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# Preface

Face recognition is a task humans perform remarkably easily and successfully. This apparent simplicity was shown to be dangerously misleading as the automatic face recognition seems to be a problem that is still far from solved. In spite of more than 20 years of extensive research, large number of papers published in journals and conferences dedicated to this area, we still can not claim that artificial systems can measure to human performance.

Automatic face recognition is intricate primarily because of difficult imaging conditions (lighting and viewpoint changes induced by body movement) and because of various other effects like aging, facial expressions, occlusions etc. Researchers from computer vision, image analysis and processing, pattern recognition, machine learning and other areas are working jointly, motivated largely by a number of possible practical applications.

The goal of this book is to give a clear picture of the current state-of-the-art in the field of automatic face recognition across three main areas of interest: *biometrics*, *cognitive models* and *human-computer interaction*. Face recognition has an important advantage over other biometric technologies - it is a nonintrusive and easy to use method. As such, it became one of three identification methods used in e-passports and a biometric of choice for many other security applications. Cognitive and perception models constitute an important platform for interdisciplinary research, connecting scientists from seemingly incompatible areas and enabling them to exchange methodologies and results on a common problem. Evidence from neurobiological, psychological, perceptual and cognitive experiments provide potentially useful insights into how our visual system codes, stores and recognizes faces. These insights can then be connected to artificial solutions. On the other hand, it is generally believed that the success or failure of automatic face recognition systems might inform cognitive and perception science community about which models have the potential to be candidates for those used by humans. Making robots and computers more "human" (through human-computer interaction) will improve the quality of human-robot co-existence in the same space and thus alleviate their adoption into our every day lives. In order to achieve this, robots must be able to identify faces, expressions and emotions while interacting with humans.

Hopefully, this book will serve as a handbook for students, researchers and practitioners in the area of automatic (computer) face recognition and inspire some future research ideas by identifying potential research directions. The book consists of 28 chapters, each focusing on a certain aspect of the problem. Within every chapter the reader will be given an overview of background information on the subject at hand and in many cases a description of the authors' original proposed solution. The chapters in this book are sorted alphabetically, according to the first author's surname. They should give the reader a general idea where the

current research efforts are heading, both within the face recognition area itself and in interdisciplinary approaches.

Chapter 1 describes a face recognition system based on 3D features, with applications in Ambient Intelligence Environment. The system is placed within a framework of home automation - a community of smart objects powered by high user-friendliness. Chapter 2 addresses one of the most intensely researched problems in face recognition - the problem of achieving illumination invariance. The authors deal with this problem through a novel framework based on simple image filtering techniques. In chapter 3 a novel method for precise automatic localization of certain characteristic points in a face (such as the centers and the corners of the eyes, tip of the nose, etc) is presented. An interesting analysis of the recognition rate as a function of eye localization precision is also given. Chapter 4 gives a detailed introduction into wavelets and their application in face recognition as tools for image preprocessing and feature extraction.

Chapter 5 reports on an extensive experiment performed in order to analyze the effects of JPEG and JPEG2000 compression on face recognition performance. It is shown that tested recognition methods are remarkably robust to compression, and the conclusions are statistically confirmed using McNemar's hypothesis testing. Chapter 6 introduces a feed-forward neural network architecture combined with PCA and LDA into a novel approach. Chapter 7 addresses the multi-view recognition problem by using a variant of SVM and decomposing the problem into a series of easier two-class problems. Chapter 8 describes three different hardware platforms dedicated to face recognition and brings us one step closer to real-world implementation. In chapter 9 authors combine face and gesture recognition in a human-robot interaction framework.

Chapter 10 considers fuzzy-geometric approach and symbolic data analysis for modeling the uncertainty of information about facial features. Chapter 11 reviews some known approaches (e.g. PCA, LDA, LPP, LLE, etc.) and presents a case study of intelligent face recognition using global pattern averaging. A theoretical analysis and application suggestion of the compact optical parallel correlator for face recognition is presented in chapter 12. Improving the quality of co-existence of humans and robots in the same space through another merge of face and gesture recognition is presented in chapter 13, and spontaneous facial action recognition is addressed in chapter 14.

Based on lessons learned from human visual system research and contrary to traditional practice of focusing recognition on internal face features (eyes, nose, and mouth), in chapter 15 a possibility of using external features (hair, forehead, laterals, ears, jaw line and chin) is explored. In chapter 16 a hierarchical neural network architecture is used to define a common framework for higher level cognitive functions. Simulation is performed indicating that both face recognition and facial expression recognition can be realized efficiently using the presented framework. Chapter 17 gives a detailed mathematical overview of some traditional and modern subspace analysis methods, and chapter 18 reviews in depth some nearest feature classifiers and introduces dissimilarity representations as a recognition tool. In chapter 19 the authors present a security system in which an image of a known person is matched against multiple images extracted from a video fragment of a person approaching a protected entrance

Chapter 20 presents recent advances in machine analysis of facial expressions with special attention devoted to several techniques recently proposed by the authors. 3D face recognition is covered in chapter 21. Basic approaches are discussed and an extensive list of refer-

ences is given, making this chapter an ideal starting point for researchers new in the area. After multi-modal human verification system using face and speech is presented in chapter 22, the same authors present a new face detection and recognition method using optimized 3D information from stereo images in chapter 23. Far-field unconstrained video-to-video face recognition system is proposed in chapter 24.
Chapter 25 examines the results of research on humans in order to come up with some hints for designs of artificial systems for face recognition. Frequency domain processing and representation of faces is reviewed in chapter 26 along with a thorough analysis of a family of advanced frequency domain matching algorithms collectively know as the advanced correlation filters. Chapter 27 addresses the problem of class-based image synthesis and recognition with varying illumination conditions. Chapter 28 presents a mixed reality virtual system with a framework of using a stereo video and 3D computer graphics model.

*June 2007*

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**Face Recognition**

Edited by Kresimir Delac and Mislav Grgic

ISBN 978-3-902613-03-5

Hard cover, 558 pages

**Publisher** I-Tech Education and Publishing

**Published online** 01, July, 2007

**Published in print edition** July, 2007

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**How to reference**

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Kresimir Delac and Mislav Grgic (2007). Preface, Face Recognition, Kresimir Delac and Mislav Grgic (Ed.), ISBN: 978-3-902613-03-5, InTech, Available from: http://www.intechopen.com/books/face_recognition/preface

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