A Study on Components and Features in Face Detection

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ABSTRACT

It’s natural and convenient that the face is used as a feature in the city safety monitoring. Components and feature extraction are two key problems in face detection. To address the local occlusion and pose variation in face detection, face can be looked on as a whole composed of several parts from up to down. First, the face is divided into a number of local regions from which various features are extracted. Each region is identified by a local classifier and is assigned a preliminary part label. A random field is established based on these labels and multiple dependencies between different parts are modeled in a CRF framework. The probability that the test image may be a face is calculated by a trained CRF model. The probability is used as a measure to test the existence of a face. The experiments were carried out on the CMU/MIT dataset. As indicated by the experiment results, the following methods can improve the detection rate and enhance the robustness of face detection in case of occlusion: 1) integrating multiple features and multiple dependencies in CRF framework; 2) dividing the face optimally.

Keywords: Conditional Random Fields, Face Detection, Multiple Dependencies, Multiple Features

1. INTRODUCTION

Face detection aims to determine existence of a face in a static image and to acquire the face’s accurate location and scope.

Video surveillance systems are very suitable for the physical security, since the video sequences from many remote areas can be presented to watchmen at a time. Face detection is interesting because it is usually an indispensable step of autonomous video surveillance system.

Face detection is an important research topic in the field of computer vision. The article (Hjelmås & Low, 2001; Yang & Kriegman & Ahuja, 2001; Zhang & Zhang, 2010) is the review of related literature. Scale and translation invariance are acquired by sliding a window over an input image at different resolutions. The research on face detection involves two issues: effective

DOI: 10.4018/IJITWE.2015070103

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search strategy and robust classifier for face and non-face. The former affects the detection speed and the latter determines the detection accuracy which is the key issue discussed in this paper.

Face detection is a complex and challenging pattern-classification question, and its main difficulty has two aspects: (1) the face’s inner changes caused by: (a) face appearance are quite complex such as different face shape, different skin color, different expressions; (b) Face occlusion such as glasses, hair, head ornaments and other external objects, etc.; (2) the change caused by external conditions: (a) The face’s multi-pose caused by the different imaging angle such as the rotation of the plane, the rotation of the depth and the rotation of the upper and lower. (b) The illumination, such as brightness, contrast, and shadow, etc. (c) Imaging conditions such as the focal length of the camera, the imaging distance, and the way of the image acquisition, etc.

Face detection methods can be classified into two types. The first one is based on the idea that a face is an indivisible whole entity (Jianguo & Tieniu, 2000; Meynet & Popovici & Thiran, 2007). The second is part-based (Heisele & Serre & Poggio, 2007; Yang & Huang, 1994; Samaria & Young, 1994; Nefian & Hayes, 1998; Nefian & Hayes, 1999; Epshtein & Ullman, 2005), which can adapt to changes in posture and partial occlusion as compared with the former. Part-based methods mainly solve two problems: 1) extracting features from parts and establishing the mapping relationship between local features and face parts; 2) modeling dependencies among face parts.

The mosaic image method presented by Yang and Huang (1994) divided the original image evenly into rectangular cells and established gray distribution in face. The test image was filtered from a low resolution to a high resolution according to the distribution. The detection rate is not high for only a kind of gray feature is used in this method.

F.S. Samaria and Nefian et al. presented HMM-based face detection (Samaria & Young, 1994; Nefian & Hayes, 1998; Nefian & Hayes, 1999) and consider a face as composed of five parts: hair, forehead, eyes, nose, mouth. They divided the face into a series of rectangle-blocks. In (Samaria & Young, 1994), the gray features were extracted from the block, in (Nefian & Hayes, 1998) the DCT coefficients and in (Nefian & Hayes, 1999) the KLT coefficients. Above all, only one kind of feature was extracted. The mapping relationship between rectangle-blocks and face parts was acquired by multi-Gauss model. Due to diversity of faces, it is difficult to determine the number of Gaussian kernel. In addition, the dependencies between parts were modeled by a one-step transition probability matrix for the Markov assumption. However, this assumption is too strict for face detection. For only such a kind of dependency was modeled, local error can be transmitted to other regions.

Besides, different parts and dependencies have different effects on face detection. The detection method presented by Epshtein and Ullman (2005) assigned different weights to different parts according to the maximum mutual information. However, each part’s matching is very complex for it’s almost a detection problem.

Above all, many researchers have tried to divide the face into a series of parts, which plays an important role in face detection. Based on this idea, we try to improve the accuracy and robustness in three ways: 1) extracting various features from each part and integrating them; 2) integrating multiple dependencies between different parts; 3) different features, different parts and different dependencies are assigned different weights by training.

The remaining of the paper is structured as follows. Section 2 introduces face segmentation and feature extraction method.

Section 3 analyses related model. The CRF framework for face detection is then discussed in detail in Section 4. Section 5 presents the experimental method and the results. Finally, we summarize this paper and explain the future work in section 6.
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