DETECTION AND CLASSIFICATION OF MOVING OBJECTS FOR AN AUTOMATED SURVEILLANCE SYSTEM

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

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Dedicated to my loving family, for their endless support

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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Chairman: **Associate Professor Adznan Jantan, PhD**

Faculty: **Engineering**

Automated surveillance system has been the subject of much research recently. A completely automated system means a computer will perform the entire task from low level detection to higher level motion analysis. Since conventional system practically using human power to monitor and did not applicable for a long hour monitoring, thus automated system had been created to replace the conventional system. This thesis focuses on a method to detect and classify a moving object that pass through the surveillance area boundary. Moving object is detected by using combination of two frame differencing and adaptive image averaging with selectivity. Technically, this method estimate the motion area before updates the background by taking a weighted average of non-motion area of the current background altogether with non-motion area of the current frame of the video sequence. This step had created a focus of attention for higher level processing and it helps to decrease computation time considerably. The output of a motion–based detector is essentially a collection of foreground that might correspond to the moving objects. But usually the output image produced from this

process contaminated with noise and shadow. As a solution, morphological operation has been employed as an approach to remove noise from the foreground object. Mutual shadow that exists with the object had been abolished by combining chromatic colour values with lightness variable. Then, standardized moment invariant is employed to extract the features for each moving blobs. To recognize these blobs, the calculated moment values are fed to a support vector machine module that is equipped with trained extracted moment values for human and vehicle silhouettes. The system operates on colour video imagery from a stationary camera. It can handle object detection in outdoor environments and under changing illumination conditions. The applied post processing module capable to remove noise and shadow from the detected objects with less than 1% of error. Finally, classification algorithm that makes use of the extracted moment values from the detected objects successfully categorize objects into pre-defined classes of human and vehicle with 89.08% of accuracy. All the methods have been tested on video data and the experimental results have demonstrated a fast and robust system

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PENGESANAN DAN KLASIFIKASI OBJEK-OBJEK BERGERAK UNTUK SISTEM PENGAWASAN AUTOMATIK

Oleh

MOHD RAZALI BIN MD TOMARI

September 2006

Pengerusi: **Profesor Madya Adznan Bin Jantan, PhD**

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Sistem pengawasan automatik telah menjadi antara bidang penyelidikan yang utama ketika ini. Sistem pengawasan automatik menyeluruh bermakna komputer melakukan semua kerja daripada peringkat terendah pengesanan hingga ke peringkat tinggi analisa pergerakan. Oleh kerana sistem sedia ada menggunakan manusia , ia tidak sesuai dan berkualiti untuk pegawasan dalam tempoh waktu yang lama, maka sistem automatik ini merupakan alternatif terbaik menggantikan sistem konvensional tersebut. Tesis ini memfokuskan kaedah untuk mengesan dan mengklasifikasi objek bergerak yang merentasi kawasan pengawasan. Objek bergerak dikesan menggunakan kombinasi teknik pembezaan dua kerangka dan teknik purata imej suai dengan pemilihan, dimana secara teknikalnya, kaedah ini menganggar kawasan pergerakan sebelum mengemaskini latarbelakang dengan mengambil kira purata piksel pemberat diluar kawasan pergerakan daripada latarbelakang dan kerangka terkini daripada susunan video. Langkah ini memfokuskan kepada kawasan yang lebih khusus dan kecil untuk proses yang lebih tinggi ,dengan itu secara tidak langsung mengurangkan masa untuk pengiraan. Hasil

daripada pengesan pergerakan ini ialah koleksi penting latar depan yang merupakan objek bergerak. Namun biasanya hasil imej daripada proses ini dicemari dengan hingar dan bayang-bayang. Sebagai langkah penyelesaiannya, operasi morfologi dipilih sebagai cara untuk membersihkan hingar daripada objek latar depan. Bayang-bayang yang terdapat pada objek pula dihapuskan dengan kombinasi nilai warna kromatik dan pembolehubah cahaya. Selepas itu piawaian momen tak varian digunakan untuk mengekstrak ciri daripada objek bergerak. Untuk mengecam objek ini, nilai momen yang telah dikira dihantar ke modul mesin penyokong vektor yang sebelum itu dilengkapkan dengan pemahaman tentang ekstrak nilai momen daripada bebayang bentuk manusia dan kenderaan. Sistem ini beroperasi menggunakan video warna daripada kamera yang dalam keadaan pegun. Ia boleh mengesan objek di persekitaran luar dan dalam keadaan perubahan keamataan cahaya. Modul pemprosesan pasca mampu menghapuskan hingar dan bayang-bayang daripada objek yang dikesan dengan ralat kurang daripada 1%. Akhir sekali, algoritma pengelasan menggunakan nilai momen yang telah diekstrak daripada objek yang dikesan berjaya mengkategorikan objek samada manusia atau kenderaan dengan ketepatan 89.08%. Semua kaedah ini telah diuji pada data video dan keputusan eksperimen membuktikan bahawa sistem ini pantas dan tegap.

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I am also thankful to my research group members. With their support my research becomes more enjoyable for me. Not to forget, my biggest gratitude goes my family for their endless love, support and trust in me. Without them I would never come up to this stage.

Finally, although my name is officially printed in this thesis, the contribution is come from all of you. So I specially dedicate this thesis for you.

I certify that an Examination Committee has met on 14 September 2006 to conduct the final examination of Mohd Razali Bin Md Tomari on his Master of Science thesis entitled "Detection and Classification of Moving Objects for an Automated Surveillance System" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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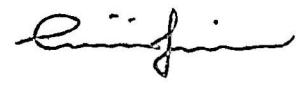

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions

MOHD RAZALI BIN MD TOMARI

Date:20 DECEMBER 2006

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LIST OF ABBREVIATIONS

AOF	Average Optical Flow
AVI	Audio Video Interleave
CMU	Carnegie Mellon University
CCL	Connected Component Labelling
COM	Centre of Mass
dll	Dynamic Link Library
DDD	Dilation-Dilation-Dilation
E	Erosion
EEE	Erosion-Erosion-Erosion
FD	Fourier Descriptor
FC	Fourier Coefficients
FP	False Positive
FN	False Negative
GRBF	Gaussian Radial Basis Function
GUI	Graphic User Interface
HSV	Hue, Saturation, Value
IIR	Infinite Impulse Response
LBP	Local Binary Pattern
LDA	Linear Discriminant Analysis
MIT	Massachusetts Institute of Technology
MoG	Mixture of Gaussians
Matlab	Matrix Laboratory

MLP	Multilayer Perceptron
MBBR	Motion Bounding Box Region
PCA	Principal Component Analysis
QP	Quadratic Programmimg
RGB	Red, Green, Blue
ROG	Radii of Gyration
ROI	Region of Interest
SMM	Shading Model Method
SBA	Selective Background Updating with Averaging
SV	Support Vector
SSE	Streaming Single Instruction Multiple Data Extension
SVM	Support Vector Machine
TP	True Positive
TN	True Negative
VSAM	Video Surveillance and Monitoring
VC	Vapnik Chervonenkis
2D	Two Dimensions
1D	One Dimension

CHAPTER I

INTRODUCTION

In recent years, with huge evolution and advancement in computer world, intelligent vision has become an active area of research , with the goal of developing visual sensing as well as processing algorithms and hardware that can distinguish and understand the world around them. Among those, visual surveillance system receives a great deal of interest. Video surveillance has been applied widely to ensure better precautions in security-sensitive areas, like factory, airports, schools or government offices.

Traditionally, the most important task of monitoring precautions is primarily based on human visual observation, which is a hard work for watchmen. During a long hour of monitoring, human concentration will slightly decrease and simultaneously affect the efficiency of the monitoring system. In addition, area enclosed under surveillance may be too large to be monitored by a few operators whereas number of cameras might exceed their monitoring capability.

These problems urge the usage of automation in surveillance system where computer performs the task that human operator normally would. Vast amount of data acquired from video imagery will be analyzed by an intelligent and useful autonomous structure. Also, this intelligent system will have the capacity to observe the surrounding environment and extract useful information for subsequent reasoning, such as detecting

and analyzing the activity (motion), or identifying objects that enter the scene. Even though this system cannot completely replace the human's presence, it will provide a great help for the watchmen to monitor large surveillance area with minimum human power supervision.

The formation of intelligence surveillance systems requires fast, reliable and robust algorithms for moving object detection, classification, and activity analysis. Moving object detection is the first step towards activity analysis. Commonly used techniques for this purpose are background subtraction, temporal differencing and optical flow [1]. This step not only creates a focus of attention for higher level processing but also decreases computation time considerably. The output of a motion–based detector is an essential collection of foreground that might correspond to the moving objects. However, classification of these regions into different categories of objects is still a huge challenge.

Object classification step categorizes detected objects into predefined classes such as human, vehicle, animal, etc. It is necessary to distinguish objects from each other in order to analyze their reliable actions. Currently, there are two major approaches towards moving object classification, which are shape-based and motion-based methods [2]. Shape-based methods make use of the objects' two dimensional spatial information whereas motion-based methods use temporal tracked features of objects for the classification solution.

Both, the outputs detection and classification algorithms can be used for providing the human operator with high level data in order to yield accurate decisions within a short time besides offering an effective offline indexing practice and a proficient routine to search for stored video data. Advancement in the development of these algorithms would lead to breakthroughs on applications that use visual surveillance. Table 1.1 showed some scenarios that these algorithms might handle [5] [7] [8] [9] [10] [13] [15] [19] [22] [25] [48]:

Table 1.1: Automated visual surveillance system application.

Application area	Example of the application
Public and commercial security	i. Monitoring banks, department stores and parking lots. ii. Patrolling highways and railways for accident detection. iii. Access control
Smart video data mining	i. Measuring traffic flow and pedestrian congestion. ii. Counting vehicle that entering and leaving the scene.
Law enforcement	i. Measuring the speed of vehicles ii. Detecting red light crossings and unnecessary lane occupation

1.1 Objectives of Research

Automated surveillance system carries a large number of benefits especially for safety precaution. The objectives of this research are:

i. To develop a motion detector module that can robustly detect and segment motions accurately from captured video sequences, in RGB colour mode and capable to cope with the changes in the scene.

ii. To propose a method for eliminating noise and shadow, from the segmented blobs, and extract important features for classification determination.

iii. To develop algorithm of an object classification system that employs the filtered blobs based on supervised learning with a small number of labelled examples, to distinguish between human and vehicle.

The software is developed using C++ and Visual Basic.

1.2 Scope of Thesis

This thesis deals with the problems of defining and developing the building blocks of moving object detection and classification system. The scope of this thesis is on method to detect and distinguish semantically-different classes of objects which have gross differences. The system can perform the classification task for multiple objects as long as the object is not occluded. Besides, it is limited to classify between human and vehicle class, for video inputs from static camera where the view frustum that may change arbitrarily are not supported. The corresponding performances of the proposed system blocks are validated by examine the extent of similarity between the outputs from the classified image with the ground truth.

1.3 Thesis Outline

This thesis is being divided into five consecutive chapters where each chapter reviews different issues regarding to the project objectives. Chapter 1 covers the introductory section of the project while Chapter 2 describes the literature review and theoretical background that related to automated surveillance system. The following Chapter 3 provides the explanation on project methodology used throughout the operation of the project analysis, result, and discussion are explained individually in Chapter 4 and the last chapter, which is Chapter 5, considers the conclusion and future recommendations in extending the project into a better prospect.