" I hereby declare that I have read through this report entitle "Development of Object Tracking Architecture Based on Colour Recognition Method for Autonomous Motion Detection System" and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Mechatronics)"

Signature : …….

Supervisor's Name : …….

Date : …….

DEVELOPMENT OF OBJECT TRACKING ARCHITECTURE BASED ON COLOUR RECOGNITION METHOD FOR AUTONOMOUS MOTION DETECTION SYSTEM

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A report submitted in partial fulfilment of the requirements for the degree of Mechatronic Engineering with Honours

Faculty of Electrical Engineering

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2016

I declare that this report entitle “Development of Object Tracking Architecture Based on Colour Recognition Method for Autonomous Motion Detection System” 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 : …….

Name : …….

Date : …….

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ABSTRACT

Object tracking has many applications in today's diverse range of embedded systems. Object detection and localization are important for many other practical applications such as manufacturing automation, navigation, part inspection, and computer aided design, (CAD) or computer aided manufacturing, (CAM). However, the object detection and motion tracking are the most important and challenging fundamental task of computer vision. It is a critical part in many applications such as image search or scene understanding due to the variety and complexity of object classes and backgrounds. The easiest way to detect and track an object in motion from image captured is the color based method. The object and the background should have a significant color difference in order to successfully detect and track the objects based on color recognition. The main objective of the development of object tracking architecture based on color recognition method for autonomous motion detection system is focusing on how to successfully track a moving object based on color recognition. Briefly, the computer vision algorithm uses the Open CV library, which is embedded into a system for manipulating the captured image of the object. The image of the object is captured by a camera. The captured image is then subjected to color conversion and is transformed to a binary image for further processing after it is being filtered. The desired object is clearly determined after removing pixel noise by applying an image processing. Finally, the area and the center of the object are determined so that object's motion can be tracked. The details concerning the implementation of this method will be discussed. The experimental evaluation is conducted to evaluate the effectiveness of the proposed method and it shows reliable color detection and smooth tracking characteristics.

ABSTRAK

Aplikasi pengesanan objek dan proses menjejaki objek yang dikesan semakin luas penggunaannya dalam julat yang pelbagai. Pengesanan objek adalah penting untuk lebih banyak aplikasi praktikal yang lain seperti automasi pembuatan, navigasi, pemeriksaan bahagian peralatan dan reka bentuk bantuan komputer atau pembuatan terbantu komputer (CAD/CAM). Walau bagaimanapun, pengesanan objek dan proses menjejaki objek yang bergerak merupakan tugas asas yang paling penting dan mencabar dalam sistem penglihatan komputer. Ia adalah satu bahagian penting dalam banyak aplikasi seperti pencarian imej atau pengadaptasian persekitaran kerana faktor kepelbagaian kelas objek dan latar belakang yang merumitkan. Cara paling mudah untuk mengesan dan menjejaki objek bergerak daripada imej objek yang ditangkap adalah melalui kaedah pengesanan objek berdasarkan warna. Objek dan latar belakang harus mempunyai perbezaan warna yang ketara untuk berjaya mengesan dan menjejaki objek berdasarkan pengiktirafan warna. Objektif utama pembangunan sistem ini adalah untuk memastikan objek yang dikesan berjaya dijejak berdasarkan ciri warna yang terdapat pada objek yang dikesan. Secara ringkasnya, algoritma untuk pemprosesan imej yang diwujudkan dalam sistem penglihatan komputer melibatkan pengekodan dari Emgu CV, di mana pengekodan program diimport masuk ke dalam sistem untuk memanipulasi imej objek yang dikesan. Imej yang ditangkap kemudiannya tertakluk kepada penukaran warna dan ditukar kepada imej binari untuk proses seterusnya seperti penapisan imej dan sebagainya. Imej objek yang dikehendaki akan ditentukan selepas gangguan piksel dikeluarkan dengan menggunakan teknik pemprosesan imej. Pusat objek ditentukan melalui kaedah pengiraan tertentu supaya pergerakan objek boleh dikesan. Pelaksanaan kaedah ini akan dibincangkan secara terperinci. Beberapa eksperimen telah dijalankan bagi menguji dan menilai keberkesanan kaedah yang dipilih. Hasil keputusan eksperimen menunjukkan kelancaran sistem pengesanan objek berdasarkan ciri warna yang ada pada objek.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The development of object tracking system in autonomous motion has gained much attention mostly in industrial manufacturing. Based on its popularity, many advanced technologies related to object tracking research has been proposed. It can be referred to past articles such as Monocular-Vision Based Study on Moving Object Detection and Tracking [1], Colour Texture Classification Using Wavelet Transform From its Grey Scale [2], Colour-Based Object Tracking in Surveillance Application [3]. Various methods have been investigated, and some of them are related to the ways of detecting an object in motion. There are many approaches to object detection. Some simple approaches to object detection are based on certain distinguishable features of the object. The object features such as colour, shape, edge, or texture will affect the process of detection. In some cases, colour can be a very good feature for detecting the object. However, it would not always work as the object to be detected may have the same colour as any object in that area of detection. This can lead to a lot of misidentification and misclassification.

Previously, the research is completely done on detection and tracking the moving colour object by monocular vision mobile robot visual feedback [4]. It presents an approach for recognizing and tracking a moving colour object which breaks into the robot's camera vision in the mobile robot. In order to obtain input feature for moving object recognition, the image processing of video sequence is performed by background subtraction method. Based on the

background subtraction method, a colour classifier based on the HS thresholds is trained to detect a moving object. The moving object recognition performance can be improved significantly by using information about object's edge as an additional feature. Through the recognition, they can find the centre of the moving object and control the mobile robot's angle and rate to realize the vision-tracking of the moving object.

One research was conducted considering an accuracy and flexible method for recognition and tracking of multiple objects even in challenging tracking conditions like occlusion and background clutter [4]. The object recognition algorithm used is based on colour moments and wavelet moments. The research on it proposes a method for object tracking by combining feature matching and Kaltman's filter tracking framework. The colour moments and wavelet moments are integrated together for recognition and tracking while Kaltman's filter framework is utilized to assist in tracking multiple objects. In other related vision study, the consideration on the object's coordinate and orientation are important in providing a trajectory movement from camera to the centre of the object detected.

1.2 Motivation

Object tracking has many applications in today's diverse range of embedded systems. Object detection and localization are important for many other practical applications such as manufacturing automation, navigation, part inspection, and computer aided design, (CAD) or computer aided manufacturing (CAM). The most important and challenging tasks of computer vision is object detection and motion tracking. Over the past decades, several performance evaluation projects for object tracking systems have been developed with different emphasis and motivation. The main issues in the development of such a system are the optimizing of the object tracking method during detection based on colour recognition. While there are many pattern recognition algorithms available, care must be taken to select an optimal pattern recognition algorithm for each task. The development of object tracking architecture based on colour recognition method is mainly focusing on how to track a moving colour object

considering the acquisition, processing and interpretation of the available information obtained from image processing.

1.3 Problem Statement

Object detection and recognition from real world situations pose many more challenges. A variety of problems of current interest in computer vision require the ability to track moving objects, whether for purposes of surveillance, manufacturing, video compression or others. In industrial manufacturing, there will have the process of classifying products based on its specific characteristics such as shape. The system may successfully detects the products based on its shape, but somehow when it comes to some cases where the products to be detected are having similar shape as any other object in the range of detection area, it would not always work. For this case, the presents of colour as an additional feature can improve the performance of detection as colour can provide an efficient visual cue for focus of attention in object tracking and recognition. In other cases, assuming that the scene illumination does not change, the image changes are due to relative motion between the scene objects and the camera. So, the development of this project can help in tracking the object motion with less error.

1.4 Objective

1. To develop a hardware architecture of an autonomous system that can track an object in motion based on colour recognition
2. To develop an algorithm that can track the object motion based on colour recognition by considering the image processing techniques.
3. To analyse the performance of developed system in terms of the accuracy in tracking the object based on its colour characteristic.

1.5 Scope

Basically, the development of this project is focusing on how to successfully track an object from USB camera based on the colour characteristics of the object. The application provides an efficient moving colour object detection along with tracking of the object from an image captured. For this to happen the algorithm involved includes Open CV library, which are embedded into a system for manipulating the captured image of the object. The image of the object is captured by USB high definition camera as a sensor. The captured image is then subjected to colour conversion and being processed in graphical user interphase, (GUI) from computer vision. The centre of the object image is determined by calculating the centroid of the object. For the object tracking process in this project, the camera sends image frames to the Visual Studio C++ which contains Open CV library running on a computer. If Visual Studio C++ program detects the image of the object from the camera then it calculates the coordinates of x, y axis and radius of the object. The coordinates are sent accordingly to the Arduino UNO through serial communication between the Arduino and Visual Studio C++. After receiving the coordinates the servo motor moves in x and y direction and follows the desired object. In this project, the tracking of moving colour object is limited from 0° to 180° as a servo motor can only turn 90° in either direction for a total of 180° movement. For a better performance, the tracking process can be conducted during daylight or when there is an optimum intensity of light.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Object detection and recognition are an important task in image processing and computer vision. It is concerned in determining the identity of an object being observed in an image captured. Human can recognize any object in the real world easily with less efforts while machines or system itself cannot. Thus, object recognition techniques need to be developed which are less complex and efficient.

Object tracking is an important job within the field of computer vision. Tracking is the process of locating a moving objects over a period of time using a camera. Technically, tracking is the problem of estimating the trajectory or path of an object as it moves around the scene. The availability of high quality and inexpensive video cameras, and the increasing need for automated video analysis has generated a great deal of interest in object tracking algorithm. There are three important elements need to be considered including the detection of moving object, tracking of such moving objects, and analysis of object tracks to recognize their behaviour. In this case, the recognition is based on colour characteristic.

Object tracking is commonly applied in certain areas such as motion-based recognition, automated surveillance, video indexing and interactive games. However, many researchers found that it is a critical part in many applications such as image search or scene understanding due to the variety and complexity of object classes and backgrounds. Sometimes it might be

complex due to noise in images, complex object shapes and motion, or scene illumination changes. So, there are several methods need to be considered in order to minimize error in colour object motion detection.

2.2 Classes of Object Recognition Methods

Object recognition is a process for identifying a specific object in a digital image or video. Object recognition algorithms rely on matching, learning, or pattern recognition algorithms using object representation such as appearance based or feature based techniques. An object is simply nothing but an entity of interest. Objects can be represented by their shapes and appearances. For example, boats on the sea, fish in an aquarium, vehicles on the road, planes in the air or people walking on a road may be important to track in a specific domain. So, there are various methods of recognizing the objects which are commonly used for tracking purpose. In general, there is a strong relationship between object representation and tracking algorithms. Object representations are chosen according to the application domain.

2.2.1 Colour Based

The presents of colour as an additional feature can improve the performance of detection as colour can provide an efficient visual for focus of attention in object tracking and recognition. A simple and efficient object detection scheme is to represent and match images on the basis of colour histograms [5].

Fahad Khan [6] and Theo Gevers [7], has proposed the use of colour attributes as an explicit colour representation for object recognition. There are three main criteria should be considered when choosing an approach to integrating colour into object recognition. There are combination of features, photometric invariance, and compactness. The authors have found that object detection based on the shape of object itself does not always work as there are complexity exists during detection unless there are an additional feature combined together to make it more efficient. The paper investigates the incorporation of colour for object recognition based on the

above mentioned criteria and demonstrate the advantages of combining colour with shape. The resulting image representations are compact and computationally efficient. It also provides an excellent detection performance. In this paper, the authors aim to examine and evaluate a variety of colour models used for recognition of multi-coloured objects according to the criteria of robustness to a change in viewing direction, object geometry, direction of illumination and intensity of the illumination. The colour models have high discriminative power, robustness to object occlusion and cluttering, and robustness to noise in the images. Figure 2.1 shows the example of colour-based detection by detecting green colour object from the original image.

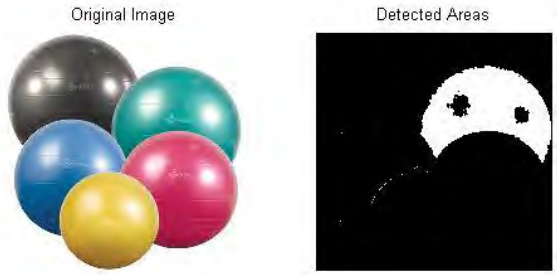

Figure 2.1 Green colour-based detection

2.2.2 Contour Based

Contour is defined as the outline of a figure or body, the edge or line that defines a shape or object. In previous work, contour curvature and junctions are important for shape representation and detection. Considerable effort was spent in the past matching geometric shape models of object to image contours [9, 10, 11]. However, it is clear that finding contours exactly belonging to the shape of an object is not easy. Joseph Schlecht [8] has discussed the representation for the complimentary characteristics of object, their contours and appearance. For object detection to work, a robust and powerful representation is required. Objects are characterized by their appearance, especially their texture, and by the shape of their contours. This paper has presented an effective and computationally efficient representation of contours and junctions that accurately localizes and describes the local shape of contours. The

combination of contour representation and a semi-local appearance has significantly improved the performance of object detection. Figure 2.2 shows the example of detection based on contour.

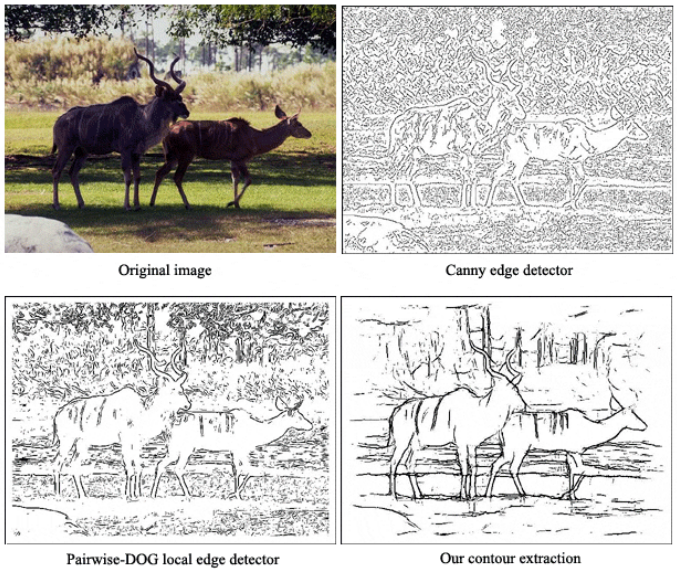

Figure 2.2 Contour-based detection

2.2.3 Edge Based

Edge based detection is an image processing technique for finding the boundaries of objects within images. It works by detecting discontinuities in brightness. Edge detection is used for image segmentation and data extraction in areas such as image processing, computer vision and machine vision. Basically, an edge is a set of connected pixels that lies on the boundary between two regions. An edge as a local concept whereas a region boundary, owing to the way it is defined, is a more global idea. During image acquisition it is obvious some noise will be introduced in the image. However, there are some prepared solutions on that. The first step is computing a measure of edge strength. It is usually a first order derivative expression such as gradient magnitude. Next, searching for local directional maxima of the gradient magnitude using a computed estimate of the local orientation of the edge. It is usually gradient direction.

There will have a smoothing process by Gaussian smoothing and thresholding in order to decide whether edges are present or not on an image point. The lower the threshold, the more edges will be detected. So, the result will be increasingly susceptible to noise as it will detect edges of irrelevant features in the image. A high threshold may miss subtle edges, or result in fragmented edges. In the end, there is edge linking step to connect the edges detected.

From the research done by K.Mikolajczyk, A.Zisserman and C.Schmid on "Shape Recognition with Edge-Based Features", an approach to recognizing poorly textured objects that may contain holes and tubular parts, in cluttered scenes under arbitrary viewing conditions is described [12]. In this paper, a recognition approach based on local edge features invariant to scale changes is presented. It is aimed to recognize classes of roughly planar objects of wiry components against a cluttered background. For example, bikes, chair, ladder, and others. To the end, a number of novel components is developed. First, they introduced a new edge-based local feature detector that is invariant to similarity transformations. The features are localized on edges and a neighbourhood is estimated in a scale invariant manner. Second, the neighbourhood descriptor computed for foreground features is not affected by background clutter, even if the feature is on an object boundary. Third, the descriptor generalizes Lowe's SIFT method [13] to edges. An object model is learnt from a single training image. The object is then recognized in new images in a series of steps which apply tighter geometric restrictions. A final contribution of this work is to allow sufficient flexibility in the geometric representation that objects in the same visual class can be recognized. Figure 2.3 shows the example of edge-based detection.

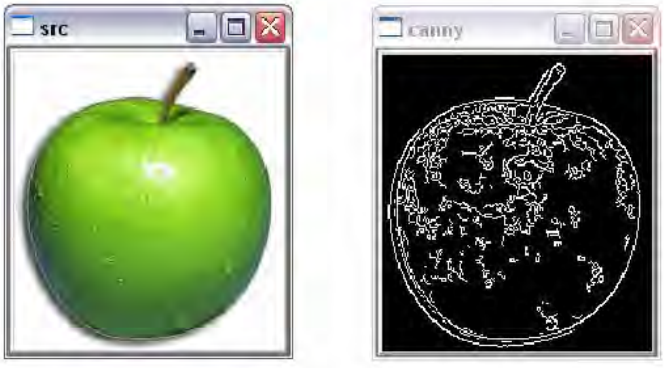

Figure 2.3 Edge-Based Detection

2.3 Moving Object Detection

Extracting moving objects from image sequences is a major interest in numerous applications. Each application has different needs, thus requires different treatment. However, they have something in common which is moving objects. Thus, detecting regions that correspond to moving objects such as people and vehicles in video is the first basic step of almost every vision system since it provides a focus of attention and simplifies the processing on subsequent analysis step. Due to dynamic changes in natural scenes such as sudden illumination and weather changes, repetitive motions that cause clutter such as tree leaves moving in blowing wind, motion detection is a difficult problem to process reliably. Frequently used techniques for moving object detection are background subtraction, frame difference methods, temporal differencing and optical flow.

2.3.1 Background Subtraction

Background subtraction is particularly a commonly used technique for motion segmentation in static scenes [14]. It attempts to detect moving regions by subtracting the current image pixel-by-pixel from a reference background image that is created by averaging images over time in an initialization period. The pixels where the difference is above a threshold are classified as foreground. After creating a foreground pixel map, some morphological post processing operations such as erosion, dilation and closing are performed to reduce the effects of noise and enhance the detected regions. The reference background is updated with new images over time to adapt to dynamic scene changes.

There are different approaches to this basic scheme of background subtraction in terms of foreground region detection, background maintenance and post processing. In [15], Heikkila and Silven used a simple version of this scheme where a pixel at a location (x,y) in the current image I_t is marked as foreground if

$$| I_t (x,y) - B_t (x,y) | > \tau \quad (2.1)$$

in satisfied where τ is a predefined threshold. The Infinite Impulse Response (IIR) filter is used to update the background image B_t

$$B_{t+1} = \alpha I_t + (1 - \alpha) B_t \quad (2.2)$$

However, the background subtraction techniques are usually sensitive to dynamic changes when there are stationary objects uncover the background. For example, a parked car moves out of the parking lot) or illumination changes occur.

2.3.2 Frame Difference Method

The frame difference is one of the method used for motion detection. This method adopts pixel-based difference to find the moving object. It is a pixel-based differencing between two or three consecutive frames in an image sequence to detect a region of moving object. Frame differencing is the simplest moving object detection as it determines the difference between input frame intensities and background model by using pixel per pixel subtraction. In general, videos consist of sequences of image which is called as a frame. In video surveillance system, the method of frame difference is commonly used to detect the moving objects by differencing the current frame and a reference frame called as 'background image'.

From the research done by Nishu Singla [15], a new algorithm for detecting moving objects from a static background scene based on frame difference is presented. The first frame is captured by a static camera followed by the sequence of frames at regular intervals. The absolute difference is calculated between the consecutive frames and the difference image is stored in the system. The difference image is then converted into grey image before it is being translated into binary image. After that, there is a process of removing noise using morphological filtering. Thus, it gives a complete movement information and detect the moving object from the background better. Figure 2.4 shows the motion detection based on frame difference method where when there is a movement in the scenes, then the binary image of the