Moving Object Follower

Kishan K

Department of Electronics and Communnication, The National Institute of Engineering, Mysore

Pramod G Kamath

Department of Electronics and Communnication, The National Institute of Engineering, Mysore

Sandeep Suresh Kerudi

Department of Electronics and Communnication, The National Institute of Engineering, Mysore

Sunil R Keri

Department of Electronics and Communnication, The National Institute of Engineering, Mysore

M. S. Vijaykumar

Assistant Professor
Department of Electronics and Communnication, The National Institute of Engineering, Mysore

Abstract - Robotics originated with the goal of building human-like machines, but it has become much more than that. Even though we are still years away from human-like machines, the developing robotics technologies are proving useful in ways that nobody expected. Robot-assisted non-invasive surgery, disposal of bombs, automated lab science for drug discovery; even auto-focus features in digital cameras. One of the types of robots is the Moving Object Follower. A robot has been built that can continuously track a particular object. For this, a vision system has been setup and interfaced. Through this vision system the information of the object is obtained. On comparison of the captured image from vision system and the stored parameters of desired object, it is detected. A control mechanism is implemented for moving the vision system to the new location of the object. The motion of the vision system is accomplished with the help of servo motors. Also, the robot would move behind the object, the distance to be moved and the direction of the motion can be determined by controller unit. Hence, the geared motors form this mechanism.

I. INTRODUCTION

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. Mobile robot 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.

One of the defining characteristics of real robots is that it is a kind of machine with a potential of interacting with other physical things and it can be provided with the electronic programming to do a particular job or to do a variety of actions. The other important robotic characteristics required in a machine to be classified as a robot is the ability to recognize and understand data on physical objects, or on its local physical environment, or to process data, or to respond to different stimuli.

The essential characteristics of robots have been classified in the following manner:

Sensing: The very basic characteristic of robots is that it must have the ability to sense its environment or the surroundings.
Movement: Another of the primary robots characteristics required in machine is that it must be able to move around its surroundings. This can be done in different ways like there can be rolling on wheels propelling by thrusters a robot needs to be able to move, to count as a robot.

*Intelligence***:** This is the area where programming enters into the scene. Smartness is awarded to a robot by the programmer. A programmer is a person whose job is to provide robot its smartness by the use of a controller or processor.

Energy: Energy is one of the most important robots characteristics. It is necessary to have an adequate source of energy so that robot is able to power itself on its own and work for a longer period of time efficiently.
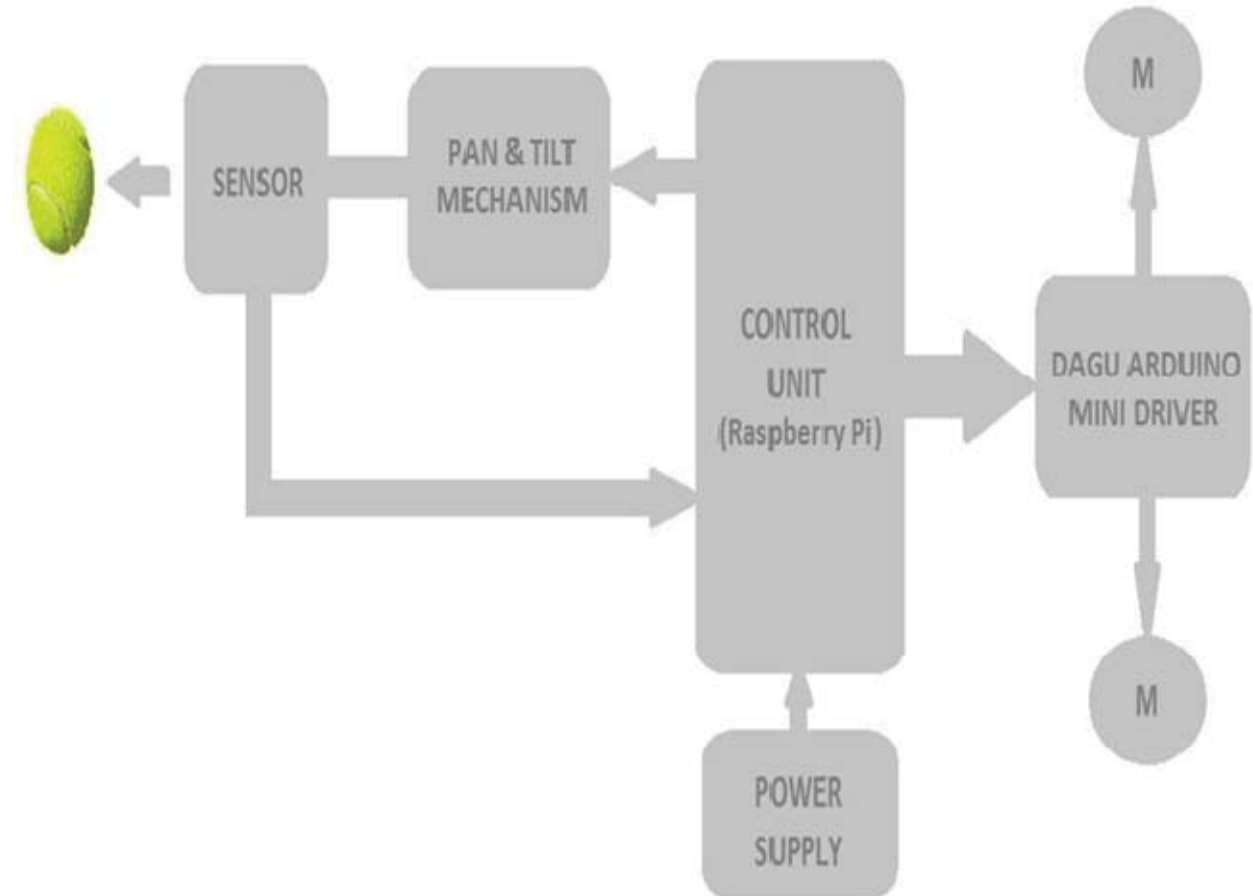
II.   BLOCK DIAGRAM

.

Fig.1 Block Diagram

The block diagram of our project is as shown above. It consists of mainly the following parts: two processors i.e. raspberry pi for image processing and dagu mini driver for controlling motors, two sensors i.e. camera module for image capture and ultrasonic sensor for distance measurement, a pan tilt mechanism for sensor movement and actuators for movement of the robot.

The camera captures the image. The processing is done by the raspberry pi which gives a set of parameters to the dagu mini driver. This sets the sensors in a straight line with that of the object by controlling the pan tilt mechanism and then it checks for the distance of the object. If it is greater than the minimum distance the robot moves towards it and if less than the minimum distance, the robot is stationary. This process is repeated continuously in an infinite loop unless the user turns off the system thus making it a real time embedded system.

III.   HARDWARE REQUIRED

A.   RASPBERRY PI:

The **Raspberry Pi** is a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation with the intention of promoting the teaching of basic computer science in schools. It does not include a built-in hard disk or solid-state drive, but it uses an SD card for booting and persistent storage. The Foundation provides Debian and Arch Linux ARM distributions. It supports various languages like python, C, JAVA, PERL etc. There are two models A and B. The latter one is used for most of the applications.

B.   CAMERA MODULE:

The Raspberry Pi camera module can be used to take high-definition video, as well as still photographs. The camera module is very popular in home security applications, and in wildlife camera traps. One can also use it to take snapshots.

C.   DAGU MINI DRIVER:

The Mini Driver is a low cost controller that is software compatible with the Arduino NG. With it is a built in dual FET "H" bridge and the ability to drive servos directly from the battery it makes a great motor or servo driver. The Mini Driver can be programmed using the Arduino IDE. The built in USB interface allows the controller to be programmed using a standard "A" to mini "B" USB cable.

D.   ULTRASONIC SENSOR:

Ultrasonic sensors work on a principle similar to radar or sonar which evaluates attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. They typically use a transducer which generates sound waves in the ultrasonic range by turning electrical energy into sound, then upon receiving the echo turn the sound waves into electrical energy which can be measured and displayed.

HC – SR04 Module:

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The modules includes ultrasonic transmitters, receiver and control circuit.

E.   PAN TILT ASSEMBLY:

This assembly is used to mount sensors onto the robot. Contains a pair of miniature 9 gram servos, along with metal mounting brackets, screws. The brackets have a large number of mounting holes on them so it's possible to attach a large variety of range sensors to them.
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.

F.   GEARED MOTORS:

Two geared motors are used to drive the robot.

G.   POWER SUPPLY:

VEX Batteries are designed to handle the large current draw typically associated with robots. The 7.2v Battery is Ni-Cd rechargeable. It is plugged directly into the Dagu Mini Driver. The robot battery pack contains Ni-Cd (Nickel-Cadmium chemical composition) rechargeable that provide significantly more energy than comparable AA Ni-Cd batteries. The Battery Pack"s cells will provide a constant reliable voltage until they are exhausted.

Contrary to popular belief, Ni-Cd batteries do not suffer from any sort of permanent "memory effect".

H.   DAGU-PI BRIDGE

The communication between the raspberry pi and the Arduino mini driver can be done using USB or serial hardware. In this project this is done using serial communication by TX and RX pins.

The Arduino mini driver is transmitting at 5V but the maximum voltage the raspberry pi can receive is 3.3V. Hence a voltage conversion is required, which is obtained from the voltage divider network as shown in the figure. When transferring the data from the pi to the mini driver, voltage conversion is not required as the pi transmits at 3.3V and the mini driver receives voltages up to 5V. In addition to the TX and RX pins, common GROUND has to be done between the pi and the mini driver or else the devices may get damaged.
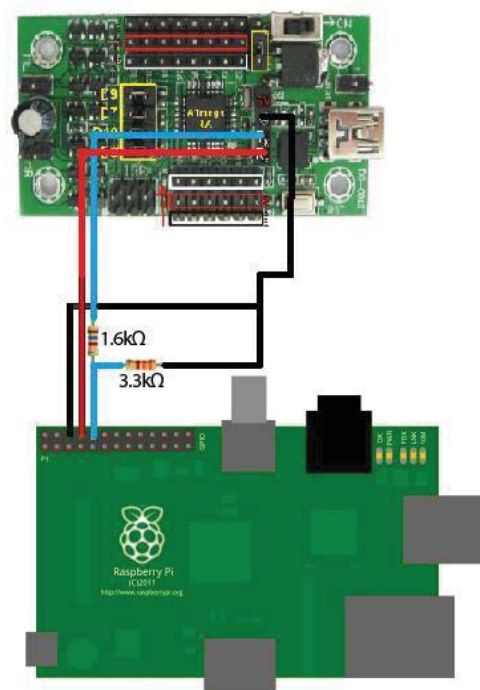

Fig. 2 Dagu –Pi bridge

IV.   SETTING THE PI

1.   Install RASPBIAN OS in SD card.

2.   Set up LAN connection.

3.   Connect the pi to pc using PUTTY.

4.   Install GUI interface like XMING or VNC.

5.   Configure the settings using: sudo raspi-config

V.   OBJECT DETECTION

OpenCV (*Open Source Computer Vision*) is a library of programming functions mainly aimed at real-time . It is free for use under the open source BSD license. The library is cross platform. It focuses mainly on real-

time image processing. OpenCV is written in C++ There are now full interfaces in Python, Java and MATLAB. Wrappers in other languages such as C#, Ch, Ruby have been developed to encourage adoption by a wider audience. OpenCV runs on Windows, Android, Linux. OpenCV uses CMake.

VI. OBJECT TRACKING ALGORITHM

1. Get image frame from picamera.

The image is captured from the picamera connected to the raspberry pi. This is stored in RGB format by default.

Fig. 3 Original Image

2. Convert RGB image into HSV image.

OpenCV usually captures images and videos in 8-bit, unsigned integer, BGR format. In other words, captured images can be considered as 3 matrices; BLUE, GREEN and RED (hence the name BGR) with integer values ranges from 0 to 255.

The RGB color model has the disadvantage that its description of color is very susceptible to lighting changes. If we picture the RGB color space as a Euclidean space with axes R, G and B, and the color value of a pixel as a point in this space, consider that to define a color range in the RGB color space one would need to define ranges over the R, G and B components. This will give as a result a "box" in which we will define every pixel that falls in it to be a certain color. Even a small lighting change in the scene that produces the picture we are analyzing will probably affect the R, G and B components of pixels so much, that it will make pixels that were in that box move out of it. In other words, the RGB model does not closely follow humans' perception of color. It is common practice to use a different color model/space called *HSV* (*hue, saturation* and *value*) to determine value ranges for a color. The main advantage of using HSV to describe pixel color is that the hue component does not depend on lightning, which produces more robust results for segmentation.
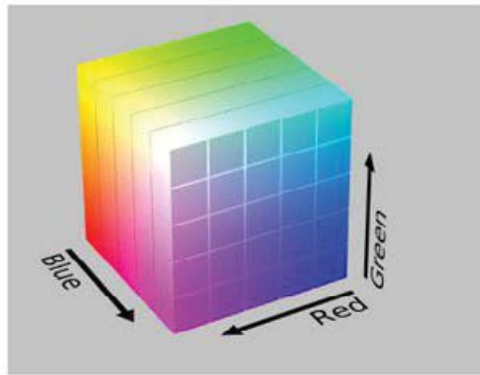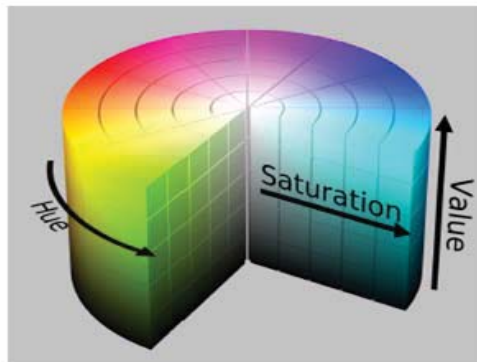
Fig. 4 RGB Model

Fig. 5 HSV Model

Fig. 6 HSV Image

3. Convert HSV image into Binary image by providing Higher and lower HSV ranges.

Fig. 7 Threshold Image

4. Remove unwanted Noise.

After thresholding the image, noises may be present due to presence of other objects or by reflection of light from the object. It can be removed by morphological opening and closing functions which is present in OpenCV library.

5. Finding contours from binary image and the largest among them.

Contours are white areas shown in binary image. The largest contour is considered. So, each contour is found and its area is calculated. Then we will keep largest contour and ignore other contours.

6. Finding the centre of the object.

In this project, moments functions are to calculate the position of the center of the object. 1st order spatial moments are calculated around x-axis and y-axis and also the 0th order central moments of the binary image. 0th order central moments of the binary image is equal to the white area of the image in pixels.

Formula to find the centre of the object:

- X coordinate of the position of the center of the object = 1st order spatial moment around x-axis / 0th order central moment

- Y coordinate of the position of the center of the object = 1st order spatial moment around y-axis / 0th order central moment

Fig. 8 Processed Image

All these processing is done by the rapberry pi. The coordinates of the centre of the object is given to the dagu mini driver for further processing. The programming for object tracking can be done using python, C or C++. Python is slower if used in real time hence C or C++ is used for object tracking using raspicam library which makes the processing faster because of its compiled nature.

VII.   OBJECT FOLLOWING

The further process of pan tilt mechanism and the robot movement is done by Dagu mini driver. As specified earlier the servos for pan tilt, ultrasonic sensor for distance measurement and the geared motors for the motion of the robot are connected to the mini driver by the on board pins. The programming for the servos and the geared motors is done in Arduino IDE. The IDE is a cross-platform application written in JAVA. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. Arduino programs are written in C or C++.

The raspberry pi finds the centre of the object. This is given to the mini driver through serial communication as explained earlier. The further processing is according to the flow chart in Fig 13

Programming is done in the following steps:

1.   Compare the centre of the object with the centre of the frame.

This is done in order to find the position of the object in the frame so that the movement of the pan tilt and the robot can be done.

2.   Control the servos and the motors.

The pan tilt mechanism is controlled using the coordinates of the centre of the object. The x coordinate is used for the pan mechanism whereas the y coordinate for the tilt mechanism. The ultrasonic measures the distance and then the geared motors are also controlled by the coordinates of the centre of the object.

All this process of object detection and object following is done in an infinite loop at boot time by writing a script in /etc/init.d in the OS so as to make it real time application.
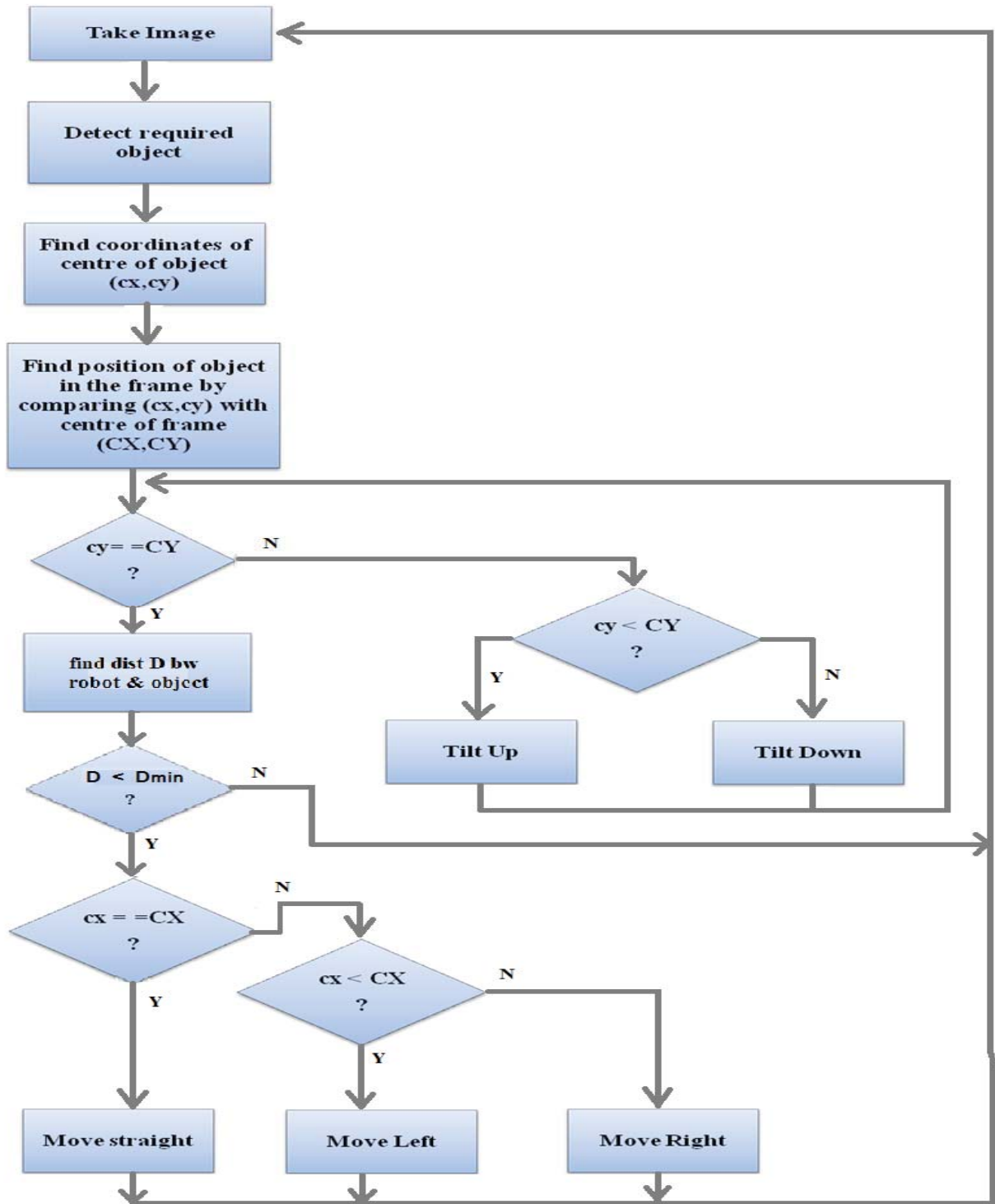
VIII.   FLOW CHART

Fig. 9 Flow chart

IX.   CONCLUSION AND SCOPE

In this project, tracking of the object uses colour based object detection algorithm. HSV values of the colour of the object are used to differentiate it from the surroundings. The position of the object is found by comparing its centre with the centre of the frame. With these as inputs, the actuators drive the robot towards the object.

X.   POSSIBLE IMPROVEMENTS

The problems faced in this method are –

1. There should not be any other object with greater area and the same colour of that of the required object. If this happens our object won't be detected.

2. Masking process in object detection is environment dependent and is not efficient if more light is reflected from the object.

3. Raspberry Pi's GPIO pins when used in more number for lot of interfaces extensively causes heating of the pi to a great extent resulting in fluctuating voltages and disrupting the smooth operation of the system.

The performance can be improved by changing the HSV values according to the environment and avoiding any other object of the same colour with a larger area and using Dagu mini driver for external peripherals like sensors, switches.

The future enhancements can be done by using higher end processors and sophisticated object detection algorithms like SURF, Cascade classifier method and various transforms of image processing to detect the required object amidst different kinds of objects of various colours in different environmental conditions.

XI.   APPLICATIONS

1. Moving object detecting principles are used in rovers in space technology to find the routes for navigation.
2. It can be used as spy robots in war fields.
3. It can be used in games like cricket, football to track the ball automatically.
4. For underwater shooting and study of the life, this principle can be used.

ACKNOWLEDGMENT

BIBLIOGRAPHY

[1]   http://roboticssamy.blogspot.pt/2013/11/rs4-robot.html
[2]   http://www.raspberrypi.org
[3]   http://learn.adafruit.com/adafruit-raspberry-pi
[4]   www.uco.es/investiga/grupos/ava/node/40
[5]   http://picamera.readthedocs.org/en/release-1.2/recipes1.html
[6]   http://opencv.org
[7]   http://opencv-python-tutroals.readthedocs.org/en/latest/py_tutorials/py_tutorials.html
[8]   http://opencv-srf.blogspot.in/2010/09/object-detection-using-color-seperation.html
[9]   http://blog.dawnrobotics.co.uk/2014/01/using-dagu-mini-driver-build-raspberry-pi-camera-robot/
[10]   http://arduino.cc/en/Reference/HomePage
[11]   http://blog.oscarliang.net/raspberry-pi-and-arduino-connected-serial-gpio/
[12]   "Getting Started with Raspberry pi" by Richardson and Wallace
[13]   "OpenCV - Python Tutorials Documentation" by Abid K and Alexander