Image Recognition and Classification

Algorithms, Systems, and Applications

edited by

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MARCEL DEKKER, INC. NEW YORK • BASEL

ISBN: 0-8247-0783-4

This book is printed on acid-free paper.

Headquarters
Marcel Dekker, Inc.
270 Madison Avenue, New York, NY 10016
tel: 212-696-9000; fax: 212-685-4540

Eastern Hemisphere Distribution
Marcel Dekker AG
Hutgasse 4, Postfach 812, CH-4001 Basel, Switzerland
tel: 41-61-261-8482; fax: 41-61-261-8896

World Wide Web
http://www.dekker.com

The publisher offers discounts on this book when ordered in bulk quantities. For more information, write to Special Sales/Professional Marketing at the headquarters address above.

Current printing (last digit):
10 9 8 7 6 5 4 3 2 1

PRINTED IN THE UNITED STATES OF AMERICA

For my Aunt Matin

Preface

Image recognition and classification is one of the most actively pursued areas in the broad field of imaging sciences and engineering. The reason is evident: the ability to replace human visual capabilities with a machine is very important and there are diverse applications. The main idea is to inspect an image scene by processing data obtained from sensors. Such machines can substantially reduce the workload and improve accuracy of making decisions by human operators in diverse fields including the military and defense, biomedical engineering systems, health monitoring, surgery, intelligent transportation systems, manufacturing, robotics, entertainment, and security systems.

Image recognition and classification is a multidisciplinary field. It requires contributions from diverse technologies and expertise in sensors, imaging systems, signal/image processing algorithms, VLSI, hardware and software, and packaging/integration systems.

In the military, substantial efforts and resources have been placed in this area. The main applications are in autonomous or aided target detection and recognition, also known as automatic target recognition (ATR). In addition, a variety of sensors have been developed, including high-speed video, low-light-level TV, forward-looking infrared (FLIR), synthetic aperture radar (SAR), inverse synthetic aperture radar (ISAR), laser radar (LADAR), multispectral and hyperspectral sensors, and three-dimensional sensors. Image recognition and classification is considered an extremely useful and important resource available to military personnel and operations in the areas of surveillance and targeting.

In the past, most image recognition and classification applications have been for military hardware because of high cost and performance demands. With recent advances in optoelectronic devices, sensors, electronic hardware, computers, and software, image recognition and classification systems have become available with many commercial applications.

While there have been significant advances in image recognition and classification technologies, major technical problems and challenges face this field. These include large variations in the inspected object signature due to environmental conditions, geometric variations, aging, and target/sensor behavior (e.g., IR thermal signature fluctuations, reflection angles, etc.). In addition, in many applications the target or object of interest is a small part of a very complex scene under inspection; that is, the distorted target signature is embedded in background noise such as clutter, sensor noise, environmental degradations, occlusion, foliage masking, and camouflage. Sometimes the algorithms are developed with a limited available training data set, which may not accurately represent the actual fluctuations of the objects or the actual scene representation, and other distortions are encountered in realistic applications. Under these adverse conditions, a reliable system must perform recognition and classification in real time and with high detection probability and low false alarm rates. Therefore, progress is needed in the advancement of sensors and algorithms and compact systems that integrate sensors, hardware, and software algorithms to provide new and improved capabilities for high-speed accurate image recognition and classification.

This book presents important recent advances in sensors, image processing algorithms, and systems for image recognition and classification with diverse applications in military, aerospace, security, image tracking, radar, biomedical, and intelligent transportation. The book includes contributions by some of the leading researchers in the field to present an overview of advances in image recognition and classification over the past decade. It provides both theoretical and practical information on advances in the field.

The book illustrates some of the state-of-the-art approaches to the field of image recognition using image processing, nonlinear image filtering, statistical theory, Bayesian detection theory, neural networks, and 3D imaging. Currently, there is no single winning technique that can solve all classes of recognition and classification problems. In most cases, the solutions appear to be application-dependent and may combine a number of these approaches to acquire the desired results.

Image Recognition and Classification provides examples, tests, and experiments on real world applications to clarify theoretical concepts. A bibliography for each topic is also included to aid the reader. It is a practical book, in which the systems and algorithms have commercial applications and can be implemented with commercially available computers, sensors, and processors. The book assumes some elementary background in signal/image processing. It is intended for electrical or computer engineers with interests in signal/image processing, optical engineers, computer scientists, imaging scientists, biomedical engineers, applied physicists, applied mathe-

maticians, defense technologists, and graduate students and researchers in these disciplines.

I would like to thank the contributors, most of whom I have known for many years and are my friends, for their fine contributions and hard work. I also thank Russell Dekker for his encouragement and support, and Eric Stannard for his assistance. I hope that this book will be a useful tool to increase appreciation and understanding of a very important field.

Bahram Javidi

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