

PERPUSTAKAAN UTHM



300000210355

**DETECTION AND CLASSIFICATION OF MOVING OBJECTS FOR AN
AUTOMATED SURVEILLANCE SYSTEM**

By

MOHD RAZALI BIN MD TOMARI

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

September 2006

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

**DETECTION AND CLASSIFICATION OF MOVING OBJECTS FOR AN
AUTOMATED SURVEILLANCE SYSTEM**

By

MOHD RAZALI BIN MD TOMARI

September 2006

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

Fakulti: Kejuruteraan

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 pengawasan 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 piawai momen tak varian digunakan untuk mengekstrak ciri daripada objek bergerak. Untuk mengenali objek ini, nilai momen yang telah dikira dihantar ke modul mesin penyokong vektor yang sebelum itu dilengkapi dengan pemahaman tentang ekstrak nilai momen daripada bayang-bayang 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 keamatan 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.

ACKNOWLEDGEMENTS

I would like to express my gratitude to Assist. Prof. Dr. Adznan Jantan for his supervision, encouragement, suggestions and trust throughout the development of this thesis.

I owe special thanks to Dr. Khairi bin Yusuf for his guidance, support and invaluable discussions that encouraged me in my research.

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:

Ir. Wan Ishak Wan Ismail, PhD

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohd Adzir Mahadi, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Abdul Rahman Ramli, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Che Mat Hadzer Mahmud, PhD

Associate Professor
School of Electrical System
Kolej Universiti Kejuruteraan Utara Malaysia
(External Examiner)



HASANAH MOHD. GHAZALI, PhD
Professor/ Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 21 DECEMBER 2006

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as a fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Adznan Jantan, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Khairi Yusuf, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)



AINI IDERIS, PhD
Professor / Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 16 JANUARY 2007

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

TABLE OF CONTENTS

	Page
DEDICATION	ii
ABSTRACT	iii
ABSTRAK	v
ACKNOWLEDGEMENTS	vii
APPROVAL	viii
DECLARATION	x
LIST OF TABLES	xiv
LIST OF FIGURES	xv
LIST OF ABBREVIATION	xviii
CHAPTER	
1 INTRODUCTION	1
1.1 Research Objectives	4
1.2 Scopes of Thesis	5
1.3 Thesis Outline	5
2 LITERATURE REVIEW	6
2.1 Moving Object Detection	6
2.1.1 Optical Flow	7
2.1.2 Frame Differencing	8
2.1.3 Background Subtraction	9
Non Recursive Techniques	12
Recursive Techniques	14
2.2 Post Processing	18
2.3 Feature Extraction	22
2.3.1 Global Contour based Shape Representation	24
Techniques	
2.3.2 Global Region based Shape Representation	26
Techniques	
2.4 Classification	28
2.5 Related Research Review	31
2.6 Summary	34
3 METHODOLOGY	36
3.1 System Design of Automated Surveillance System	36
3.2 Detection Module	39
3.2.1 Hybrid Background Estimation	41
3.2.2 Foreground Detection	44
3.3 Post Processing Module	45
3.3.1 Shadow Removal	46
3.3.2 Noise Removal	48
3.3.2.1 Morphological Operation	48

	3.3.2.2 Erosion	49
	3.3.2.3 Dilation	51
	3.3.3 Blobs Labelling	53
3.4	Feature Extraction Module	54
	3.4.1 Geometrical Moment Definition	56
	3.4.2 Zero Order Moments: Area	57
	3.4.3 First Order Moments: Centre of Mass	57
	3.4.4 Second Order Moments	58
	Principal Axes	58
	Radii of Gyration (ROG)	60
	3.4.5 Third Order Moments: Projection Skewness	61
	3.4.6 Transformation of Moments	62
	Scale Transformation	62
	Translation Transformation	63
	Rotation Transformation	63
	Reflection Transformation	64
	Intensity Transformation	64
	3.4.7 Two Dimensional HU Moment Invariant	65
3.5	Classification Module	65
	3.5.1 Support Vector Machine (SVM)	68
	3.5.2 Kernel and Parameter Setting	73
3.6	Summary	75
4	RESULTS AND DISCUSSION	76
	4.1 Background Subtraction Analysis	77
	4.1.1 Result for Motion Area Estimation and Background Subtraction	78
	4.2 Post Processing Analysis	84
	4.2.1 Result for Shadow Detection and Removal	85
	4.2.2 Result for Noise Removal and Blobs Labelling	87
	4.3 HU Moment Analysis	90
	4.3.1 Result for HU Moment Analysis	91
	4.4 Support Vector Machine Analysis	96
	4.4.1 Result for Linear Kernel Analysis	97
	4.4.2 Result for Polynomial Kernel Analysis	98
	4.4.3 Result for GRBF Kernel Analysis	99
	4.5 System Performance Analysis	103
	4.5.1 Result for Overall System	105
5	CONCLUSION AND FUTURE WORK	110
	REFERENCES	114
	APPENDICES	116
	BIODATA OF THE AUTHOR	155

LIST OF TABLES

Table		Page
1.1	Automated visual surveillance system application	3
3.1	Orientation of the Major Principal Axis	59
3.2	Skewness of projection based on signs of Sk_x and Sk_y	61
4.1	Minimum values, Maximum values, and percentage of overlapping between human and vehicle samples for Hu 1 to Hu 7.	94
4.2	Performance for several kernel functions for classifies training and testing data.	102
4.3	System performance for detect and classifying moving objects.	105
4.4	Performance comparison for several of automated surveillance system method.	107

LIST OF FIGURES

Figure	Page	
2.1	Block diagram of background subtraction algorithm	10
2.2	Hierarchy of shape based representation and description techniques	23
3.1	Overall flow chart of human/vehicle detection and classification	37
3.2	Detection module flowchart	40
3.3	Post-processing module flowchart	45
3.4	Example model for image A and kernel h for erosion	49
3.5	Examples of erosion results for image A	50
3.6	Example model for image A and kernel h for dilation	51
3.7	Example of dilation results for image A	52
3.8	Flow chart for feature extraction module	55
3.9	Block diagram of the classification module	68
3.10	SVM classification example for separable two classes	69
3.11	Support vector machine uses a nonlinear kernel ($K\langle x, y \rangle$) to map the data points into a very high dimensional feature space in which the classes have a much greater chance of being linearly separable.	74
4.1	Sample motion area estimation result for image sequence.	79
4.2	Sample detection result for image sequence.	81
4.3	Sample of detected moving object using $T_h = 15$ for several of outdoor image sequences.	83

4.4	Shadow detection and removal result.	86
4.5	Noise removal and Labelling result.	89
4.6	Example of silhouette shape that use in the system.	90
4.7	Human and vehicle HU Moment 1 value.	92
4.8	Human and vehicle HU Moment 2 value.	92
4.9	Human and vehicle HU Moment 3 value.	92
4.10	Human and vehicle HU Moment 4 value.	93
4.11	Human and vehicle HU Moment 5 value.	93
4.12	Human and vehicle HU Moment 6 value.	93
4.13	Human and vehicle HU Moment 7 value.	94
4.14	Percentage performance for testing, training and number of SV versus C for linear kernel.	97
4.15	Percentage performance for testing, training and number of SV versus C for polynomial power of 2	98
4.16	Percentage performance for testing, training and number of SV versus C for polynomial power of 3	99
4.17	Training performance versus C for <i>GRBF</i> width (d) of 0.1 to 1	100
4.18	Testing performance versus C for <i>GRBF</i> width of 0.1 to 1.	100
4.19	Support vector (SV) capacity versus C for <i>GRBF</i> width of 0.1 to 1.	101
4.20	GUI for the system in running time.	104
4.21	Sample of true detected object in the video sequences	108
4.22	Sample of misclassification of detected object in the video sequences.	109

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 Programming
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	<ul style="list-style-type: none"> i. Monitoring banks, department stores and parking lots. ii. Patrolling highways and railways for accident detection. iii. Access control
Smart video data mining	<ul style="list-style-type: none"> i. Measuring traffic flow and pedestrian congestion. ii. Counting vehicle that entering and leaving the scene.
Law enforcement	<ul style="list-style-type: none"> 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.