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Discriminant quaternion local binary pattern embedding for person re-identification through prototype formation and color categorization

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ABSTRACT

Re-identifying objects is one of the fundamental elements for visual surveillance, in the sense that images of the same object at different time or places should be assigned with the same label. In this work, we propose a new embedding scheme for person re-identification under nonoverlapping target cameras. Inspired by the prototype approach derived from cognition field, we propose to use prototype images as a reference set to achieve a discriminative representation of a person's appearance. To enhance the discrimination between different persons, we learn a linear subspace in a training phase during which person correspondences are assumed to be known. The robustness of the algorithm against results that are counterintuitive to a human operator is improved by proposing the Color Categorization procedure. By doing so, our method becomes very flexible when tracing a person in a camera network even under large illumination changes. The proposed framework was tested on VIPeR, the most challenging dataset for person re-identification. Results confirm that our method outperforms the state of the art techniques.

1. Introduction

Object tracking has been traditionally studied for surveillance purposes, where moving objects are detected and assigned to consistent labels as they move around a scene. To simplify the problem, researchers imposed constraints on the appearance and/or the motion. For example, almost all the tracking algorithms require a spatiotemporal continuity of objects so that they satisfy the following constraints: continuity (object's movement must be continuous) and exclusivity (an object cannot be in more than one place at the same time). A time delay may interrupt the continuity of an object's position over time, causing the failure of the tracker. Hence, when distinct images of objects are captured without enough temporal or spatial continuity, the re-identification process becomes the convenient approach to maintain the tracking. Another need for re-identification is the case of global tracking, where the object has to be identified after re-entering the field of view. Local tracking aims to track the object at a frame-to-frame level as long as it belongs to its field of view. Global tracking aims to find the corresponding label of some object in its earlier appearances.

Person re-identification has been a topic of intense recent studies in computer vision. It consists in recognizing a person in different places over different non-overlapping cameras in a network. A huge amount of data is provided by such networks, making human monitoring expensive and time consuming. Classical biometric cues (iris, face) are difficult to catch or not available due to sensors' scarce resolution. To solve this problem, researchers have developed systems that extract visual aspects from human body. Such systems are only stable for short period as persons change their clothes on different days.

Person re-identification is considered as a highly challenging problem due to changes in lighting conditions, occlusion and viewpoint changes in images of the same person in different camera views. The development of systems that can automatically detect and track people not only analyze the data faster but also improve the quality of surveillance.

1.1. State of the art

Person re-identification is the process of identifying the same person from images taken from different cameras. Most of the existing researches generate a ranked vector of all the persons in a gallery set (images of labeled persons) based on their resemblance with the probe image (unlabeled person). The highest similarity score in the ranked vector will assign a specific label for the probe image. Existing techniques on person re-identification usually fall into two categories.

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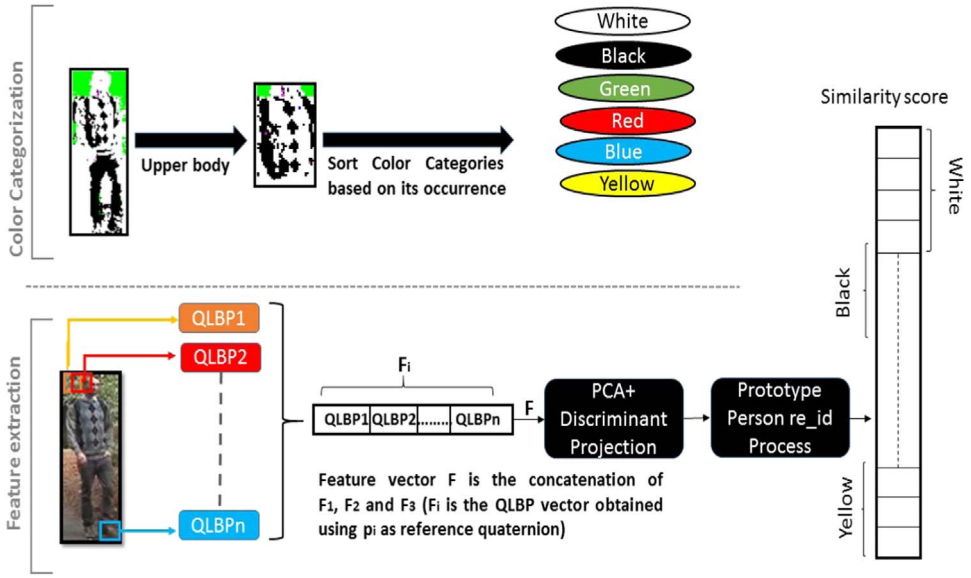

Fig. 1. The overall process for person re-identification. After feature extraction, we apply PCA (Principal Component Analysis) for dimensionality reduction. Then we project to a new subspace to enhance discrimination. The prototype process is then applied and the final ranking is based on both the Color Categorization and the similarity score.

The first category known as 'single-shot approach' (Wei and Lin, 2013), focuses on connecting pairs of images, each containing one instance of an individual. The second category uses multiple images of the same person as training data and considers short sequences for testing. It is known as 'multiple-shot approach' (Guo et al., 2014). Most of the existing approaches are based on appearance similarity where they aim to find a good representation to establish correspondences between images. Typical descriptors, like texture and color extracted from clothing, have been widely used. Popular descriptors like SIFT (Scale Invariant Feature Transform) have been used in Bauml and Stiefelhagen (2011), which consists of computing a histogram of the gradient distribution in the region around a detected interest point. Other descriptors have been used, which include Texture filters (Gray and Tao, 2008), color and shape features (Kang et al., 2004) and Principal axis (Hu et al., 2006). Salvagnini et al. (2013) seeks the most distinctive representation of an individual, in which they collect two images of each subject, one for the whole body and the other can be a zoomed body part (head, torso or legs). Satta (2013) presents a review of descriptors based on appearance.

Color is one of the important features for computer vision systems, it has been found as the most important factor in many person re-identification studies because usually, only low-resolution images can be obtained making it difficult to trace face signatures. In general, the color value can be transformed conveniently from RGB to HSV (Shao et al., 2008). The reason is that it provides an intuitive representation and approximates the way in which human perceive color. Color histogram has been successfully applied to the person re-identification problem like in Hirzer et al. (2012a). Color histograms in 3 color spaces (RGB, HSV and YCrCb) have been used in Ma et al. (2012).

After feature extraction, these methods normally choose a standard distance measurement to calculate the similarity between images, e.g. Bhattacharyya distance (Gray and Tao, 2008), L1-Norm (Wang et al., 2007b) or L2-Norm (Hu et al., 2006). In Hirzer et al. (2012b), the authors proposed to learn a metric from pairs of samples from different cameras using discriminative Mahalanobis metric learning. In Zheng et al. (2013), Zheng et al. formulated the person re-identification as a relative distance comparison problem with a Mahalanobis distance metric. All these techniques suffer from some difficulties to some extent because of the low resolution of images, camera settings and lighting conditions.

1.2. Contribution

The main contributions of our work are summarized as follows:

(1) We explore the adaptation of the Prototype Formation in the person re-identification problem. It was proposed in psychology and cognition field (Rosch, 1973), and tested on Face Recognition problem (Klare and Jain, 2013). It suggests that human being categorizes the objects based on hierarchical prototypes, and people differentiate the world using this critical skill for category learning. Psychological experiments revealed that human brain recognizes and differentiates objects using prototypes. It means that prototypes provide a measure to recognize or classify an unseen object. Based on that, we propose an approach for person re-identification where each person is described as a vector of kernel similarities to a collection of prototype person images.

(2) We propose an additional Color Categorization step to overcome one common weak point in previous approaches: mistakenly positioning two persons who wear different colors of clothes above the true match.

(3) To ensure that features extracted have favorable discriminative capability, we propose a novel discriminant method and we show the discrimination that can be provided using the Quaternionic Local Binary Pattern (QLBP) as a feature vector rather than traditional Local Binary Pattern (LBP) which neglects the relation between color channels.

This paper is organized as follows. Color Categorization method is discussed in Section 2. Section 3 reports the feature extraction process. The discriminant method is presented in Section 4. Section 5 describes the re-identification process. Experimental results and conclusion are given in Sections 6 and 7, respectively. Fig. 1 presents the overall process for person re-identification.

2. Color catgorization

The first stage of our re-identification process is Color Categorization. In this section, we first present the motivation for the Color Categorization procedure. Then, we briefly review the Probabilistic Latent Semantic Analysis (PLSA) method. Finally, we introduce our proposed method.