

**INHOMOGENOUS COLOR OBJECT RECOGNITION USING
MONOCROHMATIC-BASED TECHNIQUE
WITH COLOR CAMERA**

Noraidah binti Ahmad

Bachelor of Mechatronics Engineering

June 2012

I hereby declare that I have read through this report entitle “Inhomogeneous Color Object Recognition Using Monochromatic-based Technique” and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Mechatronics with Honours.

Signature:.....

Supervisor’s Name: Mrs. Nurdiana binti Nordin @Musa

Date: 8th June 2012

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NORAIDAH BINTI AHMAD

**A submitted in partial fulfilment of the requirements for the degree of Bachelor of
Mechatronics Engineering with Honours**

2012

I declare that this report entitle “Inhomogeneous Color Object Recognition Using Monochromatic-based Technique” is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

Signature:.....

Student's Name: Noraidah binti Ahmad

Matrix No. : B010910287

Date: 8th June 2012

ACKNOWLEDGMENT

First of all, I would like to express my utmost gratitude to almighty Allah upon compilation of the first progress report.

A million thanks to my supervisor Mrs. Nurdiana binti Nordin@Musa, who had guided be a lot of task during this semester session 2011/2012. I also want to thanks the lecturers and staffs UTeM for their cooperation during I complete the first PSM that had given valuable informations, suggestions and guidance in the compilation and preparation this fist PSM.

Deepest thank and appreciation to my parents, family and others for their cooperation, encouragement, constructive suggestion and full support for the report completion, from the beginning till the end. Also thanks to all my friends and everyone, those have been contributed by supporting my work and help myself during the first PSM progress.

ABSTRACT

Inhomogeneous color object recognition is essential especially for robotic application such as target location, path planning and route mapping. The aim of this project is to recognize inhomogeneous color object using monochromatic based technique with color camera. This technique refers to utilizing gray level image processing to each vector of color image and combines the result suitably for recognition. The level object recognition strategy will be used to analyze the possibility of the three channels (R, G, B) in color combination and their combination which RG, RB and BG to enhance the recognition of the target. The target is a ball painted with a matte paint in green, yellow and blue. The performances of gray level object recognition on the separated and combined channel is measured in processing speed and recognition rate. The channel combination with the highest percentage of both aspects will be presented in the end of this project.

ABSTRAK

Pengiktirafan objek tak homogen berwarna adalah penting terutama dalam aplikasi robotik sebagai lokasi sasaran, perancangan laluan dan pemetaan laluan. Matlamat projek ini adalah untuk mengenali objek tak homogen berwarna menggunakan teknik berasaskan monokromatik dengan kamera warna. Teknik ini merujuk kepada aplikasi pemprosesan imej tahap kelabu untuk setiap vektor imej warna dan menggabungkan keputusan yang sesuai untuk mendapatkan pengiktirafan. Strategi pengiktirafan tahap objek akan digunakan untuk menganalisis kemungkinan ketiga-tiga saluran (R, G, B) dalam kombinasi warna dan kombinasi RG, RB dan BG untuk meningkatkan pengiktirafan sasaran. Sasaran adalah bola yang dicat dengan cat matte. Tahap pengiktirafan persembahan objek kelabu di saluran berasingan dan penggabungan diukur dalam kelajuan pemprosesan dan kadar pengiktirafan. Gabungan saluran dengan peratusan tinggi terhadap kedua-dua aspek akan dibentangkan di akhir laporan projek ini.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Color images consist of 3-D vectors, which is present the sensor reading of short wavelength (red), medium length (green) and long wavelength (blue) of visible light from the scene. With this combination, more information is delivered about the scene compared to 2D gray level images (e.g. the different color of object of the same shape, the shade of the sky, the color temperature of the incident light). Therefore, the object recognition strategy for color images are vector-valued based and therefore involves a difficult strategy and time consuming compared to the gray level processing. If the contrast of the colored object from the background can be enhanced using one specific color channel or their combination of two of these channels, a simple 2D gray level image processing can be used to recognize the object. Hence, we can reduce the computational speed without compromising the recognition rate.

1.2 Problem Statement

Object recognition to human being is natural and therefore the information about the object (location, shape, color) is easily delivered. However to computers, images received by the camera are only a bunch of numbers. The mathematical model of the numbers converts the number into an image that was originally captured by the image sensor. Color camera produces 3 dimensional color images which defines the information of the object (target) along with the background. Therefore, the object recognition to computers is not an easy task. It needs to be able to differentiate between object and the background. Considering the fact most of the surfaces on earth is inhomogeneous, this project focuses on inhomogeneous object recognition. This is essential especially for

robotic application such as target location (object recognition), path planning (passive path planning require beacons for localization) and route mapping. This project is to recognize inhomogeneous color object by using monochromatic based technique with color camera from individual color channels and then combines the individual result to obtain acceptable recognition.

1.3 Objectives

- i. To obtain the gray level object recognition strategy for inhomogeneous spherical object recognition.
- ii. To obtain appropriate combination of color channel and color object for better contrast of object compared to background.
- iii. To analyze the effectiveness of the color channel and color channel combination in terms of recognition rate and speed.

1.4 Project Scope

- i. The combination of color channels opted for this project in color camera: R, G, B, RG, RB and GB.
- ii. The inhomogeneous object is of a spherical shape is defined as target.
- iii. The object will be painted with matte paints in three color; red, green and blue.
- iv. Range of the object to the image sensor is one meter.
- v. Normal office
- vi. Lighting condition \cong 500 lux.

These following matters are not taken into account in this project:

- i. The amount of surfaces roughness.
- ii. The spectral variation and color temperature of illuminating light.
- iii. The correlation between color channels.

CHAPTER 2

LITERATURE REVIEW

2.1 Object Recognition

According to Oxford Dictionaries [9], inhomogeneous is diverse or uniform in character or content. Figure 1.1 shows the light reflection on homogenous surface. When an amount of light enters an inhomogeneous surface beam will instantly reflect back into the air and then the balance will break in the body of the object. The break in of the lights beam will shoot through the body while the others will reflect back onto the surface and then into the air [11]. Object recognition in images is an essential and important task in applications that use machine vision. There are many related image processing methods which has been proposed. Theo Gevers [3] described a system to recognize multicolored objects invariant to a substantial change in overview, object geometry and illuminations. The result showed that, the most appropriate for multicolored colored object recognition when all imaging with controlled conditions is RGB (red, green, blue). Peng Chang [4] proposed a system which used the color cooccurrence histogram (CH) for recognizing objects in images which the color CH keeps track of the number of pairs of certain colored pixels that occur at certain separation distances in image space. This method is an effective way for recognition to represent object. The algorithm works even though the image in confusing background clutters and average amounts of occlusion and object flexing. Choubeila Maaoui [5] proposed a new method for the detection and the recognition of objects in color images consist two steps which concern the object detection by a color segmentation method and a labeling algorithm and deals with the recognition of extracted objects. Each object is described by color Zernike moments. The recognition system is proposed in the terms of robustness to texture background, occlusion, illumination and noise. The experimental results in (percentage, %) obtained from the database contain color images of 100 different objects shown in Table 1.1.

Table 1.1 Recognition Rate (%) For Different Alterations

Uniform background	Noise background	Textured background	Occlusion with grey level background	Occlusion with black background	Illumination	noise
89.42	86.46	88.17	87.80	87.82	87.82	93.5

Signe Redfield [6] proposed a real-time prototype system to identify soda can using histogram indexing with only 16 colors with excellent results. The accuracy under the fixed conditions which in a room achieved almost 100% with a variety of soda cans. Marcin Smereka [14] proposed a method from Hough Transform to detect a circular object. This approach has been applied in medical field which to recognize nuclei of cells. Dr. Neelu Jain [15] proposed a new recognition strategy on coin recognition. Dr. Neelu Jain noting that the main advantage of using Hough Transform (HT) is high reability and it gives ideal result even in presence of noises. Then, HT led to reduced processing time for edge-finding of objects. This project continues to propose a strategy of recognition based on method [14] and [15] using Circular Hough Transform and produce grayscale images as result.

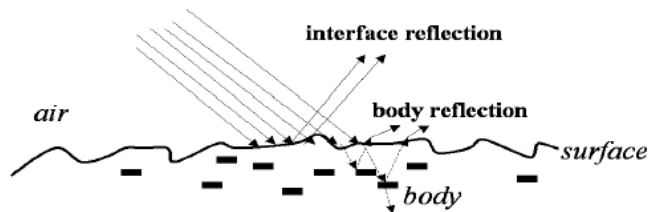


Figure 2.1 The mechanism of reflected light on inhomogeneous surface

2.2 Monochromatic-based technique

Monochromatic-based technique gained information from individual color channels and then combines the individual result to obtain acceptable recognition. Most of the color edge detections are monochromatic based techniques which produces a better result when gray-value techniques are applied. A disruption in gray-level images is specified as an edge and for color images is not defined the term of

color edge. From Wikipedia [16], the edge detection is an important task in image processing and computer vision specifically in features detection and feature extraction which is aiming the identify points in a digital image at the brightness of an image then simultaneously changes sharply and has discontinuities. In color images, a color vector which consists of three color channels is assigned to a pixel and then mixed in different combinations which produce color that visible to the human eye.

2.3 Color images

A color image requires three separate items of information for each pixel and they represent value levels of the information given. For RGB images, the images are built from three separate channels for red, green and blue. Each pixel has intensities from 0 (black) to 255 (white) and each pixel eight bit and a total of $255^3=16,777,216$ represent any possible color in the image as 24-bit color [7]. The image also consists of a three matrices representing the value of red, green and blue for each pixel. The resulting of grayscale images from each channel produces similar brightness. The red channel has a brighter part in red part and caters the contrast map, green channel has much brighter part in green part and shown to have more sources detail and blue channel has much brighter in blue part and take over for the noise [8]. From objectives as illustrated in Chapter 1, this color images produced a three gray-scaled images from three color components; red, green and blue color components and its combination; RB, RG and GB. The results produced the most significant and less significant color channels on color images based on contrast, recognition rate and speed to recognize object. The image with an m-by-n frame size represented by $m \times n \times 3$ in MATLAB.



Figure 2.2 RGB Images on Single Channels Conversion and RGB histogram

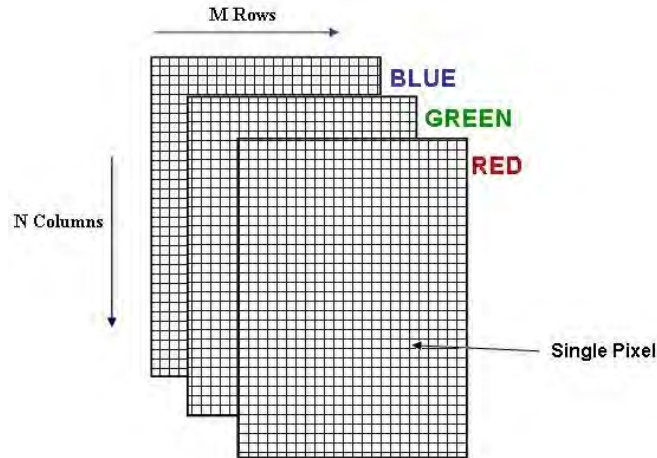


Figure 2.3 A three dimensional array of RGB image

2.4 Digital Camera

According to Oxford Dictionaries [10], a camera which produces digital images that can be stored in a computer and displayed on screen. An acceptable color reproduction from an image that has been captured in an output device display (softcopy) or printer (hardcopy) can be described in a several stages consist of workflow for digital photography shown in Figure 1.4 [2]. The terms described the state of the image and the first step is the image with a scene is being captured, as seen through the zoom lens off electronic picture camera. Then, the conversion between image sensor which has two types: CCD (Charge-coupled device) or CMOS (Complementary metal-oxide semiconductor) shown in Figure 1.5 with optical image into a digital image representing the device dependent raw response of the camera. Without any distortion, the aspects of color quantization and conversion scaling, image compression and the data format file of the file, the transformation of an image into a device independent representation (CIE XYZ, CIE-Lab) which represents the scene and not the input or output device. In the ISO 17321 standard, this color transformation between raw RGB and CIE XYZ spaces is the subject of this work. The image is color generated which is the image may be undergoing some transformations in order to compensate for the different in the input and output viewing conditions. In color generated stage it is a still device independent which the state of the images changes from input referred to standard output

referred such sRGB and etc. Hence, the transformation of an image to a device dependent representation, the device color characterization model has been reverse so that the image can be downloaded in an output ready state to a specific output device. A final viewable image is produced by this output device as their softcopy (LCD) or hardcopy (printer).

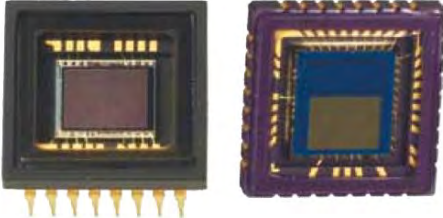


Figure 2.4 Image Sensors: CCD (left) and CMOS (right)

Courtesy: Google

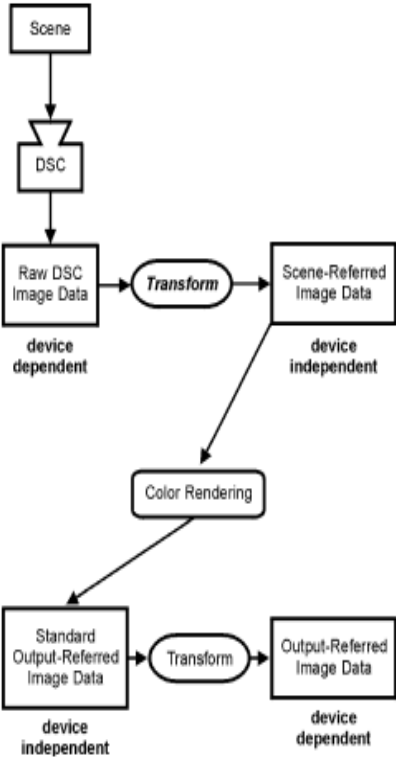


Figure 2.5 Imaging chain for digital photography

2.5 Graphical User Interface (GUI)

A graphical user interface (GUI) is a human-computer interface (i.e., a way for humans to interact with computers) that uses windows, icons and menus and which can be manipulated by a mouse and a keyboard as well. Hence, GUIDE is MATLAB's Graphical User Interface (GUI) design environment that stores two files, which are generated the first time we save or run the GUI; .fig file contains a complete description of the GUI figure layout and the component of the GUIA and .m file contains the code that control the GUI. The example of GUI interface is shown in Figure 1.8. The major advantage of GUIs is that they make computer operation more intuitive, and thus easier to learn and use. For example, it is much easier for a new user to move a file from one directory to another by dragging its icon with the mouse than by having to remember and type seemingly arcane commands to accomplish the same task.

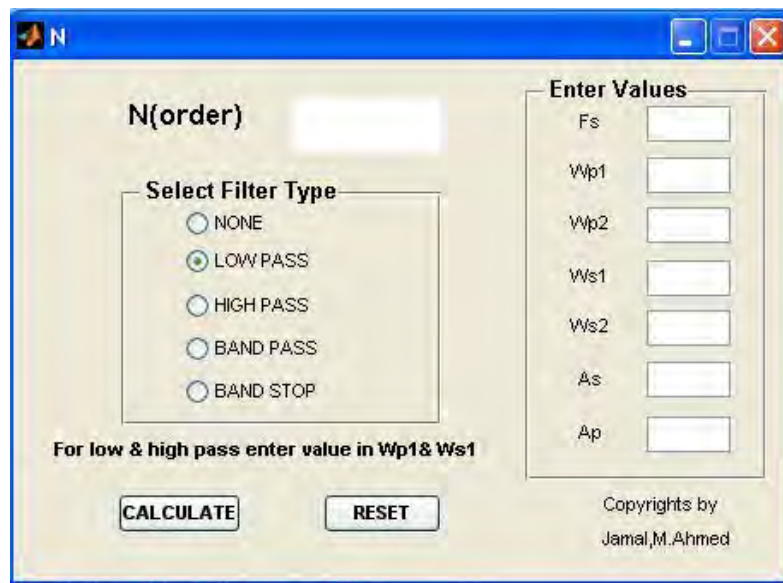


Figure 2.6 Example of GUI Interface

CHAPTER 3

METHODOLOGY

The research process flow has been built to describe the plan of the study. The flow chart is the general flow chart for the whole project. All the activities made up the whole project report are illustrated in this flow as shown in Figure 3.1 below.

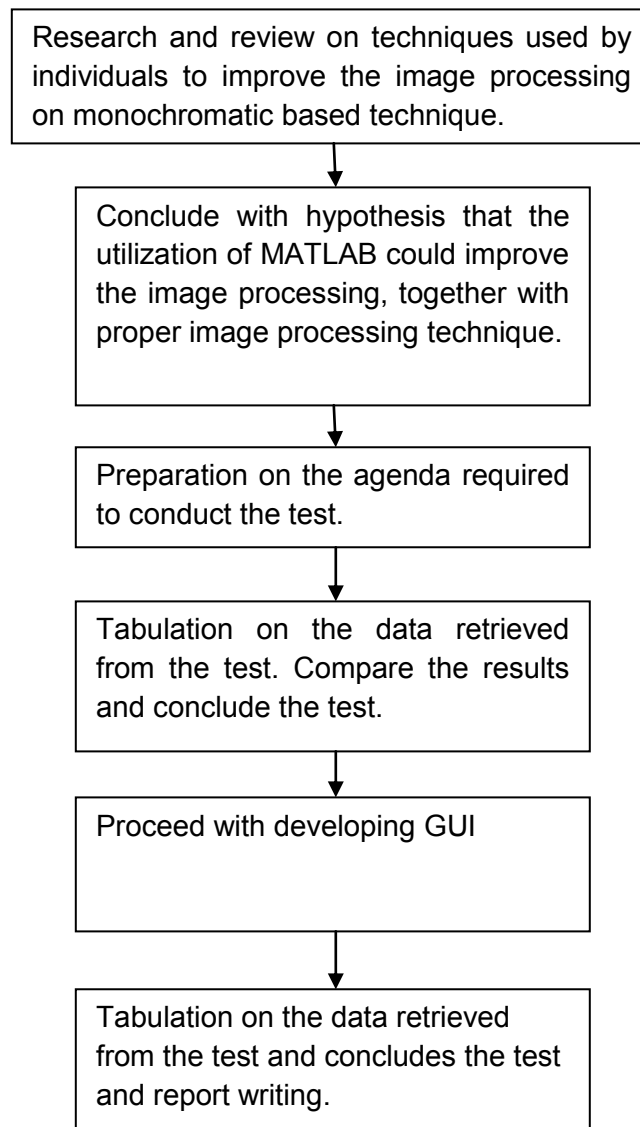


Figure 3.1 Flow diagram of the project

3.1 Research and review on techniques used by individuals to improve the monochromatic image processing.

Most of the research and reviews are referred via reading materials on academic articles, journals and websites. The research on variety of issued that has been highlighted and taken noted, including the method used to determine the edge of the spherical shape in an image, the color constancy, light conditions, algorithm for spectral and colorimeter characterization and many others more. Thus, this information are tabulated and compared with each other, as illustrated in chapter 2: literature review.

3.2 Conclude with a hypothesis that the utilization of MATLAB could improve the image processing together with proper image processing technique

The MATLAB Software is proposed to improve the current analysis result of the monochromatic image processing. MATLAB software is enriched with high-level language and interactive environment, suitable for intensive and complex tasks, with faster performances as compared with traditional programming languages. Besides that, MATLAB supports the entire data analysis process for image processing, ranging from reading images, conversion of image to any different format, filtering the image with any provided algorithm library to producing an accurate visualization, making it suitable choice of implementing image processing via IT.

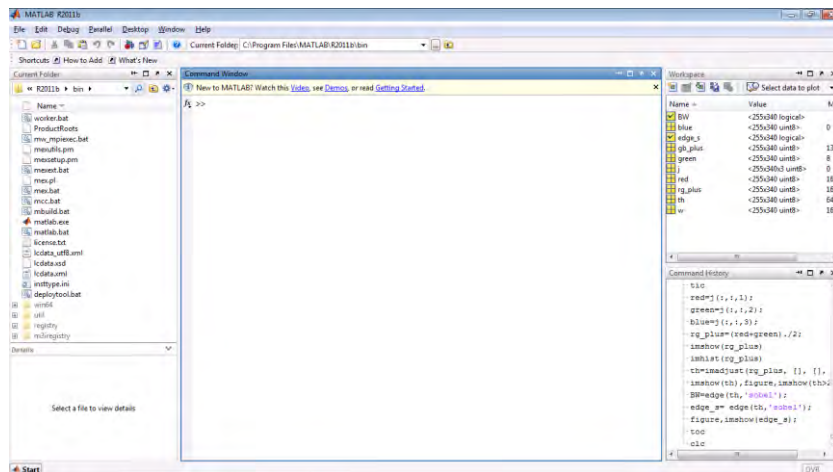


Figure 3.2 MATLAB 2011 Windows

With MATLAB, an image can be converted to a matrix and then various operations can be performed on it to get the desired results and values such identify colors, intensity, edges, texture and pattern in an image.

3.3 Preparation on the agendas required to conduct the test

3.3.1 The general procedure towards conducting the test is as below and the flow chart is shown in Figure 3.4:

1. The DFK 21AU04 color camera is calibrated for optimum output.
2. The spherical object is coated with matte colored paint, placed in front of the camera.
3. The image of the spherical object is captured and analyzed in term of grayscale images on single color channel and its combinations.
4. The grayscale images are analyzed through Circular Hough Transform method and the result is obtained in recognition and processing time.
5. The experiment is then repeated with spherical objects of the others color. The data is then tabulated.

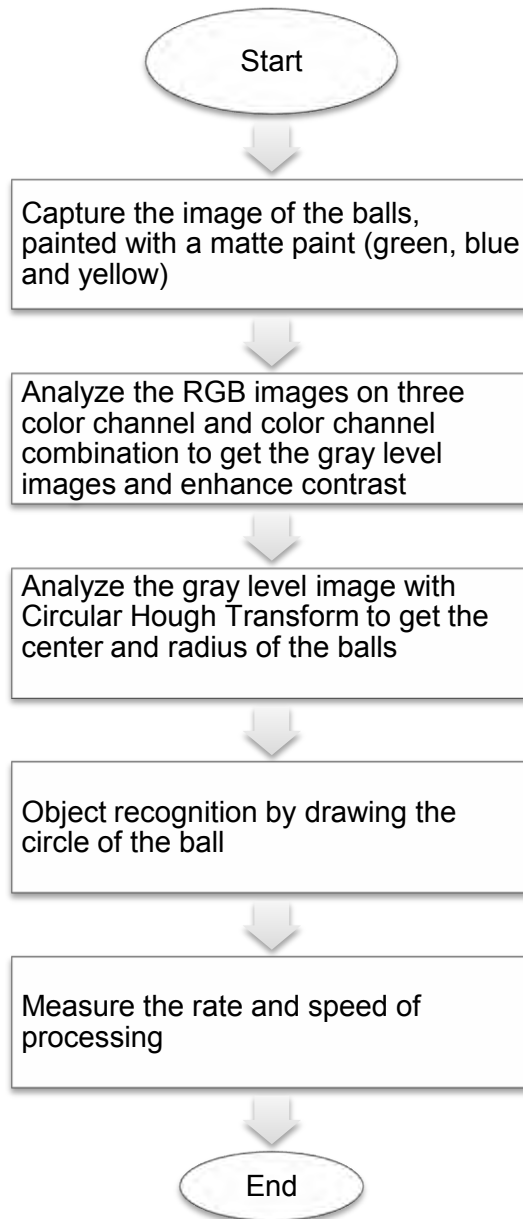


Figure 3.3 Flow Diagrams of General Procedures

3.3.1.1 Calibrate the color camera and capture the image of the balls

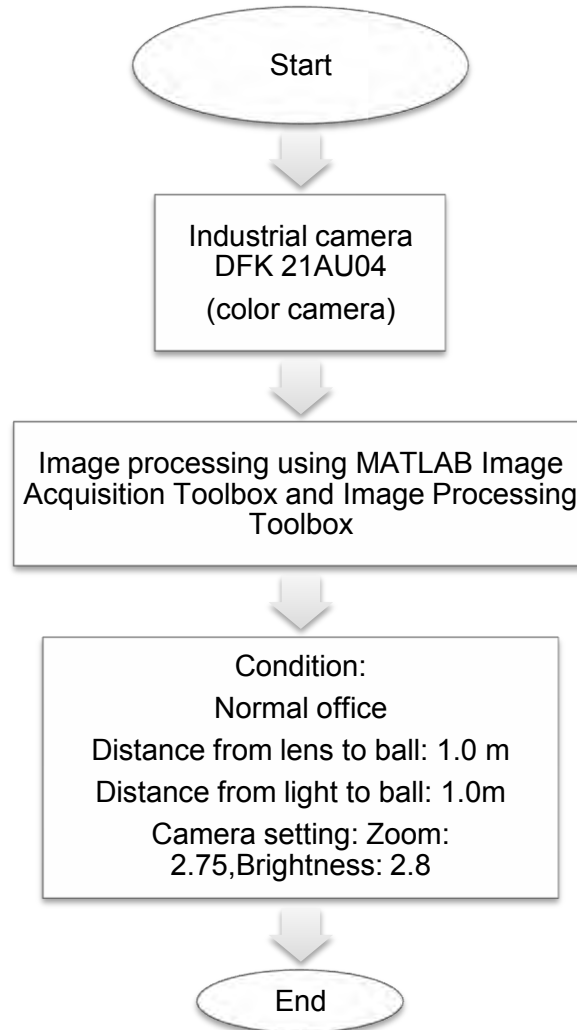


Figure 3.4 Flow Diagram of Calibrating the color camera and capturing the image of the balls.

The ball image is captured by using an industrial camera and the output of the image can be viewed in using Matlab software. Above is the procedure of capturing the ball image and the flow diagram of capturing the images of the balls

1. The ball and camera is set as follow;
 - Distance from lens to ball: 2.5m
 - Distance from light to ball: 1.0m
 - Camera setting:
 - Zoom: 2.75
 - Brightness: 2.8

2. The industrial camera is connected with the computer. Open Matlab software and type command 'Imaqtool'. Then, the command window as above will show.

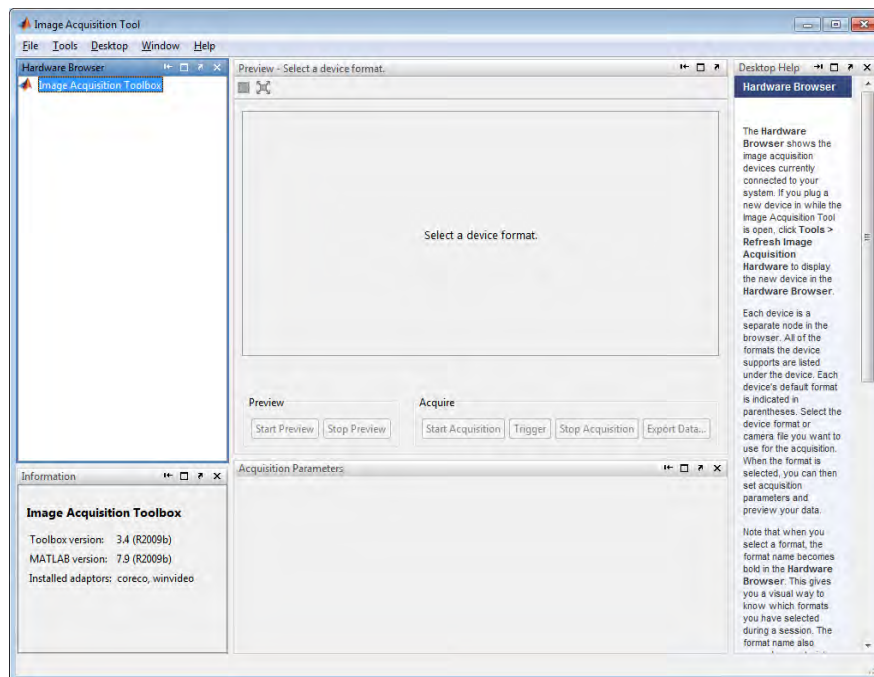


Figure 3.5 Image Acquisition Tool

3. The hardware of the image acquisition toolbox is selected which is the industrial camera at hardware tool. Then, select the pixel of the output image.

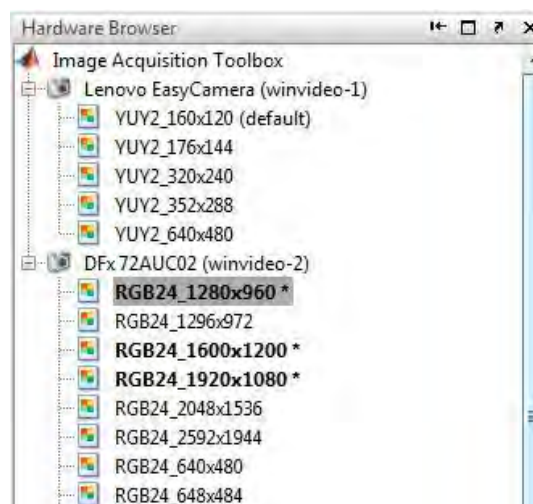


Figure 3.6 Hardware Browser