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Finding suits in images of people in unconstrained environments

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ABSTRACT

Clothing style analysis is a critical step for understanding images of people. To automatically identify the style of clothing that people wear is a challenging task due to various poses of person and large variations for even the same clothing category. Suit as one of the clothing style is a key element in many important activities. In this paper, we propose a novel suits detection method for images of people in unconstrained environments. In order to cope with various human poses, human pose estimation is incorporated. By analyzing the style of clothing, we propose the color features, shape features and statistical features for suits detection. Experiments with four popular classifiers have been conducted to demonstrate that the proposed features are effective and robust. Comparative experiments with Bag of Words (BoW) method demonstrate that the proposed features are superior to BoW which is a popular method for object detection. The proposed method has achieved promising performance over our dataset, which is a challenging web image set with various human poses and diverse styles of clothing.

1. Introduction

Clothing style is a salient feature to understand the content of images of people, e.g. people always wear different styles of clothing when participate in different activities. As shown in Fig. 1, when people attend a meeting they always wear suits and when people do sports they always wear sportswear. Meanwhile, clothing provides significant information for people search in consumer photo albums and surveillance videos, e.g., Daniel et al. [1] used the colorfeature of clothing to perform attribute-based people search in surveillance environments. Besides the color feature, the style is also an important factor to reflect the characteristic of clothing. As shown in Fig. 2, in consumer photo selection systems, finding photos of people wearing suits from an increasing amount of personal photos is also very useful.

There are various styles of clothing, e.g. suit, t-shirt and skirt. In this paper, we focus on finding suits in images of people for that suits have the uniform appearance and are generally a key element in many important activities. However, the features proposed in [2–7] cannot be used in suits detection for the colors and textures are different in suits. Furthermore, there are some popular local features which have received a lot of research attention in recent years [2]. These features have been successfully used in many applications. However, the detectors of most of the local features are based on local extreme which cannot work if the clothing regions do not have textures (e.g., a suit always has a single color). Thus some more effective features are desired.

By analyzing lots of suits and non-suits images, we discover several regular patterns for suits, and then we propose features to represent these patterns respectively. Furthermore, in order to cope with various human poses, human pose estimation is incorporated. Part of this work has been presented in [8]. Based on our previous work in [8], we further introduce main direction determination scheme to improve the performance to various human poses.

The main contribution of the paper is that, torso direction is introduced as the main direction for following feature extraction in order to cope with various human poses (Section 4), and we discover several regular patterns for suits, for these patterns, we propose three color features, one shape feature and two statistical features for suits detection (Section 5). The proposed features will also be helpful for other clothing style detection (Section 7).

The remaining of the paper is organized as follows. The related work is described in Section 2. In Section 3, the system overview is introduced. The clothing region location and feature extraction scheme are presented in Sections 4 and 5 respectively. In Section 6,

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(a) Meeting (b) Playing Football & Baseball (c) Cooking

Fig. 1. Clothing style is a salient feature to understand images of people. (a) When people wear suits, they may be attending a meeting. (b) When people wear sportswear, they may be playing. (c) When people wear chef apparel, they may be cooking.

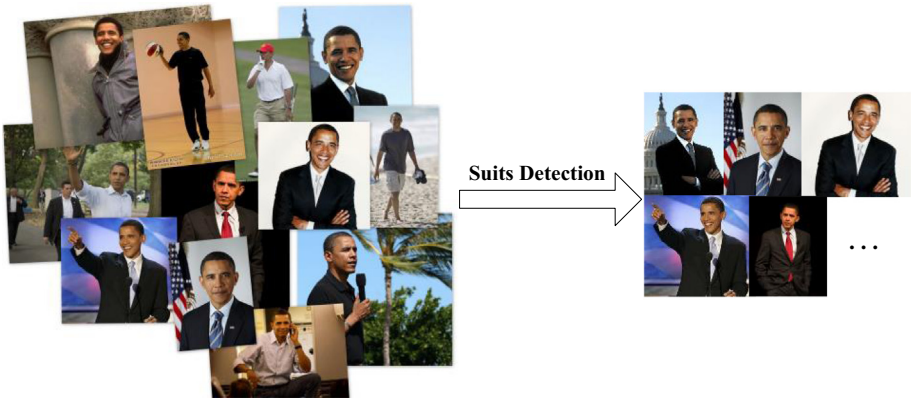

Fig. 2. Finding Obama in suits through suits detection, which is useful in consumer photo selection systems and attribute-based portrait search.

comprehensive experiments are done and comparative results are given. Finally, some conclusions are drawn in Section 7.

2. Related work

Many researchers have noted that clothing feature is important in two computer vision tasks [9,2–6], including human detection [9] and human recognition [2–6]. Sprague et al. [9] used the segmentation results of clothing to detect human in still images. In [2–6], researchers took the clothing feature as context information to aid human recognition. Song et al. [2] used the trained codewords to represent the clothing region, and this is an effective method concerning clothing's different types of color and texture. Gallagher et al. [3,4] represented the clothing via three color features and two texture features. For the color features, they used the values of luminance-chrominance space (LCC) and for the texture features, they used the responses to a horizontal and vertical edge detector. Zhang et al. [5] exploited the spatial relationship of features. They used the color signature, color pyramid and texture pyramid to represent the clothing. Khoury et al. [6] employed 3D histogram of the dominant color for clothing matching. In addition, there are many other studies on clothing analysis. Chen et al. [10] proposed an And-Or graph to represent the wide diversity of cloth configurations for clothing sketching. Tian et al. [7] proposed a clothing matching method to help the blind or color blind people. All the above researches mainly concentrated on extracting clothing features for clothing matching, using the segmentation of clothing for human detection and sketching.

In recent years, there are some works focus on clothing analyses for various intents. Huang et al. used color features, texture features and skin features to represent clothing for a portraits ranking system [11]. Meanwhile, Wang et al. used the Bow framework to search clothes by combining color features and attribute features [13]. Liu et al. proposed "color", "pattern", "material" and "shape" features for cross-scenario clothing retrieval [12]. In order to cope with diverse clothing styles, Nataraj et al. used superpixels as the element for clothing parsing [14]. Liu et al. used HOG, LBP and skin features to represent the clothing for occasion-oriented clothing recommendation.

3. System overview

The overview of our approach is shown in Fig. 3. Generally, our method consists of three stages, i.e., clothing region location, feature extraction and classification. At the clothing region location stage, we use pictorial structure model to get the pose of human first. In order to extract features under a pose-invariant way, we use the direction of the torso as the main direction for later feature extraction scheme. The details of pose estimation and main direction determination of human body are described in Section 4. At the feature extraction stage, six novel features are proposed. Traditional methods always use local features for object detection and classification, but are not suitable for clothing classification for that the clothing regions may not have textures. Thus, we introduce color features, texture features and statistical features. The details of feature extraction are presented in Section 5. At the classification stage, Support Vector Machine (SVM) is used as the classifiers, which have got the best results at our experiments. The details of classification are presented in Section 6.

4. Clothing region location

Thanks to the recent progress of human pose estimation, the analysis of various human poses has been made possible. With the knowledge of the physical pose of the person clothing region