" I hereby declare that I have read through this report entitle "*Inhomogenous Color Object Recognition Using Monochromatic Based Technique With Monochrome Camera And Color Filter*" and found that it has comply the partial fulfilment for awarding the degree of *Bachelor of Mechatronics Engineering*".

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Supervisor's Name   :   NURDIANA BINTI NORDIN@MUSA

Date   :   ....

INHOMOGENOUS COLOR OBJECT RECOGNITION USING MONOCHROMATIC
BASED TECHNIQUE WITH MONOCHROME CAMERA
AND COLOR FILTER

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

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8th JUNE 2012

I declare that this report entitle "*Inhomogenous Color Object Recognition Using Monochromatic Based Technique With Monochrome Camera And Color Filter*" 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   : ....

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ABSTRACT

The project initiated is aimed to recognize color objects varying colors and intensity. Color image provides additional information to the scene however also contributes to additional noise. When a color image is scaled down to a gray image, millions of color information data will be reduced into 256 level of gray, thus significantly reduces the information for the image. By using a color filter as an aid to enhance the contrast of the object from its background, this project will present whether the method is capable to make up for the loss of information due to gray level thresholding. Furthermore, simple monochromatic based recognition techniques can be applied to the image therefore increases the processing speed. Monochrome camera is used to take the pictures of the object, with the colors in the image are portrayed as grayscale output. The intended object is spherical for the experiment, because it has the largest area per perimeter ratio compared to other shapes, hence better recognition. Successful identification of the spherical object will therefore depends on two factors, recognition rate and processing speed.

ABSTRAK

Projek ini dikajikan atas dasar untuk mengenalkan sesuatu bentuk ataupun rupa dengan pemprosesan imej dengan memanipulasikan warna dan keamatan cahaya. Warna imej membekalkan informasi yang mencukupi kepada corak, akan tetapi juga menyumbang kepada herotan ataupun ' bunyi'. Apabila warna imej ditukarkan kepada imej kelabu, berjuta-jutaan data informasi warna telahpun ditukarkan kepada 256 tahap kelabu, oleh itu menyebabkan kekurangan informasi kepada imej tersebut.Dengan menggunakan penapis warna sebagai alat membantu bagi meningkatkan objek tersebut di dalam imej tersebut, projek ini akan mempersembahkan sama ada cara tersebut dapat membekalkan informasi-informasi warna yang hilang akibat proses ' mengelabukan imeg' Pada masa yang sama, algorithm yang singkat dan mudah telahpun digunakan dalam pemprosesan imej untuk menyingkatkan masa proses.Kamera sewarna ataupun hitam putih telahpun digunakan untuk mengambil gambar, dengan warna corak tersebut ditunjukkan sebagai hitam putih.Objek yang diekperimentkan adalah bulat, disebabkan ia mempunyai luas permukaan per perimeter yang besar berbanding dengan bentuk yang lain, dan membolehkan bentuk tersebut dikenalpastikan . Kadar kejayaan untuk mengenalpastikan bentuk bulat adalah berdasarkan atas faktor kadar mengenal objek dan kelajuan pemprosesan.

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ABBREVIATIONS

Etc	Etcetera
MaxlgLS	Maximum ignorance by least-squares regression
MaxlgWPPLS	Maximum ignorance by least-squares regression Preserving the white point vector
LSAPK	Least-squares regression with a priori knowledge
PC	Principal components
VMF	Vector Median Filter
ISO	International Organization of Standardization
CIE	International Commission of Illumination
MRI	Magnetic Resonance Imaging
RGB	Red Green Blue

APPENDICES

CHAPTER 1

INTRODUCTION

1.1 PROBLEM STATEMENT

Color images provide additional information on the scene compared with grayscale images. However, color images too could contribute to additional noise which will impede the recognition of the target object in the image. Therefore, it is suggested to convert color image to grayscale image to reduce noise and speed up the recognition. Furthermore, lesser information is acquired when grayscale image is adopted hence the consequence is that the simple algorithm will require more steps to recognize the object. With all respect to the problems highlighted above, a solution is suggested to solve this problem.

1.2 BACKGROUND

Image processing has been vastly used in many fields, namely the production industries [16], forensic [13][14], filter production, lens industries and also the medical fields[15]. The demand to produce an accurate and precise color mixing, intensity, hue, and sharpness together with optimum resolutions had push the imaging and sensors industries to a higher level of research. Image processing comes in many different manners, in which different protocol or techniques are used to process and analyze the image. For example, a color image would involve RGB (Red, Green, Blue) sensors to combine the color into complex colors that could be in form of 16 level, 256 level, 13 thousand levels and many more. Therefore, a precise algorithm is required to carefully sort the information, to extract them into places and also to remove the noise by methods of filtering the image.

On the other hand, a grayscale image is an image where the value of each pixel in the carries only intensity information. Grayscale image composed of shades of gray, varying from

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black at the weakest intensity to white at the strongest [31]. A binary image consists of 2 level of color, in which it's either black or white. The conversion of grayscale image to binary is done by computation of interest from image processing software. For example, MATLAB does not distinguish a binary image and also a grayscale image, where binary image is treated as a special case of a grayscale image, in which they contains only two intensities[8].Therefore, a simple algorithm can be utilized to perform any black and white image processing. The importance of grayscale image processing has been growing rapidly with the emerging urge to implement vision system into machinery production, also not forgetting the need for accuracy in terms of bones structures and brain imaging by medical instruments namely X-ray, CT scan and also MRI (Magnetic Resonance Imaging) [15] .In whole, the research on image processing is right in time to further improve the method and techniques implemented and proposed to enhance image qualities.

1.3 OBJECTIVES

The objectives of this project are as below:

- To enhance the contrast of the object from its background by means of color filter
- To recognize the spherical object from the grayscale image using monochromatic based technique in real time
-
- To reduce the speed of the grayscale object recognition and increase the recognition rate by means of suitable recognition strategy

1.3 SCOPES

The scope of this project is:

- Target: Inhomogeneous spherical objects with diameter of 5cm painted with matte paints separately with three different colors (Red, Green, Blue).
- Location: Target is located within (1m or 2 m) from the image sensor
- Image acquisition: Monochrome camera with 5MP resolution, 25 mm focal length (put additional info here)
- The development and testing of image processing algorithm are done with MATLAB.
- The development of graphical user interface (GUI) with either visual basic (VB) or C++.
- Assumptions:
    - No distortion of the acquired image
    - The surface reflection is distributed normally across the image
    - The object reflected the incident light totally without scattering

CHAPTER 2

LITERATURE REVIEW

This review is written based on the elements and criteria of the project. Both elements and criteria are subjected to academic studies report, article and also journal review written by expertise and also professionals.

2.1 COLORS

Colors is the visual perceptual property, corresponding in humans senses that allows all healthy individuals to watch and determine the nature so as the complex vision, well bounded in the human receptor range[17] .Ranged from early development and research till current on colors, human had invented several instruments to further refine the knowledge on colors, for example A spectrophotometer measures the spectral reflectance of a color sample[18][19], spectroradiometer determines the absolute intensity of a light source [19]and densitometer is used to measures the degree of light through an object or obstacles.

2.2 WAVELENGTH OF COLORS IN A COLOR SPECTRUM

A spectral image is defined as an image where each pixel is represented by a spectrum [20].Spectral color can be defined as the color that is evoked by a narrow band of light wavelength in the visible spectrum [21]. These spectral colors are then identified and categorized with a given name colors, namely red, orange, yellow, violet and many others more, with no clear boundaries between one color and the next in a color spectrum [21]. In other words, colors that are produced by visible light of a single wavelength are categorized in the color spectrum. The wavelength of a certain color in a color spectrum varies in a ranged value. These values are categorized as in the given figures and table below:
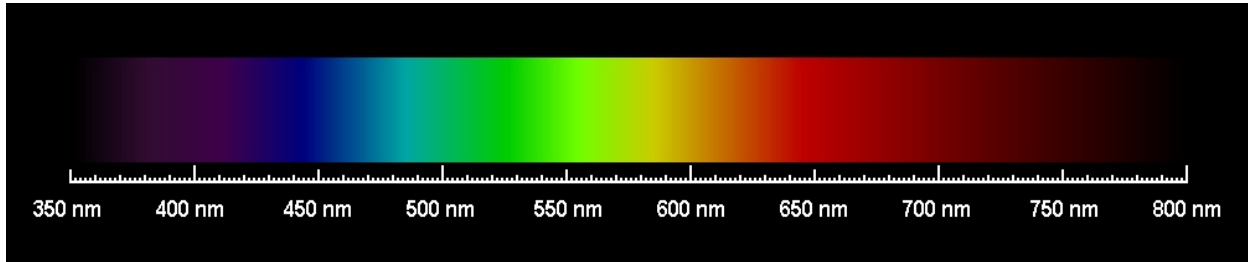
Figure 1: The color spectrum of a visible light.

Color	λ (nm)	υ (THz)	υ_b (μm^{-1})	E (eV)	E (kJ mol^{-1})
Red	700	428	1.43	1.77	171
Orange	620	484	1.61	2.00	193
Yellow	580	517	1.72	2.14	206
Green	530	586	1.89	2.34	226
Blue	470	638	2.13	2.64	254
Violet	420	714	2.38	2.95	285

Table 1: The wavelength, frequency and energy of light according to the colors.

2.3 RECOGNITION OF CIRCULAR OBJECT

Renatom. Hadad, Arnalwd E A. Araujo, Paul0 P. Martinjrs [29] proposed that image recognition of circular object would need to undergo several stages. The preprocessing stage would enable the image to be read, together with the region of interest (ROI) selected, and converted to the system. Next, it is then segmented with several proposed method as below:

i) Using algorithms of multispectral segmentation

ii) Segmenting the images separately and to combine them later

iii) Combining the images and segmenting the image obtained.

Next, the images undergo the critical part of the image processing – pattern recognition where the circular patterns are to be found, and the information is transformed from pictorial to textual. Lastly, the identification of the image is done by analyzing the textual information retrieved from previous phase, and a matching is done with the intended model. Hough transformation is recommended in this paper [29]. LIU Yangxing, GOTO Satoshi, IKENAGA Takeshi [30] too highly recommended the Hough Transformation technique to perform the recognition stages on circular object. Initially the image processing undergoes edge detection using self develops formulae, and then a circular algorithm is performed with Hough transformation with the general equation of circular is given by:

$$(x - a)^2 + (y - b)^2 = r^2$$

With the circular pattern recognized, the center and the radius of the circular pattern is attempted to be calculated.
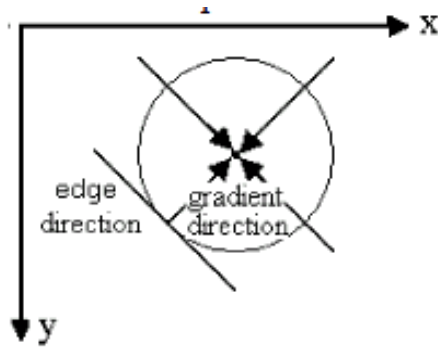

Figure 2 : Illustration of edge direction and gradient direction

The parametric equation of the circular in polar coordinate is given by:

$$x = a + r cos\theta$$

$$y = b + r sin\theta$$

After collecting all the edge point of the circular object, the true circles in image edge map can be detected. The Criterion for locating the centre of circle is defined as the accumulator count must be greater than $2 \times \pi \times r \times L$, where L is a constant, which indicates at what extent the shape as a circle.

In conclusion, the recognition of the circular object would be done by Hough Transformation in this project.

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2.4 GAUSSIAN FILTER

Filter is necessary in image processing to enhance the intended object, at the same time the filter helps to reduce noise. The idea of a filter can be illustrated where a shape is determined over the given image. As a result, a new image whose pixels have grey values is calculated from the grey values under the mask is referred to as filter [8]. Alasdair McAndrew [8] mentioned that a Gaussian filters are a class of low-pass filters, in which they are all based on the Gaussian probability distribution function

$$f(x) = e^{-\frac{x^2}{2\sigma^2}}$$

where σ is the standard deviation, mathematical analyze shows that greater value of σ would yield a flatter curve, while a small value of σ would results in a pointer curve, as illustrated in the diagram below.
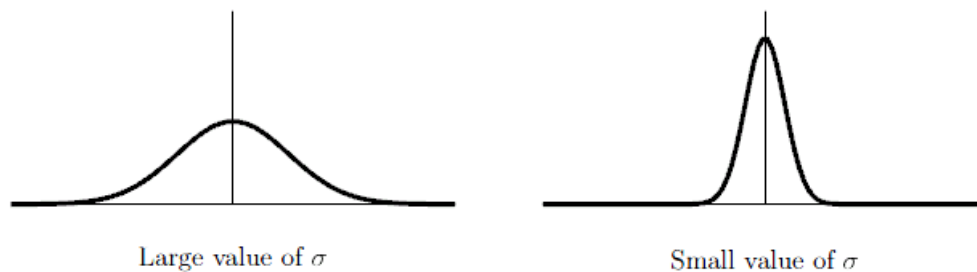

Large value of σ Small value of σ

Figure 3 : One dimensional Gaussians

Richard A. Haddad and Ali N. Akansu [22] had an opinion that the Gaussian filters are categorized as one and two dimensional FIR filters with binary-valued coefficients. In other words, they can be utilized as a bank of filters, corresponding towards lowpass, band-pass and high-pass filters. They proposed an algorithm that could speed up the analyzing of an image by performing an enhanced Gaussian filter method. In application, the proposed binomial filter was applied in the low pass filter pyramid coding of images, and compared with the ordinary Gaussian filter devised by Burt [23][24].

Burt [23] and Burt and Adelson [24] has proposed another type of filters, called the "hierarchical discrete correlation", capable of performing the low-pass or band pass processor with Gaussian-alike magnitude frequency response characteristic. This filter has been implemented in image pyramids. Results from comparing both binomial filter and Burt filter indicates that binomial performs better than Burt in low pass, however much superior in terms of computational efficiency and speed [22].

Pei-Yung Hsiao, Shin-Shian Chou, and Feng-Cheng Huang [25] had proposed another way of filtering with Gaussian. The proposed filter capable of providing various levels of noise smoothing and reduction, includes the power-of-two approximation arithmetic algorithm for the Gaussian coefficients that comes together with an effective hardware design, which can be implemented using simple shifters and adders.

2.5 MORPHOLOGY

Morphology is a branch of image processing, being helpful in analyzing shapes in images [8]. Although limited to only grey-scale images, MATLAB has many build-in tools and library for binary image processing. Among the morphological methodology available in MATLAB is dilation, erosion, opening and closing. The single use of this method or combinations of these methods will help to exclude objects that are not circular in nature from the image. For example, by performing morphological restriction strategy in this project, we are able to distinguish the ball from other distortion and noise that could affect the outcome of the image. An example is illustrated as below:
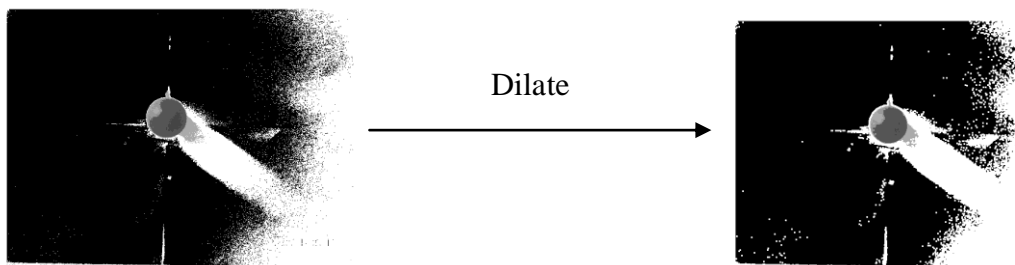

Figure 4: Morphology operation of dilate of before and after image processing.

2.5.1 DILATION

Alasdair McAndrew [8] states that dilation can be mathematically describe in such that

$$A \oplus B = \bigcup_{X \in B} A_X$$

Indicating that for every $\in B$, A is translated by those coordinates, and the union of all the translation is summed.
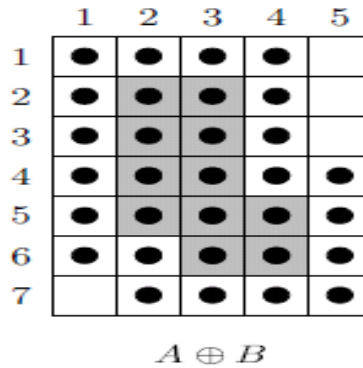

$A \oplus B$

Figure 5 : Dilation

In image processing, dilation is used to add pixels at region boundaries or to fill in holes in the image [26] [27], particularly useful in connecting disjoint pixels and add pixels edges. However, they encounter disadvantage that dilation would completely closes up or narrow down holes. Sanaa E. Hanfj, Mohiy M. Hadhoud , & Khaled E. Mustafa [29] shares the similar opinion that dilation incorporating into the object all the background points that touch it, leaving it larger in area by that amount.

2.5.2 EROSION

Alasdair McAndrew [8] states that erosion can be mathematically describe in such that

$$A \ominus B = \{W : B_W \sqsubseteq A \}$$

By performing erosion onto image, the position is translated depending on the value of erosion.
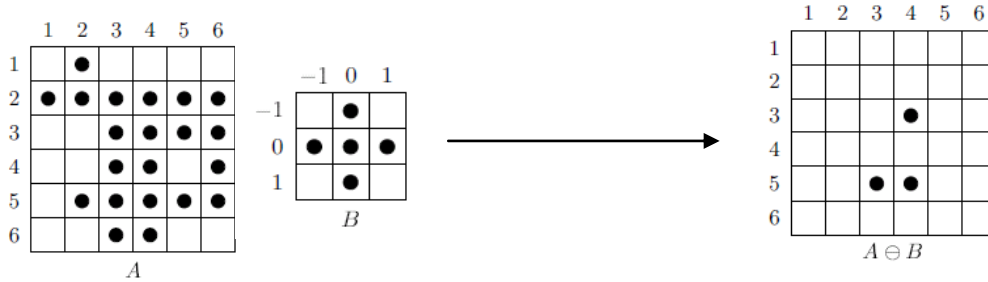

Figure 6 : Erosion

The Erosion operation does the opposite operation of dilation. While dilation expands boundaries and fills holes, erosion reduces boundaries and increases size of holes. The authors also stress that utilization of dilation can reduce noise [26]. Besides, Erosion eliminates the entire boundary from an object, thus leaving the object smaller in area by one pixel all around its perimeter, making it feasible in terms of removing segmented image objects that are too small to be of interest [29].

2.5.3 OPENING

The opening and closing morphology is a secondary level operation – they are devised based on the principals of dilation and erosion [8]. Opening operation involves 2 continuous steps of erosion and then dilation morphology.

The opening operation can be mathematically illustrated in such:

$$A \circ B = (A \ominus B) \oplus B$$

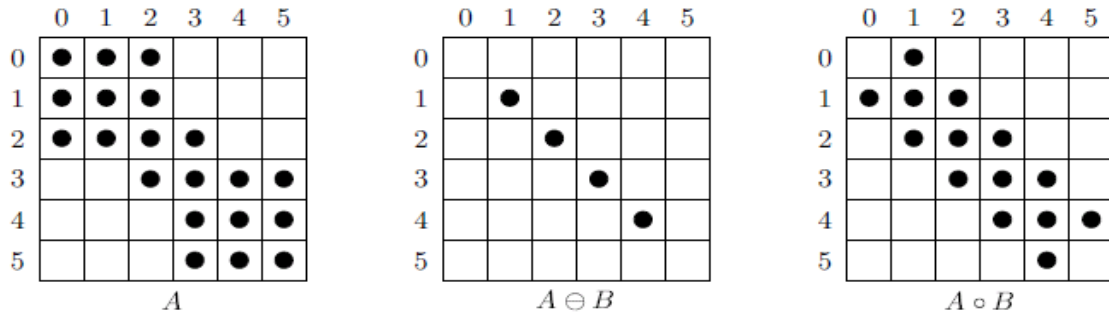Opening tends to smooth an image, to break narrow joins, and to remove thin protrusions [8][26].

Figure 7 : Opening

2.5.4 CLOSING

In contrast to opening, closing does the opposite; it performs an operation of erosion and then dilation [8]. It is denoted as:

$$A \cdot B = (A \oplus B) \ominus B$$

The closing operation tends to smoothing sections of contours, however fuses narrow breaks and thin gulfs, filling gaps in contour and eliminates small holes [8][26].
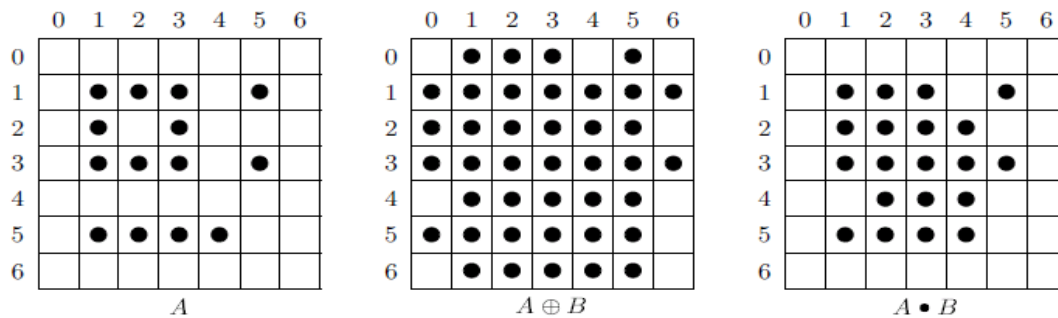

Figure 8 : Closing

2.6 MORPHOLOGY PROCESSING

Nursuriati Jamil , Tengku Mohd Tengku Sembok, & Zainab Abu Bakar [26] has conducted an experiment to find out the required morphological operation and sequence performed on an image, ranking them in terms of noise reduction and best possible representation of the actual value

Image	Morphological Operation	Image	Morphological Operation
1	Erode(3x), Dilate(3x), Majority-Close(4x)	8	Erode, Close, Dilate, Fill, Majority
2	Erode(2x), Dilate(3x)	9	Dilate, Open, Dilate
3	Majority-Close(2x)	10	Majority-Close(3x), Erode
4	Erode, Dilate	11	Close
5	Majority-Close (5x)	12	Majority
6	Majority-Close	13	Erode(3x), Dilate(3x), Close-Majority, Close
7	Erode, Fill, Majority-Close(4x), Open	14	Close-Majority(3x)

* Majority - set a pixel to 1 or 0 depending on the majority of its neighborhood pixels.

Table 2: Morphological Operation results

The results shows that close, dilate, majority and erode are the most used morphological operations in the paper [26]. They suggested that the combination of majority close and erode-dilate are able to significantly improve their appearance.

Therefore with reference with the results above, I would use the close, dilate, majority and erode operation to perform the image processing analysis.