Chapter 11
Adaptive Face Recognition of Partially Visible Faces

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ABSTRACT

Face Recognition is an active research area. In many practical scenarios, when faces are acquired without the cooperation or knowledge of the subject, they are likely to get occluded. Apart from image background, pose, illumination, and orientation of the faces, occlusion forms an additional challenge for face recognition. Recognizing faces that are partially visible is a challenging task. Most of the solutions to the problem focus on reconstruction or restoration of the occluded part before attempting to recognize the face. In the current chapter, the authors discuss various approaches to face recognition, challenges in face recognition of occluded images, and approaches to solve the problem. The authors propose an adaptive system that accepts the localized region of occlusion and recognizes the face adaptively. The chapter demonstrates through case studies that the proposed scheme recognizes the partially occluded faces as accurately as the un-occluded faces and in some cases outperforms the recognition using un-occluded face images.

1. INTRODUCTION

With increasing need for surveillance, use of smart cards, and applications related to information security, Face Recognition has remained active research area in the last few years. The number of applications that involve recognizing faces is continuously on the increase. The main advantage of face recognition as biometric emanates from the ability of acquiring of subjects in non-intrusive manner.

Recognizing faces in a controlled environment is relatively a straight forward problem, albeit it has a number of challenges such as variation in

illumination, pose and scale. The face recognition system is a typical pattern recognition system where learning takes place based on training set of images. The model is validated against validation dataset before it can predict a label or identity of a test image. Practically, when the images are acquired without the cooperation of the subject, often, they result in partial images with obstructions caused by multiple sources.

Often one encounters situations like a previously known person in a crowd needs to be identified whose face could be non-frontal, non-uniformly illuminated, oriented in some direction, and partially visible. Each of them is an important issue in recognizing the face. Depending on the *a priori* information on the subject that is available at our disposal, solutions based on mathematical and image processing techniques exist. In the current Chapter, however, we focus the issue of recognizing partially visible faces. Some indicative examples of common causes for partial visibility are the following.

1. Eyes covered with large, dark spectacles
2. Facial hair
3. Occlusion by a raised tea-cup, newspaper, cap, scarf or similar artifacts.

In addition to ability to detect partial faces, the methods discussed have applications in detecting a person in disguise where some part of the face is covered. The proposed scheme shall be able to handle (a) Occlusion at various regions within face region and (b) Variation in facial expression.

In the current Chapter, we propose an efficient and adaptive scheme, where occlusion of the face is not assumed as one among *a priori* known regions. The scheme makes a data dependent inference of the occluded region, synthesize the training data accordingly and identify the test face image with good classification accuracy. Hence it forms an adaptive scheme.

The solution integrates the following domains.

- Face Recognition
- Pattern Classification
- Pattern Clustering
- Image Processing Techniques
- Support Vector Machines

We conduct experiments by synthetically occluding various parts of the face and demonstrate the applicability of the proposed scheme to various test scenarios on an internally generated face database.

The Chapter is organized in the following manner. Section-2 contains a brief discussion on motivation in taking up the current work. Section-3 contains background details such as literature review, alternate schemes adapted earlier to solve the problem and a brief discussion of terminology that is used further in describing the scheme and some terms related to the topic. Section-4 discusses the proposed scheme in detail including experimentation and presentation of results. In Section-5, we present future research directions. We provide concluding remarks in Section-6. In the end we provide references and additional reading section.

In summary, the contributions of the Chapter are the following.

- Brief discussion on Face Recognition Systems
- Various approaches to handle face recognition with occlusions
- Proposed adaptive approach to handle occlusions by training data synthesis
- Demonstration of the approach through experimentation
- Research Trends

2. MOTIVATION

Recognition of partially visible faces is a challenging problem. Often when face images are collected without the knowledge and/or coop-

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