

COMPUTER VISION SYSTEM



Kamarul Hawari Ghazali , Nurul Wahidah Arshad , Faradila Naim,
Rohana Abdul Karim, Nor Farizan Zakaria, Mohd Falfazli Mat Jusof,
Nazriyah Che Zan@ Zain, Rosyati Hamid, Lailatul Niza Muhammad

COMPUTER VISION SYSTEM

COMPUTER VISION SYSTEM

Kamarul Hawari Ghazali , Nurul Wahidah Arshad , Faradila Naim,
Rohana Abdul Karim, Nor Farizan Zakaria, Mohd Falfazli Mat Jusof,
Nazriyah Che Zan@ Zain, Rosyati Hamid, Lailatul Niza Muhammad

Publisher
Universiti Malaysia Pahang
Kuantan
2016

Copyright ©Universiti Malaysia Pahang, 2016

First Published, 2016

All right reserved.

Apart from fair dealing for the purpose of study, research, criticism or review, as permitted under the Copyright Act, no part of this book may reproduced, stored in retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior written permission of the publisher. Enquiries to be made to the author and the publisher, Penerbit Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang Darul Makmur. Negotiation subject to royalty arrangement or honorarium.

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

Kamarul Hawari Ghazali

COMPUTER VISION SYSTEM / Kamarul Hawari Ghazali,
Nurul Wahidah Arshad, Faradila Naim, Rohana Abdul Karim,
Nor Farizan Zakaria, Mohd Falfazli Mat Jusof.

Includes index

ISBN 978-967-0691-99-2

1. Computer vision. 2. System theory.

I. Nurul Wahidah Arshad. II. Faradila Naim. III. Rohana Andul Karim.

IV. Nor Farizan Zakaria. V. Mohd Falfazli Mat Jusof.

IV. Title.

371.9046

Published By:

Publisher

Universiti Malaysia Pahang
Lebuhraya Tun Razak, 26300 Gambang
Kuantan, Pahang Darul Makmur
Tel: 09-549 3273 Fax: 09-549 3281

Layout & Printing:

Percetakan Muafakat Jaya Sdn. Bhd (105038-M)
6, Jalan Perdagangan 16, Taman Universiti Industrial Park,
81300, Skudai Johor.
Tel: 07-520 6740 Fax: 07-520 6741

Contents

CHAPTER 1	1
Introduction to Vision Technology.....	1
1.0 Introduction	1
1.1 History of Computer Vision	1
1.2 Software and Hardware	3
1.2.1 Hardware	4
1.2.2 Software	5
1.3 Application in the Field of Engineering	5
1.3.1 Agriculture	6
1.3.2 Medical Imaging	6
1.3.3 Surveillance and Security.....	7
1.3.4 Automotive.....	7
1.3.5 Summary of other applications	8
1.4 Application in the Field of Engineering.....	8
CHAPTER 2	9
Digital Image Fundamental.....	9
2.0 Components of Vision Systems.....	9
2.1 Elements of Visual Perception	9
2.1.1 Structure of the Human Eye.....	10
2.1.2 Brightness Adaptation & Discrimination.....	11
2.1.3 Optical Illusions	12
2.1.4 Light and the Electromagnetic Spectrum.....	12
2.1.5 Reflected Light.....	13
2.2 Image Representation, Sensing and Acquisition	13
2.2.1 Image Representation.....	14
2.2.2 Types of Digital Image.....	14
2.2.3 Image Sensing and Acquisition.....	17
2.2.4 Image Sampling and Quantization	18
2.2.5 Spatial Resolution	19
2.2.6 Intensity Level Resolution	20
2.3 Some Basic Relationships between Pixels	22
2.3.1 Neighbors of a Pixel.....	22

2.3.2	Connectivity	23
2.3.3	Distance Measures.....	23
2.5	Introduction to Mathematics Tools.....	24
2.5.1	Array Indexing	24
2.5.2	Vector Indexing.....	25
2.5.3	Matrix Indexing.....	26
2.5.4	Some Important Standard Arrays.....	27
CHAPTER 3		29
Spatial and Frequency Domain Filtering		29
3.1	Histogram Processing.....	29
3.1.1	Histogram Processing for Intensity Transformation.....	30
3.1.2	Histogram Equalization	31
3.2	Fundamentals of Spatial Filtering	34
3.2.1	Neighborhood Operation	34
3.2.2	Spatial Filtering.....	35
3.2.3	Smoothing Spatial Filters.....	37
3.2.4	The Edges Effect.....	40
3.3	Fourier Transform	41
3.3.1	Periodic Signals	41
3.3.2	Types of Fourier Transform.....	43
3.3.3	Fourier Series	43
3.3.4	The Discrete Fourier Transform (DFT)	44
3.3.5	The Inverse Discrete Fourier Transform (DFT)	45
3.3.6	The Discrete Fourier Transform and Image Processing	46
3.3.7	Basic Frequency Domain Filter	46
CHAPTER 4		49
COLOR ANALYSIS		49
4.1	Color Model	50
4.1.1	RGB	51
4.1.2	HSI	52
4.1.3	CMYK.....	53
4.2	Color Transformation	54
4.2.1	Histogram Processing	55

4.2.2	Conversion Color Image to Grayscale	56
4.2.3	Color Thresholding	57
CHAPTER 5	.....	59
MORPHOLOGICAL AND SHAPE ANALYSIS	.....	59
5.1	Image Morphology	59
5.1.1	Basic Concept of Set Theory	59
5.1.2	Structuring Elements	61
5.2	Dilation and Erosion, Opening and Closing.....	62
5.2.1	Dilation and Erosion	62
5.2.2	Opening and Closing.....	65
5.3	Introduction to Some Basic Morphological Application.....	67
5.3.1	Boundary Extraction	67
5.3.2	Region Filling	68
5.3.3	Extraction of Connected Components	70
5.3.4	Thickening	72
5.3.5	Thinning.....	73
5.3.6	Skeletonization.....	73
5.4	Labeling Connected Components	75
5.5	Edge Detection	76
5.5.1	Sobel Edge Detector	78
5.5.2	Prewitt Edge Detector	78
5.6	Thresholding.....	80
5.6.1	The basic of intensity thresholding.....	80
5.6.2	Basic Global Thresholding	82
5.6.4	Optimal Global Thresholding Using Otsu's Method.....	83
Exercise	.....	85
CHAPTER 6	.....	87
OBJECT RECOGNITION.....	.....	87
6.1	Object Representation and Recognition	87
6.1.1	Object Representation.....	87
6.1.2	Descriptions/Recognitions	89
6.2	Pattern and Pattern Class	91
6.2.1	Pattern Arrangements.....	91

6.3	Features Extraction Selection	94
6.3.1	Features Extraction vs. Features Selection	95
6.3.2	Features Category	95
6.4	Statistical Analysis	97
6.4.1	Minimum Distance Classifier	97
6.5	Classification Tools (Neural Network)	98
6.5.1	Perceptron for Two Classes Model.....	99
	Exercise	100
	Segmentation by region growing.....	100
CHAPTER 7		103
VISION SYSTEM APPLICATION		103
7.1	Pineapple Maturity Index Classification	103
7.1.1	Image Acquisition.....	103
7.1.2	Image Pre-processing.....	104
7.1.3	Image Processing	105
7.1.4	Feature Extraction.....	106
7.1.5	Object Classification.....	107
7.1.6	Classification Decision	107
7.2	Drowsiness Detection.....	107
7.2.1	Introduction.....	107
7.2.2	Methodology	108
7.2.3	Image Acquisition.....	108
7.2.4	Image Pre-processing.....	110
7.2.5	Image Processing	111
7.2.6	Feature Extraction.....	114
7.2.7	Decision	114
7.3	Detecting a Cell Using Image Segmentation	115
7.3.1	Basic Concept	115
7.3.2	Image Acquisition.....	115
7.3.3	Image Processing	115
7.3.4	Coding example	117
	Exercise	118

PREFACE

Computer vision system is a subject that has a growing applications in diverse fields, such as manufacturing, robotic, automations system, biomedical, biometrics, remote sensing, and pattern recognition. As a result, it has become extremely important for students to study and understand image processing. This module attempts to provide some basic knowledge in computer vision system.

Chapter 1 of this module introduces the computer vision system and provides a window to the overall organization of the module. Chapter 2 deals with the fundamental techniques of computer vision. Chapter 3 is devoted to spatial and frequency domain filtering. In addition to the fundamental and analysis of frequency and spatial domain, the concept of color analysis in solving engineering application is introduced in Chapter 4. Morphology is a technique that is widely used in image analysis, and Chapter 5 is devoted to Morphology technique.

The importance of computer vision system is to know how an image analysis approach can solve a certain problem specifically in engineering application. Chapter 6 discussed how an object can be recognized or how to solve problem in real situation using image processing technique. Chapter 7 of this module demonstrates examples of applications using vision system technology.

The audience of this module are the undergraduate and graduate students in universities, as well as teachers, engineers and professional in RnD.

We sincerely thank to Faculty of Electrical and Electronics Engineering, Universiti Malaysia Pahang, for their full support in completion of this module. We are indebted to the management of the faculty as well as UMP publishing unit for their continuous support and encouragement in our endeavors.

We would like to thank our Editor, Kamarul Hawari, Wahidah, Faradila, Farizan, Rohana, Nazriyah, Falfazli, Lailatul and Rosyati for their assistance in this project. We thank all our colleagues in FKEE, UMP for their continuous support and encouragement. Finally, we thank Almighty Allah for each of His blessings.

Chief Editor
Kamarul Hawari