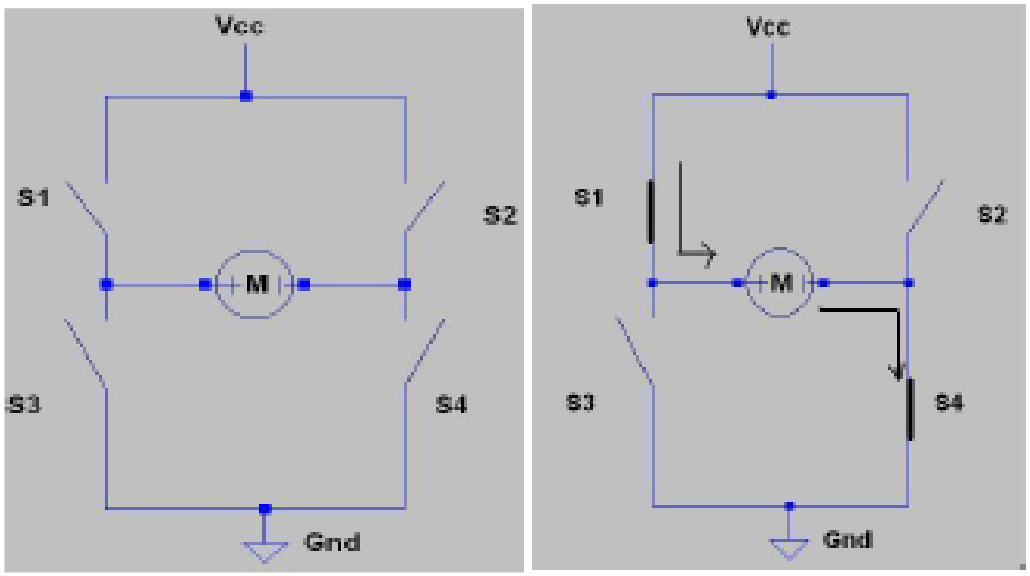


Figure 2.6: H-Bridge Working

Motor Forward Direction

If we choose switch S1 and S2 at one instance of time, both the ends of the motor sits at Vcc potential the motor does not run. If we close switch S3 and S4, both the ends of the motor sit at ground potential and here the motor does not run. Now consider if we are closing the switches S1 and S4, one end of the motor sit at the Vcc potential and the other end of the motor sit at the ground potential resulting in the motor to run in forward direction. From the picture below, the direction of current flow can be inferred. This makes the motor run in forward direction.

Motor Reverse Direction

Now consider if we are closing the switches S2 and S3, one end of the motor sit at the Vcc potential and the other end of the motor sit at the ground potential resulting in the motor to run in reverse direction. From the picture below, the direction of current flow can be inferred. This makes the motor runs in the reverse direction.

The chart below shown the conditions when the motor runs in forward, backward of when it stops.

Using H-Bridge

The electronics counterpart of a switch is a transistor. The most common way to electronically control DC motors is to use the H-Bridge network, as shown in figure below.

An H-bridge is an electronic circuit which enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forward and backward. H-bridges are available as integrated circuits, or can be built from discrete components.

Working with Transistors

A typical H-bridge comprises four transistors of which two are and the other two are NPN. As the arrangement of the transistor appears in the form of capital h, it I called as H-bridge. In the above, when the left PNP and right NPN transistors are ON and other two OFF, the motor moves in one direction. And, when the PNP and left NPN transistors are ON and the two are OFF, motor moves in the other direction. When the two PNP or NPN transistors are ON, the motor stops owing to dynamic braking. A running motor stops, there is a sudden drop in current in the induction coil of the motor resulting in a spike voltage voltage across. This high voltage is sufficient to damage the transistors. To avoid four fly-back diodes are used as shown in the figure below.

The transistors are switched ON/OFF selectively by using Drive L293D.

L293D Driver IC

L293D is a driver IC consisting of two channels. Each channel consists of two transistors, one PNP and one NPN, in which the collectors and bases of the two devices are connected. In this arrangement when a logic-level signal is applied to common base, one transistor will be in saturation while the other transistor will be in cut-off. The diagrammatic representation of L293D is as below.

L293D is a 16 pin DIP (dual in-line package) IC. Pin 1 and Pin 9 are enable pins, EN1 and EN2 respectively. The basic purpose of enable pins is to enable a particular channel. EN1 enables the first channel while EN2 enables the second channel. If both the channels are to be used simultaneously, then both the enables pins, EN1 and EN2 should be enabled by applying 5V power supply.

2.3. Webcam

We are using logic tech camera for live feedback video, with delay time of approximately 1 sec and varies with the distance between the transmitting and receiving unit and it has 1280 x 720 resolution. The basic requirements are:

- 512 MB RAM or more
- 200 MB hard drive space
- Internet connection
- USB 1.1 port (2.0 recommended)

Figure 2.7: Webcam

2.4. DC motor

A DC motor is any of a class of electrical machines that converts direct current electrical power into mechanical power. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor. Most types produce rotary motion; a linear motor directly produces force and motion in a straight line.

Figure 2.8: DC Motor

2.5. Servo Motor

A servomotor is a rotary actuator that allows for precise control of angular position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.

Figure 2.9: Servo Motor

SOFTWARE

Chapter 3
SOFTWARE

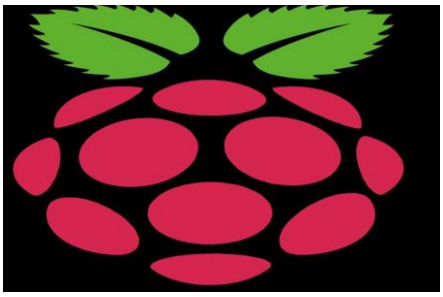
The software's to be used are listed below:

The data fetched and transmitted through wi-fi medium are tended to be processed to extract useful information. In this project, MATLAB, PUTTY are the application software used for signal analysis. The live feed from the raspberry pi is obtained by using a web browser.

3.1. Raspbian Wheezy

Raspbian Wheezy is a Raspberry Pi operating system which is installed on SD card. It is nothing but bootable image file. Installing wheezy involves only few steps. The components required for installation are a SD card (4GB or more), windows or Mac computers and raspbian image file.

3.2. MATLAB



Raspbian Wheezy Operating System

MATLAB is the high-level language and scientific and interactive environment used by millions of engineers and scientists worldwide. MATLAB is a programming language developed by Mathworks. It started out as a matrix programming language where linear algebra programming was simple. It can be run both under interactive sessions and as a batch job. All types of signals processing and analysis is done with easiness in MATLAB. Image processing- a specific signal processing field, is performed smoothly in MATLAB. Images are considered a 2-dimentional matrix. Therefore making MATLAB is predominately used choice for video and image processing. MATLAB is an integrated environment developed by combining a number of toolboxes. Each toolbox or a group of toolboxes are used for processing of data of real world. Image processing is a major component of any surveillance system. A surveillance system may consist of a face recognition and face detection system. MATLAB provides an excellent platform for both these components. It consists of an image

processing toolbox that provides many inbuilt functions and tons of parametric options that can be used to better adapt the functions to our use.

In this project, we use to toolboxes preferably. They are Image Processing toolbox and Computer vision toolbox. Image processing toolbox includes functions that are applied for image analysis while computer vision toolbox helps to represent data in form that can by analysed by digital machines – computers.

The face recognition code initially used a DCT based algorithm. It gave a 93 % recognition rate with standard benchmark databases. However, it could not be used for our application as it dint give desired results. Therefore, we changed the algorithm. Now, a PCA based face recognition algorithm is being used and efforts for application are going on.

Face detection using Voila-John detector

The Viola–Jones object detection framework is the first object detection framework to provide competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones. Although it can be trained to detect a variety of object classes, it was motivated primarily by the problem of face detection. This algorithm is implemented in OpenCV as cvHaarDetectObjects(). The basic problem to be solved is to implement an algorithm for detection of faces in an image. This can be solved easily by humans. However there is a stark contrast to how difficult it actually is to make a computer successfully solve this task. In order to ease the task Viola–Jones limit themselves to full view frontal upright faces. That is, in order to be detected the entire face must point towards the camera and it should not be tilted to any side. This may compromise the requirement for being unconstrained a little bit, but considering that the detection algorithm most often will be succeeded by a recognition algorithm these demands seem quite reasonable. Feature types and evaluation

The main characteristics of Viola–Jones algorithm which makes it a good detection algorithm are:

- *Robust* – very high detection rate (true-positive rate) & very low false-positive rate always.
- *Real time* – For practical applications at least 2 frames per second must be processed.
- *Face detection and not recognition* - The goal is to distinguish faces from non-faces (face detection is the first step in the identification process)

The algorithm has mainly 4 stages:

1. Haar Features Selection
2. Creating Integral Image
3. Adaboost Training algorithm
4. Cascaded Classifiers

The features employed by the detection framework universally involve the sums of image pixels within rectangular areas. As such, they bear some resemblance to Haar basis functions, which have been used previously in the realm of image-based object detection. However, since the features used by Viola and Jones all rely on more than one rectangular area, they are generally more complex. The figure at right illustrates the four different types of features used in the framework. The value of any given feature is always simply the sum of the pixels within clear rectangles subtracted from the sum of the pixels within shaded rectangles. As is to be expected, rectangular features of this sort are rather primitive when compared to alternatives such as steerable filters. Although they are sensitive to vertical and horizontal features, their feedback is considerably coarser.

1. Haar Features – All human faces share some similar properties. This knowledge is used to construct certain features known as Haar Features.

The properties that are similar for a human face are:

- The eyes region is darker than the upper-cheeks.
- The nose bridge region is brighter than the eyes.

That is useful domain knowledge:

- Location - Size: eyes & nose bridge region
- Value: darker / brighter

The four features applied in this algorithm are applied onto a face and shown on the left.

Rectangle features:

- Value = Σ (pixels in black area) - Σ (pixels in white area)
- Three types: two-, three-, four-rectangles, Viola & Jones used two-rectangle features
- For example: the difference in brightness between the white &black rectangles over a specific area

- Each feature is related to a special location in the sub-window

However, with the use of an image representation called the integral image, rectangular features can be evaluated in constant time, which gives them a considerable speed advantage over their more sophisticated relatives. Because each rectangular area in a feature is always adjacent to at least one other rectangle, it follows that any two-rectangle feature can be computed in six array references, any three-rectangle feature in eight, and any four-rectangle feature in just ten.

The integral image at location (x, y), is the sum of the pixels above and to the left of (x,y), inclusive.

Face recognition using Principal Component Analysis

Principal component analysis (PCA) is a statistical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated variables called principal components. The number of principal components is less than or equal to the number of original variables. This transformation is defined in such a way that the first principal component has the largest possible variance (that is, accounts for as much of the variability in the data as possible), and each succeeding component in turn has the highest variance possible under the constraint that it is orthogonal to (i.e., uncorrelated with) the preceding components. The principal components are orthogonal because they are the eigenvectors of the covariance matrix, which is symmetric. PCA is sensitive to the relative scaling of the original variables.

PCA was invented in 1901 by Karl Pearson, as an analogue of the principal axis theorem in mechanics; it was later independently developed (and named) by Harold Hotelling in the 1930s. The method is mostly used as a tool in exploratory data analysis and for making predictive models. PCA can be done by eigenvalue decomposition of a data covariance (or correlation) matrix or singular value decomposition of a data matrix, usually after mean centring (and normalizing or using Z-scores) the data matrix for each attribute. The results of a PCA are usually discussed in terms of component scores, sometimes called factor scores (the transformed variable values corresponding to a particular data point), and loadings (the weight by which each standardized original variable should be multiplied to get the component score).

PCA is the simplest of the true eigenvector-based multivariate analyses. Often, its operation can be thought of as revealing the internal structure of the data in a way that best explains the variance in the data. If a multivariate dataset is visualised as a set of coordinates in a high-dimensional data space (1 axis per variable), PCA can supply the user with a lower-dimensional picture, a projection or "shadow" of this object when viewed from its (in some sense; see below) most informative viewpoint. This is done by using only the first few principal components so that the dimensionality of the transformed data is reduced.

PCA is closely related to factor analysis. Factor analysis typically incorporates more domain specific assumptions about the underlying structure and solves eigenvectors of a slightly different matrix.

PCA is also related to canonical correlation analysis (CCA). CCA defines coordinate systems that optimally describe the cross-covariance between two datasets while PCA defines a new orthogonal coordinate system that optimally describes variance in a single dataset.

PCA can be thought of as fitting an *n*-dimensional ellipsoid to the data, where each axis of the ellipsoid represents a principal component. If some axis of the ellipse is small, then the variance along that axis is also small, and by omitting that axis and its corresponding principal component from our representation of the dataset, we lose only a commensurately small amount of information.

To find the axes of the ellipse, we must first subtract the mean of each variable from the dataset to center the data on the origin. Then, we compute the covariance matrix of the data, and calculate the eigenvalues and corresponding eigenvectors of this covariance matrix. Then, we must orthogonalize the set of eigenvectors, and normalize each to become unit vectors. Once this is done, each of the mutually orthogonal, unit eigenvectors can be interpreted as an axis of the ellipsoid fitted to the data. The proportion of the variance that each eigenvector represents can be calculated by dividing the eigenvalue corresponding to that eigenvector by the sum of all eigenvalues.

It is important to note that this procedure is sensitive to the scaling of the data, and that there is no consensus as to how to best scale the data to obtain optimal results.

3.3. Python IDE

Python is widely used general-purpose, high-level programming language. The language provides constructs intended to enable clear programs on both a small and large scale. Its design philosophy emphasizes code readability and its syntax allows programmers to express concepts in few lines of code that would be possible in languages such as C++ or Java. Python interpreters are available for installation on many operating systems, allowing Python code execution on a wide variety of systems. Python IDE provides an integrated environment for compilation and execution of python code.

3.4. Putty and Remote Desktop Connection

It is an additional software that is used in windows operating systems to connect to a server in this case raspberry pi. Putty is installed in windows machine to provide a command line environment required for Raspberry pi module configuration. Usually, Raspberry Pi modules are configured using Linux operating systems as they have inbuilt functionality to do so. In windows platforms, these functionalities are obtained using PUTTY software.

MECHANICAL STRUCTURE AND SPECIFICATION

Chapter 4
MECHANICAL STRUCTURE AND SPECIFICATION

4.1. Construction of the bot

The bot is a very concise, small, compact, yet including many hardware components. Integrating them on a small platform was a challenge. The bot is made up of 2 H-Bridges controlling 3 DC motors, a servo motor, a webcam, the raspberry pi module itself and finally, the arm. The construction of arm done with proper specifications. The first step is chassis mounting which includes attaching of wheels and H-bridge.

4.1.1 Construction of the Body Cover

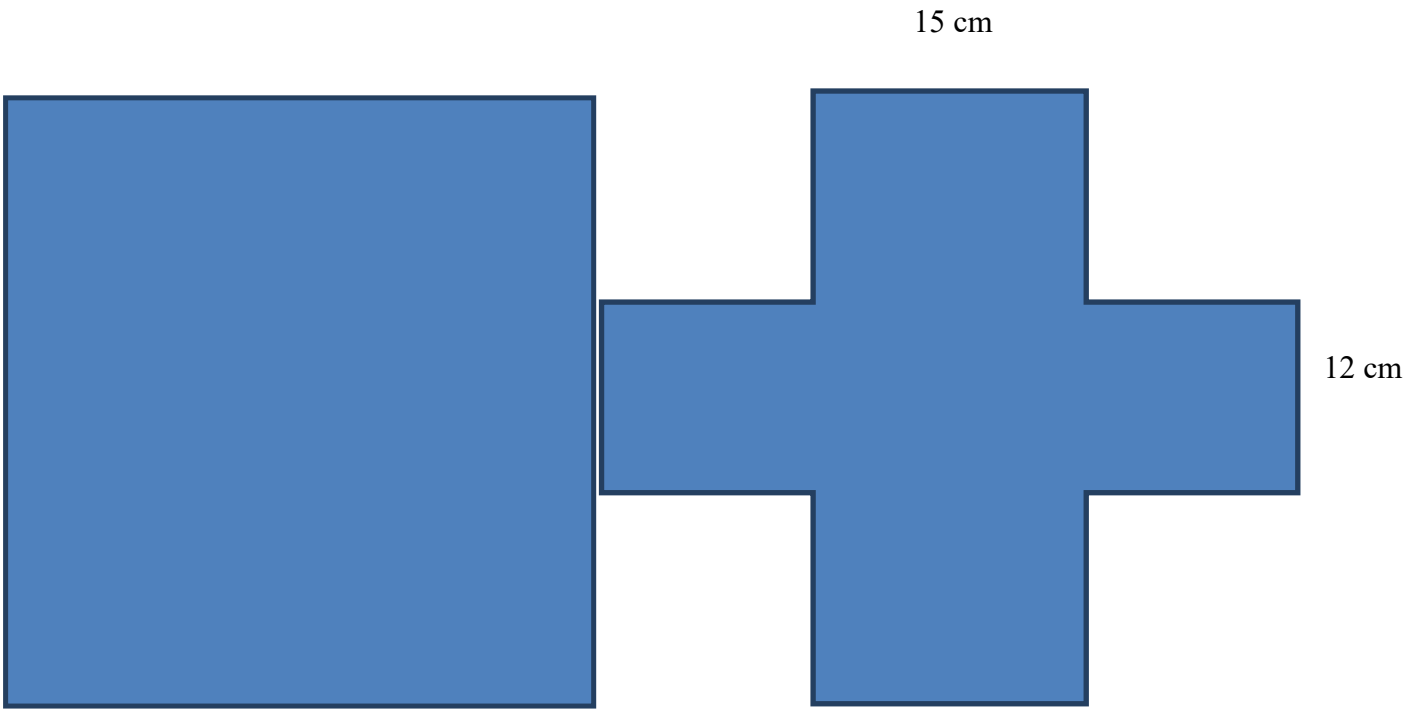
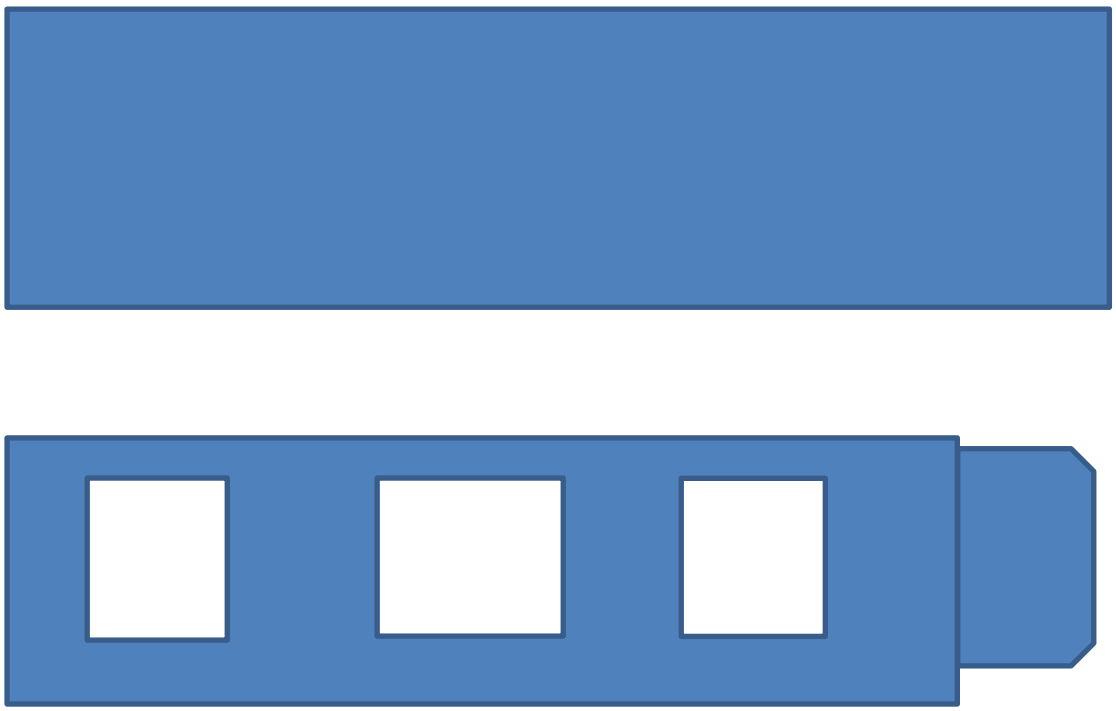


Figure 4.1: Construction of the body cover

4.1.2 Construction of the Arm



4.1.3 Construction of Camera Case

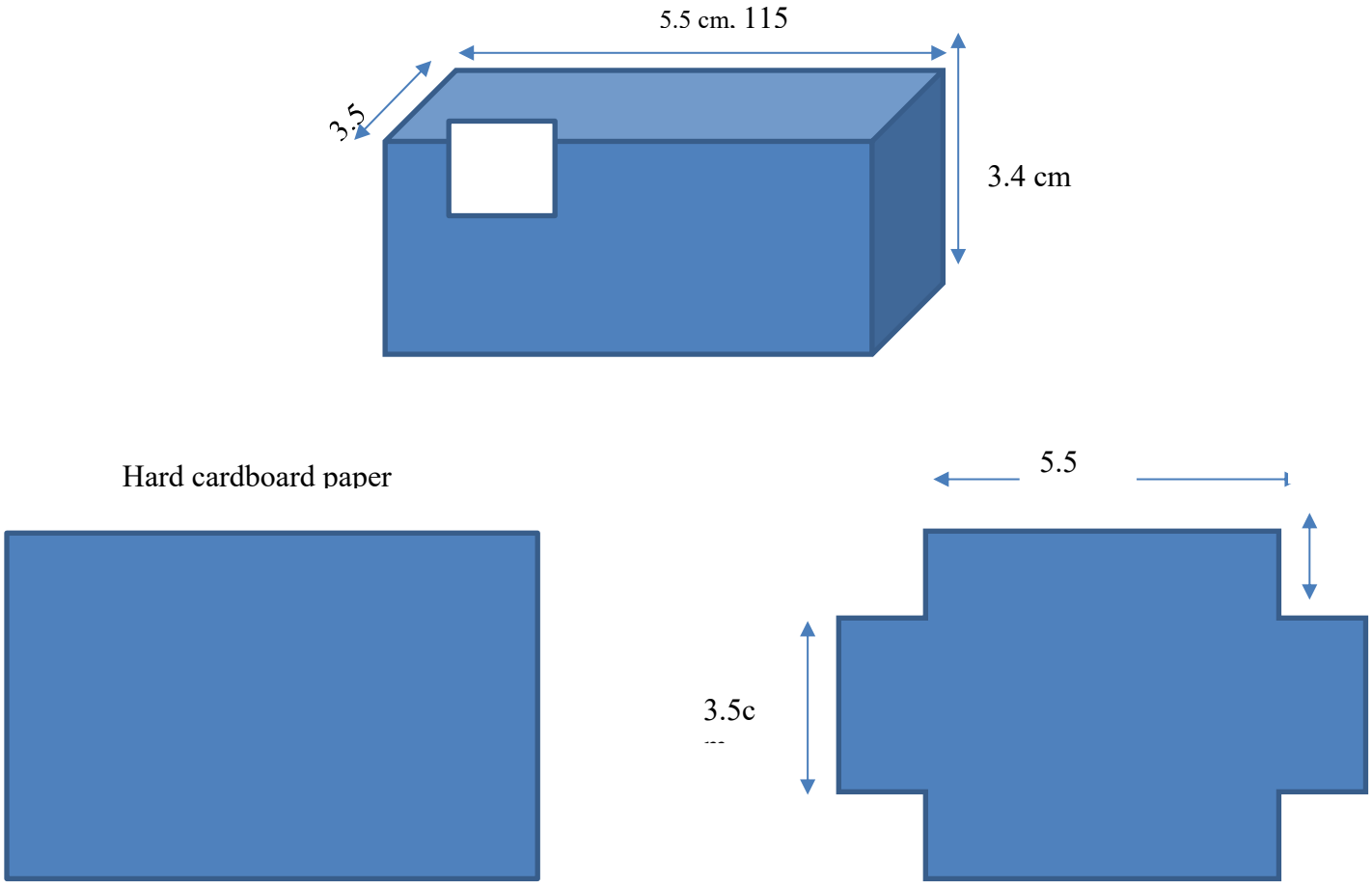


Figure 4.3: Construction of Camera case

4.2. Specifications

Sl. No	*Features*	*Dimension (cm)*
1.	*Diameter of the wheel*	*5.5*
2.	*Diameter of balance ball*	*1.2*
3.	*Length of the Chasis*	*15*
4.	*Breadth of the Chasis*	*12*
5.	*Height of the Rover*	*12.5*
6.	*Length of the Arm*	*18*
7.	*Max. Height of the Arm*	*21*
8.	*Min. Height of the Arm*	*9*
9.	*Speed of the Rover*	*7.5 cm/s*
10.	*Length of Camera Case*	*5.5*
11.	*Breadth of the Camera Case*	*3.5*
12.	*Height of the Camera Case*	*3.4*

Figure 4.4: Front view of the bot.

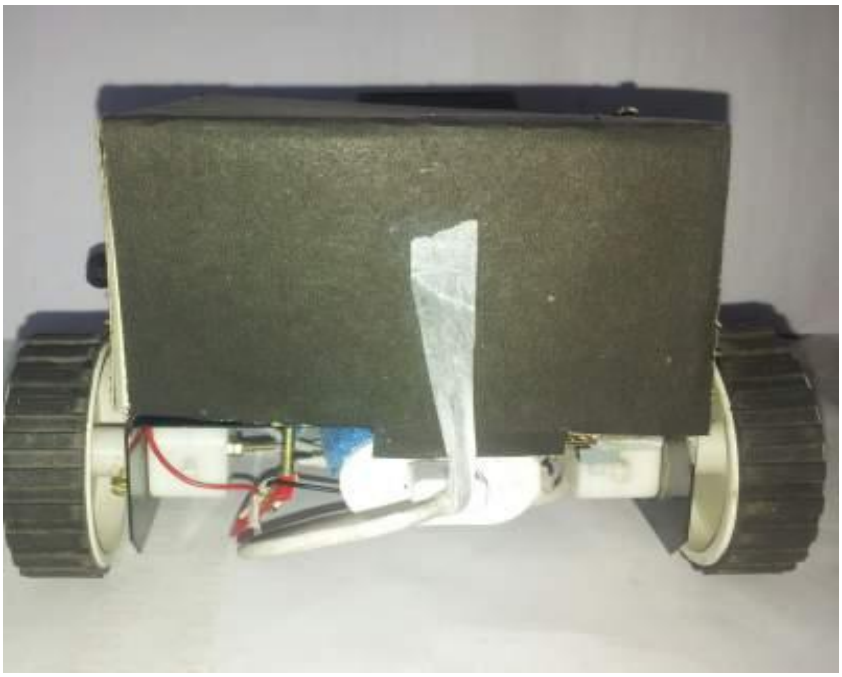


Figure 4.5: Back view of the bot.

Figure 4.6: Side View Of the bot.

Figure 4.7: Top view of the Bot

IMPLEMENTATION

Chapter 5

Implementation

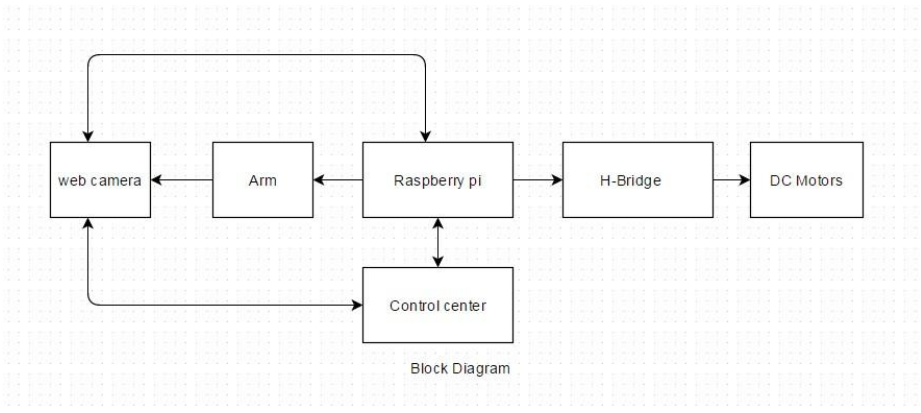


Figure 5.1: Block Diagram

5.1. Getting Started With Raspberry Pi

5.1.1 Configuring the raspberry pi

1. Download NOOBS from the raspberry pi website and extract it on the sd card on your laptop.
2. Now, insert the micro SD card on the raspberry pi.
3. Connect pi to the monitor using a HDMI cable.
4. Connect a usb mouse and keyboard to the pi's usb ports.
5. Plug in the Wi-Fi adapter to one of the pi's usb ports.
6. Plug in the power supply.
7. A start up screen should appear showing you a list of operating systems available for install chose Raspbian OS and install it.
8. It will 15-20 minutes for completion.
9. The raspberry pi must be configured for local time zone and set date time etc.
10. Type in your username and password when asked.
11. To go to the visual appearance of the OS type the command: startx

5.1.2 Setting up Wi-Fi

1. Connect the Wi-Fi adapter to the usb port of the raspberry pi.
2. Double click on Wi-Fi Config icon on the desktop.
3. Click on scan button and select the desired network.
4. In the connection window that appears, enter the network password and click on add button to connect to the network.

5.1.3 Setting up Static ip

Open the terminal window and then type in the following commands:

1. cd /etc/network
2. route
    a. Route is used for knowing the ip address, gateway, broadcast and netmask of the router.
3. ifconfig
    a. Ifconfig is used for knowing the ip address of the raspberry pi.
4. sudo pico interfaces

    A window will appear, type in the following:

    - Allow-hotplug wlan0
    - Auto wlan0
    - iface wlan0 inet static
    - address 192.168.0.3
    - netmask 255.255.255.0
    - network 192.168.0.0
    - broadcast 192.168.0.255
    - gateway 192.168.0.1
    - wpa-ssid “Router”
    - wpa-psk “password”

Press ctrl + x then y followed by enter.

For multiple wifi networks:

Figure 5.2: Multiple Wi-Fi connection

5.1.4 To access the pi

1. for the windows users:

1. Download putty
2. Run putty and enter the ip address of the raspberry pi.
3. Select ssh
4. Chose port 22
5. Select x11 and click OK

A window dialogue will open asking for the username and password, type in the username and password of the pi.

Now you are logged in to the pi server.

2. for the mac users:

1. Type in sudo apt-get install xrdp on the raspberry pi.
2. Download remote desktop connection on mac.
3. Run it and type the ip address of the raspberry pi and click connect

A window dialogue will open asking for the username and password, type in the username and password of the pi.

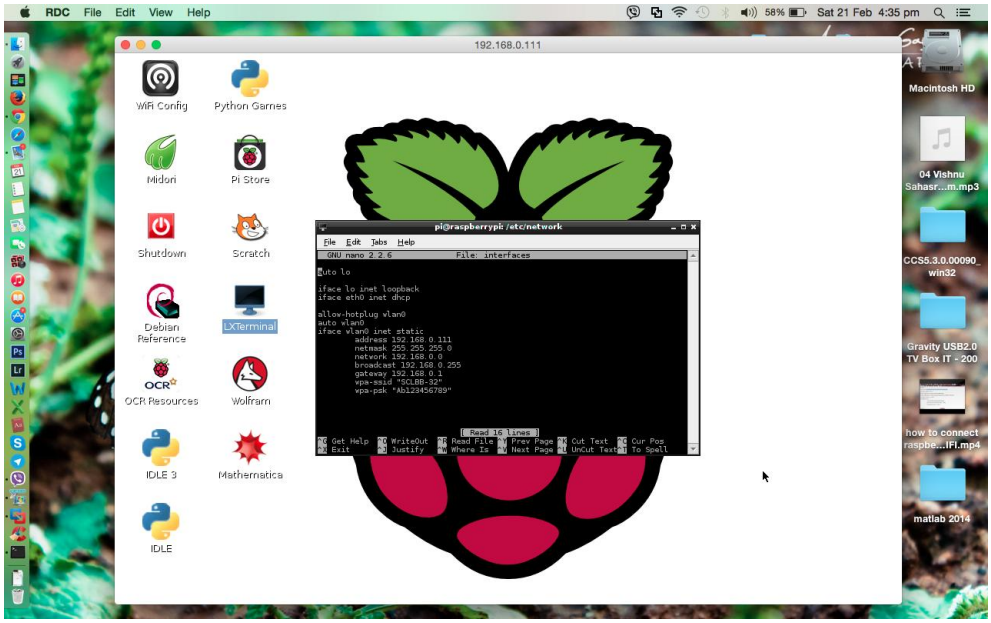


Figure 5.3: Remote Desktop Connection of Pi

There is another way of logging into pi from the mac laptop by typing in the following command in the terminal window of mac:

- ssh –l pi 192.168.0.111

Enter the username and password of the raspberry pi.

5.1.5 Setup the camera:

Type in the following commands on your raspberry pi terminal

1. sudo apt-get update
2. sudo apt-get upgrade
3. sudo apt-get install motion
4. lsusb
5. sudo apt-get install libjpeg8-dev imagemagick libv4l-dev
6. wget http://sourceforge.net/code-snapshots/svn/m/mj/mjpg-streamer/code/mjpg-streamer-code.zi
7. unzip mjpg-streamer-code.zip
8. cd mjpg-streamer
9. make mjpg_streamer input_file.so input_uvc.so output_http.so
10. sudo cp mjpg_streamer /usr/local/bin
11. sudo cp output_http.so input_file.so input_uvc.so /usr/local/lib/
12. sudo cp -R www /usr/local/www
13. export LD_LIBRARY_PATH=/usr/local/lib/

Once it is now installed now if you want to run it type in the following command:

- /usr/local/bin/mjpg_streamer -i "/usr/local/lib/input_uvc.so" –o "/usr/local/lib/output_http.so -w /usr/local/www" &

5.2. Bot Control

The bot has many controls such as movement of the bot using two wheels with two DC motors, Arm control with a DC and a servo motor. The arm control, however is dealt in the next section. This section mainly involves concepts of controlling the bot as a whole unit. The wheels are controlled with distinct 6v DC motors driven with the help of L293D IC. The digital signals are sent from the pi to the IC. In this case, since the speed of the bot needed to be controlled, PWM signals were generated from the pi and sent to the IC to give analog voltages or lesser voltage to the DC motor Thereby resulting in Low speed. The forward backward motion and left and right are controlled through the H-Bridge as explained in the H-bridge section. For right and left one of the two wheels move faster, i.e., a larger voltage is supplied and the other wheel moves slower by supplying a less voltage. This action turns the bot towards the lower speed wheel.

5.3. Arm Control

The arm has three degrees of freedom. One degree is given by the bot itself. The other one is at the interface of the bot and the arm through a DC motor controlled using a L293D. The interface of the Camera case and the arm has a servo motorto control the angular rotations precisely.

5.4. Face Recognition

5.4.1. Face detection using Voila John Algorithm

The Viola–Jones object detection framework is the first object detection framework to provide competitive object detection rates in real-time proposed in 2001 by Paul Viola and Michael Jones. Although it can be trained to detect a variety of object classes, it was motivated primarily by the problem of face detection. The basic problem to be solved is to implement an algorithm for detection of faces in an image. This can be solved easily by humans. However there is a stark contrast to how difficult it actually is to make a computer successfully solve this task. In order to ease the task Viola–Jones limit themselves to full

view frontal upright faces. That is, in order to be detected the entire face must point towards the camera and it should not be tilted to any side. This may compromise the requirement for being unconstrained a little bit, but considering that the detection algorithm most often will be succeeded by a recognition algorithm these demands seem quite reasonable. Feature types and evaluation. The main characteristics of Viola–Jones algorithm which makes it a good detection algorithm are:

- Robust – very high detection rate (true-positive rate) & very low false-positive rate always.
- Real time – For practical applications at least 2 frames per second must be processed.
- Face detection and not recognition - The goal is to distinguish faces from non-faces (face detection is the first step in the identification process)

The algorithm has mainly 4 stages:

1. Haar Features Selection
2. Creating Integral Image
3. Adaboost Training algorithm
4. Cascaded Classifiers

The features employed by the detection framework universally involve the sums of image pixels within rectangular areas. As such, they bear some resemblance to Haar basis functions, which have been used previously in the realm of image-based object detection. However, since the features used by Viola and Jones all rely on more than one rectangular area, they are generally more complex. The figure at right illustrates the four different types of features used in the framework. The value of any given feature is always simply the sum of the pixels within clear rectangles subtracted from the sum of the pixels within shaded rectangles. As is to be expected, rectangular features of this sort are rather primitive when compared to alternatives such as steerable filters. Although they are sensitive to vertical and horizontal features, their feedback is considerably coarser.

5.4.2. Face recognition using Principal Component Analysis

Face Recognition is implemented using Principal Components Analysis method. PCA is dimensionality reduction technique which extracts principal components. The first principal components are linear combinations of highest variability components while nth principal components are linear combinations of maximum variability among features. This scheme is based on an approach where each face is decomposed in to small sets of significant features called "Eigenfaces". These are nothing but principal components. Afterwards, eigenvectors are computed and later Euclidean distance and thresholding are used for recognition of faces. PCA is most simple algorithm while highly sensitive to variations. The recognition flow using PCA is detailed below.

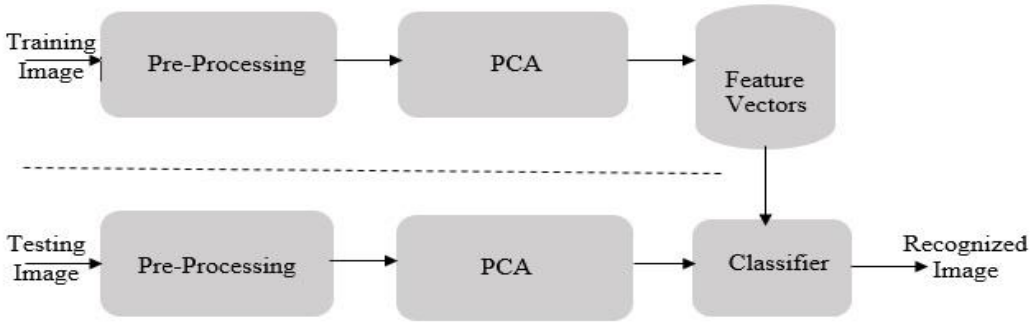


Figure 5.4: Face Recognition Using PCA algorithm

RESULTS AND CONCLUSIONS

Chapter 6

Results and Conclusions

The efficiency and performance of recognition code was tested on real time customized databases. The database was formed by combining images of four different subjects and images are taken from a mobile phone camera having 8 Megapixels resolution under good lighting and uniform background. The images in the database have five different orientations

Figure 6.1: Database Images (a) Right view (b) Partial right view (c) Frontal view (d) Partial left view (e) Left view

namely, frontal view, right partial-side view, left partial side view, left view and right view. Occluded images are precluded from adding.

The feasibility of PCA algorithm is checked by rigorous experimentation on customized database. It is seen that used code has success-to-failure ratio of 9:1 for every ten trials on database images.

SCOPE

Chapter 7

Scope

This project result is a robot which has two major applications adumbrated below:

1. *Surveillance:* The robot can be used as a surveillance system. In this, the robot is monitored from the remote control centre by sending proper commands to the controller attached or included in robot body. Besides, security guards can use this system to have an eye at various zones while being in his cabin.

2. *Live Information Source:* This can be said as the most appropriate application of the designed robot. Connoisseurs of nature and arts can use robotic system of proposed type to see live videos of the desired destinations without actually being present physically.

FUTURE WORK

Chapter 8

Future Work

The designed rover is highly applicable and many more modules can be integrated on this system to make it more and more autonomous. Sensors can be integrated to make the rover more intelligent. The bot can be integrated with obstacle detection to make its movement autonomous. The face recognition process can be made more reliable by increasing its efficiency and performance. Video processing can be implemented and along with object tracking may lead to complete autonomy of the system.

BIBLIOGRAPHY

Chapter 9

Bibliography

References

[1]. G. Subrayudu, Y. Aruna Suhasini Devi and Subhani Shaikul. "Autonomous Mobile Platform for Intelligent Control of Robot." International Journal of Engineering Trends and Technology (IJETT) – Vol. 4 Issue 9, pp. 4022, 2013.

[2]. Deepali H. Shah, Dr. J S Shah and Dr. Tejas V Shah. "The Exploration of Face Recognition Techniques." International Journal of Application or Innovation in Engineering & Management-Vol. 3, Issue 2, pp. 2319-4847, 2014.

[3]. Andrea F., A Bate, Michele Nappi, Daniel Riccio and Gabriele Sabatino. "2D and 3D face recognition: A survey." Elsevier, Pattern Recognition letters 28, pp. 1885-1906, 2007.

[4]. Hou-Tsan Lee, Wei-chuan Lin and Ching-Hsiang Huang. "Indoor Surveillance Security Robot with a self-propelled Patrolling vehicle." Hindawi Publishing Corporation Journal of Robotics – Article ID 197105, 2011.

[5]. Ching-Heng Ku and Yen-Chieh Cheng. "Remote Surveillance by Network Robot using WLAN and Mobile IPv6 techniques." IEEE, 2007.

[6]. Deepali H. Shah and Tejas V. shah. "The Exploration of Face Recognition Techniques", International Journal of Application or Innovation in Engineering & Management, 2014.

[7]. Kevin W. Bowyer and Kyong Change. "A Survey of approaches and challenges in 3D and multi-model 3D+2D face recognition", Elsevier, 2006.

[8]. http://www.cnet.com/au/news/samsung-nx-rover-is-a-camera-bot-you-can-control-remotely/

[9]. http://www.samsung.com/uk/nxrover/project.html

[10]. http://readwrite.com/2014/05/07/arduino-vs-raspberry-pi-projects-diy-platform

[11]. http://www.raspberrypi.org/

[12]. http://blog.miguelgrinberg.com/post/how-to-build-and-run-mjpg-streamer-on-the-raspberry-pi

[13]. http://computers.tutsplus.com/tutorials/controlling-dc-motors-using-python-with-a-raspberry-pi--cms-20051

[14]. http://www.pickupapi.com/blog/pitronics-part-7-servo-motors/

[15]. http://www.raspberrypi-spy.co.uk/2014/11/how-to-create-a-raspberry-pi-video-capture-unit-part-3/

[16]. https://www.sparkfun.com/products/9670

[17]. http://www.matlab.com