Chapter 16
Eye Detection Using Color, Haar Features, and Efficient Support Vector Machine

Shuo Chen
New Jersey Institute of Technology, USA

Chengjun Liu
New Jersey Institute of Technology, USA

ABSTRACT

Eye detection is an important initial step in an automatic face recognition system. Though numerous eye detection methods have been proposed, many problems still exist, especially in the detection accuracy and efficiency under challenging image conditions. The authors present a novel eye detection method using color information, Haar features, and a new efficient Support Vector Machine (eSVM) in this chapter. In particular, this eye detection method consists of two stages: the eye candidate selection and validation. The selection stage picks up eye candidates over an image through color information, while the validation stage applies 2D Haar wavelet and the eSVM to detect the center of the eye among these candidates. The eSVM is defined on fewer support vectors than the standard SVM, which can achieve faster detection speed and higher or comparable detection accuracy. Experiments on Face Recognition Grand Challenge (FRGC) database show the improved performance over existing methods on both efficiency and accuracy.

1. INTRODUCTION

Being an important initial step in an automatic face recognition system, eye detection has become a popular research topic in the last decade. Since face alignment for recognition is usually conducted according to eye positions, incorrect eye location would corrupt the face alignment in both spatial scale and rotation, and thus lead to the extremely poor performance of face recognition.

DOI: 10.4018/978-1-61350-429-1.ch016

Wang et al (2005) did experiments on FRGC 1.0 database to evaluate the impact of eye detection error on face recognition accuracy. It is shown that only 1% eye location error reduces the face recognition accuracy by over 10% while about 5% error reduces the accuracy by 50%. Phillips et al. (2000) did experiments on FERET database and similar conclusion was also reached. The "partial automatic face recognition algorithm", in which manual eye locations are given to align the face image, performs much better than the "fully automatic recognition algorithm".

Generally speaking, current eye detection methods can be classified into three categories (Zhu & Ji, 2005): template based methods, feature based methods and appearance based methods. For the template based methods, a sliding window is moved over the whole image to match with a pre-designed generic eye model in order to detect the eye position (Lam & Yan, 1996; Xie et. al., 1994). Feature based methods focus on the characteristic of eyes, such as the shape, color distribution, and intensity gradient information around eye regions (Kawaguchi & Rizon, 2004; Feng and Yuan, 1998; Zhou & Geng, 2004). Appearance based methods detect eyes based on their photometric appearance. These methods always need to train a classifier at first by collecting a large amount of training data and then detection is achieved via two-fold classification (Nguyen et. al., 2008; Zhang & Zhan, 2006; Wang et. al., 2005; Wang & Ji, 2007). Usually, feature based methods have much faster detection speed since they always only involve some image processing operations while appearance based methods have much higher detection accuracy since statistical learning technology is applied. We will further discuss these methods in details in the following section.

Though numerous eye detection methods have been proposed (Zhou & Geng, 2004; Khairosfaizal & Noraini, 2009), many problems still exist, especially in detection accuracy and efficiency under challenging image conditions. In this chapter, we present an accurate and efficient eye-center detection method, which combines the advantages of both feature and appearance based methods. In particular, this method consists of two stages: the features based eye candidate selection and appearance based validation. In the candidate selection stage, 99% non-eye pixels are rejected through eye color distribution analysis in the YCbCr color space. Only up to 1% pixels in an image as eye candidates enter the validation stage. In the validation stage, 2D Haar wavelet (Viola & Jones, 2001) is used for image representation in multi-scales and PCA (Stork, 2000) is applied for dimensionality reduction. Several popular and effective image representation methods for object detection, like HOG (Dalal & Triggs, 2005), Gabor (Liu & Wechsler, 2002), and LBP (Ahonen et. al., 2006), are assessed and the 2D Haar wavelet is chosen as the best for eye representation. Finally, a new efficient Support Vector Machine (eSVM) is proposed as the classifier. SVM has been widely applied in solving recognition and object detection problems in the last decade (Nguyen et. al., 2008; Jia & Martinez, 2009). Although the standard SVM exhibits many theoretical and practical advantages such as good generalization performance, when applied to complicated large-scale classification tasks, its classification speed is slower than other approaches due to its complex decision function. The eSVM, based on the idea of minimizing the maximum margin of misclassified samples, is defined on fewer support vectors than the conventional SVM, which can achieve faster detection speed and comparable or even higher detection accuracy.

To evaluate the effectiveness of our proposed method, we conduct experiments on the whole training dataset of FRGC version 2 experiment 4, which contains 12,776 controlled and uncontrolled images (Phillips et. al., 2005). Experiment results show that (i) our proposed method has higher detection accuracy compared with other state of the art approaches and (ii) eSVM greatly improves the efficiency and the detection system