Chapter 96
Face Recognition in Adverse Conditions:
A Look at Achieved Advancements

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ABSTRACT

In this chapter, the authors discuss the main outcomes from both the most recent literature and the research activities summarized in this book. Of course, a complete review is not possible. It is evident that each issue related to face recognition in adverse conditions can be considered as a research topic in itself and would deserve a detailed survey of its own. However, it is interesting to provide a compass to orient one in the presently achieved results in order to identify open problems and promising research lines. In particular, the final chapter provides more detailed considerations about possible future developments.

INTRODUCTION

The aim of this book is to discuss the main open issues regarding face recognition. While results in controlled settings are quite satisfying, the most interesting challenges are presently related to adverse/uncontrolled conditions. New and most accurate sensors can be part of the solution. As 3D techniques become more affordable, both computationally and economically, they are more and more often proposed as a viable alternative as well as complement to 2D approaches. However, 3D is not always available or feasible. New models are being investigated to identify features allowing to better address recognition problems in noisy environments and with unaware/non cooperative users, even in 2D. Such models often imply local approaches to recognition, whereas global ones seem to suffer more for Pose, Illumination and Expression (PIE) distortions commonly found in real uncontrolled situations. Suitable normalization procedures, for pose or illumination, can be applied both in global and local approaches. However, disguise variations, e.g. variations due to plastic surgery or make-up, seem to be better addressed through

DOI: 10.4018/978-1-5225-5204-8.ch096

local approaches. A promising line of research implies using more classifiers, with different strengths and flaws, or even more biometric traits, to improve the final accuracy through intelligent information fusion.

Given the list of possible solutions to present problems, it is also interesting to consider the set of advanced applications that can take advantage of the new face recognition performance. Ambient intelligence, tracking in critical environments, automatic tagging of large image collections, advanced mobile facilities are only examples, while new applications may rise as technology advances. Regarding this, the Chapter "Real world applications: a Literature Survey" by Tistarelli and Lin has provided a sample of the challenging application of face recognition in present real world scenarios. This necessarily short overview has provided a shortlist of interesting applications, which may be useful to orientate those who are approaching this research field. Even though the study of face recognition techniques has been initially spurred by problems related to security and access control, nowadays the analysis of human faces can further support law enforcement, foster a more natural man-machine interaction, and also provide an aid to disabled people. Among emerging applications, a crucial requirement is to facilitate a better interaction. Therefore, also due to the specific operational settings where security is not the main issue, it is often the case that a high recognition accuracy may be sacrificed to rather achieve a higher flexibility and capability to deal with minimally constrained environments.

THE ROLE OF POSE

Pose variation is one of the great challenges for robust face recognition. We can divide techniques to address this problem in two broad categories: those only relying on 2D images and those using 3D models.

Methods based on 2D images were the first to be investigated (see for example Reisfeld and Yeshurun, 1998). In their simplest basic versions, those methods perform face normalization based on the location of the eyes and mouth. A two dimensional affine transformation is uniquely determined by three points. *Warp* is defined as the affine mapping of a face image determined by the location of the eyes and mouth in the given image and by the usual standard locations. In a more general case, if two given samples are well aligned, there exists an approximated linear mapping between the two images of the person captured under variable poses. In order for this mapping to be consistent for all subjects, it is required that their facial images are aligned pixel-wise. Since this kind of alignment is a problem in itself, theone actually performed usually relies on very few facial landmarks, such as the two eye centers. However, in this way face images are aligned quite coarsely, so that the assumption of linear mapping no longer holds theoretically.

A popular solution for dealing with the pose variations is to rely on real (or synthetized, i.e. virtual) multiple views of the subject face. Along this line we can mention the work by Vetter and Poggio (1997) who exploit a 2D example-based view synthesis approach to generate novel virtual views under multiple poses. Prior face knowledge is represented by different 2D views of prototype faces. The method assumes that the 3D shape of an object as well as its 2D projections can be represented by a linear combination of prototype objects. According to this, a rotated view of an object is a linear combination of the rotated views of the prototype objects. Thy exploit the concept of Linear Object Classes (LOC) to synthesize rotated views of facial images from a single example view. In particular, in LOC approach a facial image is first separated into a shape vector and a texture vector, and then LOC is applied to them separately to generate the virtual rotated images. These virtual views are highly dependent on the correspondence

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