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DEVELOPMENT OF OBJECT TRACKING ARCHITECTURE BASED ON OPTICAL FLOW VECTOR FOR AUTONOMOUS MOTION DETECTION SYSTEM

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DEVELOPMENT OF OBJECT TRACKING ARCHITECTURE BASED ON OPTICAL FLOW VECTOR FOR AUTONOMOUS MOTION DETECTION SYSTEM

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A report submitted in partial fulfillment of the requirement for the Bachelor of Mechatronics Engineering with Honours

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I declare that this report entitle Development Of Object Tracking Architecture Based On Optical Flow Vector 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.

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To my beloved mother and father.

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ABSTRACT

Autonomous motion detection system is important in many developed application. The applications of object tracking can be utilize in various categories for a numerous important reason such as humans, vehicles random and other random objects movement. The motion captured from the video stream will be analyze and the direction and speed of the dynamic object have to be obtained. Hence, the suitable method of calculating the optical flow need to be chooses wisely. This research is to identify moving object and dominant moving direction for each of motion vector and analyze the data within execution time. Then, to process a video frame by frame as they appear in video stream and display in GUI. The system need to capture object motion from the video stream and display it using GUI which in this research Myrobotlab software will be used as the system interface. By implementing optical flow technique, the system has to model and provide data collection of motion existed. The pattern modeling motion of the object has to be analyzing in order to determine direction and speed of dynamic object motion. OpenCV library will be integrated in Myrobotlab as well as Arduino which act as a microcontroller between Webcam camera and the GUI. The algorithm which is Lucas Kanade is used as part of the system. The results provide the motion direction and speed of the camera target by the system. The technique is successful to detect object and provide the parameter needed to display the processed motion existed. In general, the developed system can achieve the objective to track an object and being used in related vision technology field.

ABSTRAK

Automasi sistem pengesanan gerakan adalah penting dalam banyak aplikasi maju. Aplikasi pengesanan objek boleh digunakan dalam pelbagai kategori untuk pelbagai sebab penting seperti manusia, kenderaan, pergerakan objek rawak dan lain-lain.Pergerakan yang ditangkap dari aliran video akan dianalisis seterusnya arah dan kelajuan objek dinamik akan diperolehi. Oleh itu, kaedah yang sesuai untuk mengira keperluan aliran optik perlu dipilih dengan bijak. Tujuan kajian ini adalah untuk mengenal pasti pergerakan objek dan arah pergerakan dominan bagi setiap vektor gerakan dan menganalisis data dalam masa pelaksanaan. Kemudian, pemprosesan bingkai dengan bingkai video yang lain yang muncul dalam aliran video akan dipaparkan dalam GUI. Sistem ini perlu untuk menangkap gerakan objek daripada aliran video dan memaparkannya menggunakan GUI di mana dalam kajian ini Myrobotlab akan digunakan sebagai antara muka sistem. Dengan melaksanakan teknik aliran optik, sistem ini akan membuat pengumpulan data gerakan yang wujud. Pemodelan corak pergerakan objek akan dianalisis untuk menentukan arah dan kelajuan gerakan objek dinamik. Perpustakaan OpenCV akan disepadukan dalam Myrobotlab dan juga Arduino yang bertindak sebagai pengawal mikroantara kamera Webcam dan GUI. Algoritma Lucas Kanade digunakan sebagai sebahagian daripada sistem. Hasilnya, hala tuju gerakan dan kelajuan sasaran kamera oleh sistem dapat disediakan.Teknik ini berjaya mengesan objek dan menyediakan parameter yang diperlukan untuk memaparkan kewujudan gerakan yang telah diproses.Secara umumnya, sistem yang dimajukan ini dapat mencapai objektif untuk mengesan objek dan digunakan dalam bidang berkaitan teknologi visual.

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CHAPTER 1

INTRODUCTION

1.1 Overview

In this chapter, the detail of the project will be explained which is research background, motivation, problem statement, objectives and scope of the research.

1.2 Research Background

There is a various ways in developing an object tracking architecture. This research implements optical flow vector technique. Detection of motion is crucial in many tasks depending on the need such as video surveillance, robotics, user interface by gestures, tracking of movement and many others [1]. Optical flow method is a method used for particular fields such as allowing better video compression, image segmentation for tracking a moving object and motion estimation to predict the motion vector of a moving object [2]. Optical flow is the pattern that represents the motion of objects, edges, surfaces in real world by using displacement vectors or color flow [3].

Autonomous motion detection system seeks to automatically detect objects from the vision of the camera target. Basically, these systems consist of either static or moving cameras

to detect the motion existed. Computer system and micro-controller are used to process the video captured by the camera and recognized the object in each frames.

The system has to process a video frame by frame as they appear in video stream. Given the observed optical flow orientations at each pixel, estimate the motion parameters and pixels labels [4]. The object will be identified and the dominant moving direction of each of them will be labeled. Optical flow vectors, color features and stereo pair disparities were used as visual features. Each of these approaches for ground moving vehicles impose a different set of constrains for the determination of the optical flow [5].

The system need to acquire object motion from the video stream and display it using Graphical User Interface(GUI) which in this research visual basic will be used as the system interface. By implementing optical flow technique, the system has to model and provide data collection of motion existed. The pattern modeling motion of the object has to be analyze in order to determine direction and speed of dynamic object motion.

1.3 Motivation

These days, vision system plays a significant role in enhancing modern life application. One of the applications is object tracking which being implementing in various categories for a numerous important reason such as humans, vehicles and other random objects movement. The technology is expanding by days, for example visualization in drone engineering which becoming obsession for multipurpose objective such as traffic monitoring, disaster control and others.

So, the vision technology needs to be developed as it will ease human in completing a tasks that beyond the human capability in monitoring, video surveillance and so on. The thing is that what the object tracker is capable of recording an object, thus it provides a complete movement such as speed. This is important so that it can track the behavior of an object they want to study or knowing where the object movement is leading to in term of direction.

In order to tackle the issue, this research will be based on optical flow technique in autonomous motion detection system as optical flow methods is happen to be a quite better alternatives based on comparative study of object detection methods as shown in Table.1.1.In object tracking architecture, there is a lot of technique available to detect the object or a motion of an object. However, it back to the objective of what the system wants to solve. In order to develop a robust technique to describe the characteristic of an image, optical flow is a solution where it provides complete information of a movement. Hence, detect the moving object better [6].

Table 1.1: Comparative study of object detection methods [6]

Methods		Accuracy	Computational Time	Comments
Background Subtraction	Gaussian of Mixture	Moderate	Moderate	+ Low memory requirement
				-It does not cope with multimodal background
	Approximate Median	Low to Moderate	Moderate	+ It does not require sub sampling of frames for creating an adequate background model
				-It computation requires a buffer with the recent pixel values
Optical Flow		Moderate	High	+It can produce the complete movement information
				- Require large amount of calculation
Frame Differencing		High	Low to Moderate	+Easiest Method. Perform well for static background
				- It require a background without moving objects

1.4 Problem Statement

There are three main challenge in the field of creating an autonomous motion detection system by using optical flow technique which as follows;

The first challenged is to implement object tracking technique. There are several methods existed and the suitable method have to be choose wisely in term of how his system will be operated using applied technique.

The second challenged is the movement of an object can be track. The object tracking should follow the movement of an object and how this should be done.

The third challenged it is difficult to implement object tracking in most surveillance system. Thus, how optical flow may affect the tracking of the object.

1.5 Objectives

Based on the problem statement stated above, the objectives of this project are described as follows:

- To design a vision system based on optical flow vector technique that implement Lucas Kanade algorithm and hardware configuration.
- To develop the designated system which can identify the object movement by using OpenCV library that consists of hardware and software.
- To analyze the optical flow performance on developed system.

1.6 Scope of Research

The scope of this project is optical flow which using the Lucas Kanade algorithm in the system. The system analyses the motion parameter of the object detection process in video stream and display in GUI. 5 Megapixel Webcam Camera is used to detect the object and track the movement. The experiments were conducted in two different environment which are indoor (standard room light intensity) and outdoor which is 150 lx and 5254 lx.

1.7 Thesis Outline

The thesis is organized as follows. Chapter 2 presents a general overview as well as the analysis and synthesis of each part consists. Then, Chapter 3 describes the methodology on the optical flows techniques in order to track the real dynamic motion of an object. In Chapter 4 present result and discussion of the acquire result obtained. Finally, Chapter 5 highlights conclusions and recommendation of this system as a whole.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of System

In the previous chapter, the surface of this research is exposed in term of scope, objectives, statement of problem, motivation as well as project background. In this chapter, the previous research will be analyze, synthesis and evaluate so that this research is based on real research which had been done.

2.2 Optical Flow Orientation

Optical flow plays an important role in vision system as it develops a robust technique in object tracking architecture field. In addition, optical flow provides the extraction of motion in order to get the velocity and angle. Thus, this technique will able to calculate the displacement as well as the dense of intensity in each frame of the movement video[7].

Suzimah, M. Lazim, T. Khalisah, Norulzahrah stated in Implementing Optical Flow algorithm for Human Aggressive Movement Detection that optical flow can give important information about the spatial arrangement of the object viewed and the rate of change of this

arrangement. The discontinuities that appear in the optical can assist in segmenting the image into area that related to different objects. As the optical flow block can estimates the direction and speed of object motion video frame, the method have to be choose using Horn-Schunk, Lucas-Kanade or Brox's method. Horn-Schunk method is based on residuals from the brightness constancy constraint and a realated regularization term expressing the expected smoothness of the flow field while Lucas-Kanade method refer to image patches and an affine model for the orientation of the flow field[7].

In research of Improved Optical flow Estimation in Traffic Monitoring System by Nguyen, Brox's method algorithm is based on the gradient constancy assumption. Thus, when there is an object with similar gradient value with background, the flow can be incorrect. This due to Brox's method results in dense optical flow. The comparison of the technique shows the method that gives smaller angular errors and works better in an environment with noise. The standard error of measurement of optical flow fields against vertical object displacement as shown in Figure. 2.1[3].

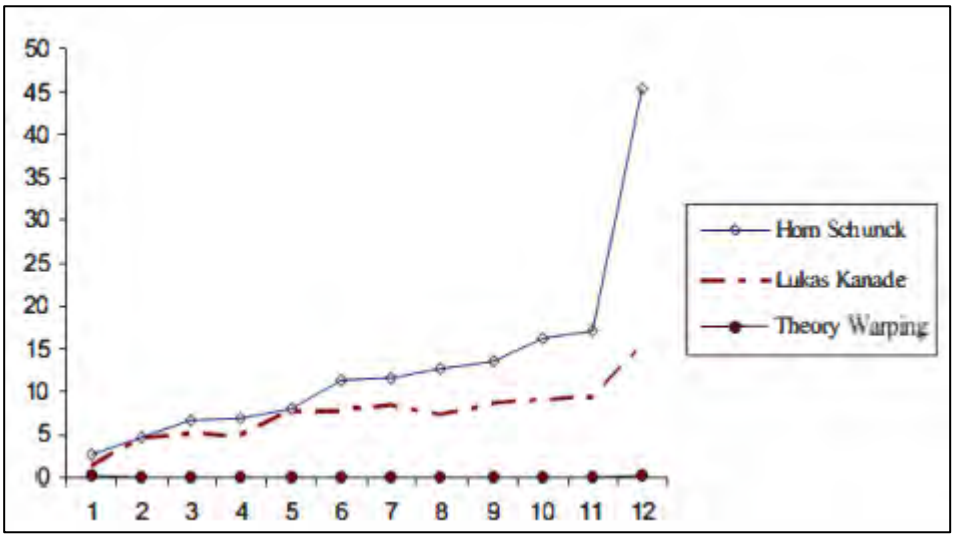

Figure 2.1: The SEM of Optical flow Fields against vertical object displacement [3]

Patel, Parmar state in Moving Object Detection with Moving Background using Optic Flow that by computing Lucas- Kanade algorithm its provide accurate and efficient results with moving background. However, this research implementing bilateral filter followed by the

stated optical flow algorithm so that the time to detect object only become lesser. Inter-frame difference method is used to measure the flow. The aim of this method is to compute motion vector to detect motion. The position of a point in frame I_2 should match the intensity of frame I_1 at a certain position (x, y) in order to design a motion vector as shown in Figure 2.2 [2].

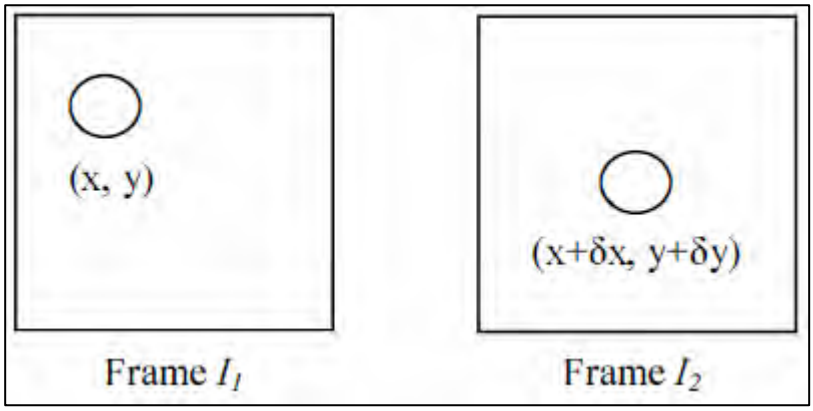

Figure 2.2: Example of Motion Flow [2]

In research of Coherent Motion Segmentation in Moving Camera Videos using Optical Flow Orientations by M. Narayana, A. Hanson, E. Learbed-Milller, optical flow orientation is used as it is independent in term of object depth. Optical flow is use as it is a common theme in removing camera motion segmentation. Optical flow is implement to avoids the over segmentation of the scene into depth-dependent entities. The Brox technique is used as it improved the spectral clustering by using higher order interactions that consider triplet of trajectories. However, the algorithm will prone to error when the assumption of pure translation is violated. In the case of rotating the camera, the foreground object that move with the same flow orientation as camera motion will be undetected.[4]

In research of Visual Tracking: An Experimental Survey by Arnold W. M. Smeulders state that Lucas Kanade Tracker gives an optimization for the best match is often found limits the search to direct gradient ascent. Despite the algorithm available, Deviation Measure can determine the most accuracy tracker. Figure 2.3 shows that Lucas Kanade search to the maximum the direct match of the target. The plots observe no correlation of Deviation Measure with F-score. The left subplot show that whenever the target and the ground truth overlap whereas the right subplot when the target is being tracked correctly, which is with an

overlap >50%. The flat part of the TMC-curve represents the videos for which the tracker loses track in the second frame [8].

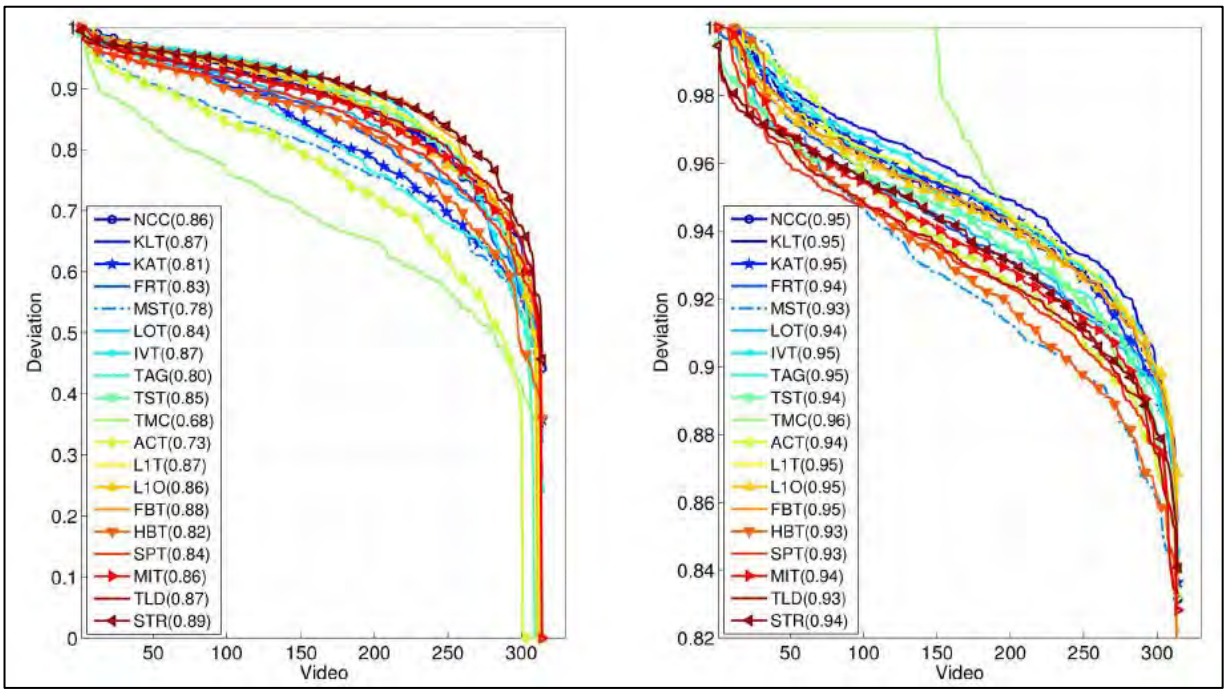

Figure 2.3: Trackers with respect to the Deviation Metric [8]

Based on Figure 2.1[3], the technique in optical flow was display in term of Standard Error of Measurement (SEM) of optical flow fields against vertical object displacement. Horn Schunk method show a higher SEM when the vertical object displacement is increase. However, Lucas-Kanade method shows a slightly constant SEM over the increases of vertical object displacement. For the warping theory such as Brox's warping technique, it is shown that the SEM remains zero as the vertical object displacement increase. In addition, Figure 2.3[8] show Lucas Kanade can track the object correctly compared to others.

However, Brox'smethod have an additional constraint in order the algorithm can perfectly implemented as stated in [7]. The research in [4] shown that the system developed models only translational and prone to error when the camera rotates. The flow can be incorrect by certain constrain as stated in [3]. Lucas Kanade method is considered to be