Handbook of Face Recognition

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Editors

Handbook of Face Recognition

With 210 Illustrations

Springer

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Preface

Face recognition has a large number of applications, including security, person verification, Internet communication, and computer entertainment. Although research in automatic face recognition has been conducted since the 1960s, this problem is still largely unsolved. Recent years have seen significant progress in this area owing to advances in face modeling and analysis techniques. Systems have been developed for face detection and tracking, but reliable face recognition still offers a great challenge to computer vision and pattern recognition researchers.

There are several reasons for recent increased interest in face recognition, including rising public concern for security, the need for identity verification in the digital world, and the need for face analysis and modeling techniques in multimedia data management and computer entertainment. Recent advances in automated face analysis, pattern recognition, and machine learning have made it possible to develop automatic face recognition systems to address these applications.

This book was written based on two primary motivations. The first was the need for highly reliable, accurate face recognition algorithms and systems. The second was the recent research in image and object representation and matching that is of interest to face recognition researchers.

The book is intended for practitioners and students who plan to work in face recognition or who want to become familiar with the state-of-the-art in face recognition. It also provides references for scientists and engineers working in image processing, computer vision, biometrics and security, Internet communications, computer graphics, animation, and the computer game industry. The material fits the following categories: advanced tutorial, state-of-the-art survey, and guide to current technology.

The book consists of 16 chapters, covering all the subareas and major components necessary for designing operational face recognition systems. Each chapter focuses on a specific topic or system component, introduces background information, reviews up-to-date techniques, presents results, and points out challenges and future directions.

Chapter 1 introduces face recognition processing, including major components such as face detection, tracking, alignment, and feature extraction, and it points out the technical challenges of building a face recognition system. We emphasize the importance of subspace analysis and learning, not only providing an understanding of the challenges therein but also the most suc-

cessful solutions available so far. In fact, most technical chapters represent subspace learning-based techniques for various steps in face recognition.

Chapter 2 reviews face detection techniques and describes effective statistical learning methods. In particular, AdaBoost-based learning methods are described because they often achieve practical and robust solutions. Techniques for dealing with nonfrontal face detection are discussed. Results are presented to compare boosting algorithms and other factors that affect face detection performance.

Chapters 3 and 4 discuss face modeling methods for face alignment. These chapters describe methods for localizing facial components (e.g., eyes, nose, mouth) and facial outlines and for aligning facial shape and texture with the input image. Input face images may be extracted from static images or video sequences, and parameters can be extracted from these input images to describe the shape and texture of a face. These results are based largely on advances in the use of active shape models and active appearance models.

Chapters 5 and 6 cover topics related to illumination and color. Chapter 5 describes recent advances in illumination modeling for faces. The illumination invariant facial feature representation is described; this representation improves the recognition performance under varying illumination and inspires further explorations of reliable face recognition solutions. Chapter 6 deals with facial skin color modeling, which is helpful when color is used for face detection and tracking.

Chapter 7 provides a tutorial on subspace modeling and learning-based dimension reduction methods, which are fundamental to many current face recognition techniques. Whereas the collection of all images constitutes high dimensional space, images of faces reside in a subspace of that space. Facial images of an individual are in a subspace of that subspace. It is of paramount importance to discover such subspaces so as to extract effective features and construct robust classifiers.

Chapter 8 addresses problems of face tracking and recognition from a video sequence of images. The purpose is to make use of temporal constraints present in the sequence to make tracking and recognition more reliable.

Chapters 9 and 10 present methods for pose and illumination normalization and extract effective facial features under such changes. Chapter 9 describes a model for extracting illumination invariants, which were previously presented in Chapter 5. Chapter 9 also presents a subregion method for dealing with variation in pose. Chapter 10 describes a recent innovation, called Morphable Models, for generative modeling and learning of face images under changes in illumination and pose in an analysis-by-synthesis framework. This approach results in algorithms that, in a sense, generalize the alignment algorithms described in Chapters 3 and 4 to the situation where the faces are subject to large changes in illumination and pose. In this work, the three-dimensional data of faces are used during the learning phase to train the model in addition to the normal intensity or texture images.

Chapters 11 and 12 provide methods for facial expression analysis and synthesis. The analysis part, Chapter 11, automatically analyzes and recognizes facial motions and facial feature changes from visual information. The synthesis part, Chapter 12, describes techniques on three-dimensional face modeling and animation, face lighting from a single image, and facial expression synthesis. These techniques can potentially be used for face recognition with varying poses, illuminations, and facial expressions. They can also be used for human computer interfaces.

Chapter 13 reviews 27 publicly available databases for face recognition, face detection, and facial expression analysis. These databases provide a common ground for development and evaluation of algorithms for faces under variations in identity, face pose, illumination, facial expression, age, occlusion, and facial hair.

Chapter 14 introduces concepts and methods for face verification and identification performance evaluation. The chapter focuses on measures and protocols used in FERET and FRVT (face recognition vendor tests). Analysis of these tests identifies advances offered by state-of-the-art technologies for face recognition, as well as the limitations of these technologies.

Chapter 15 offers psychological and neural perspectives suggesting how face recognition might go on in the human brain. Combined findings suggest an image-based representation that encodes faces relative to a global average and evaluates deviations from the average as an indication of the unique properties of individual faces.

Chapter 16 describes various face recognition applications, including face identification, security, multimedia management, and human-computer interaction. The chapter also reviews many face recognition systems and discusses related issues in applications and business.

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