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Correlation based efficient face recognition and color change detection

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ABSTRACT

Identifying the human face via correlation is a topic attracting widespread interest. At the heart of this technique lies the comparison of an unknown target image to a known reference database of images. However, the color information in the target image remains notoriously difficult to interpret. In this paper, we report a new technique which: (i) is robust against illumination change, (ii) offers discrimination ability to detect color change between faces having similar shape, and (iii) is specifically designed to detect red colored stains (i.e. facial bleeding). We adopt the Vanderlugt correlator (VLC) architecture with a segmented phase filter and we decompose the color target image using normalized red, green, and blue (RGB), and hue, saturation, and value (HSV) scales. We propose a new strategy to effectively utilize color information in signatures for further increasing the discrimination ability. The proposed algorithm has been found to be very efficient for discriminating face subjects with different skin colors, and those having color stains in different areas of the facial image.

1. Introduction and motivation

Correlation-based techniques have shown a remarkable promise for next generation face recognition and pattern recognition systems [1–2]. For fundamental understanding and development of robust technologies to discriminate between different classes of objects on the basis of their correlation features, it is extremely important to consider color information in scenes. The color information can play a critical role in the decision making process. For example, the ability to classify objects based on boundaries and color are important in inspection technology for improving food safety and quality. This reconnaissance technology can also be used for patient monitoring via home video surveillance to detect serious injury as a result of accidental falls of disabled and elderly persons [3], or to analyze the difference between benign and precancerous/cancerous lesions on the face i.e. pigmented lesions on the skin.

Before delving into the technical part of the study, we briefly review related investigations which have been done on object recognition by correlation techniques. These techniques can be broadly classified as two kinds of architectures based on the joint transform correlator (JTC) or the Vanderlugt correlator (VLC) [1–11]. Various types of filters have been proposed for improving the performance of VLC [11–14]. Composite filters are characterized by a good trade-off between discrimination ability and robustness. Since they are based on spectral fusion, the number of correlations needed for making reliable decision can be considerably reduced [14]. In an earlier work [5], an optimized version of this filter has shown to significantly increase the number of references to be merged in the composite filter. The spectral plane of the correlation filter was segmented into several independent regions and each region was allocated to a single reference based on a prescribed energy criterion. However, practical implementation of this analysis is hampered by the appearance of isolated pixels. Isolated pixels are detrimental to the filter performance. This effect becomes more and more pronounced as the number of references used to define the filter is increased. To overcome the issue of isolated pixels, another segmentation criterion was suggested in [15]. However, such filters cannot be used in their original forms to deal with color images. More recently, multiple JTC architectures have been proposed for various invariant pattern recognition applications [16–19]. In particular, a set of color-sensitive JTC techniques for two- and three-dimensional pattern recognition was reported in the literature [16–18]. However, these techniques show sensitivity to illumination variations.

Recently, Elbouz et al. [4] proposed a new approach for color correlation [4]. This approach is based on the decomposition of color target images and reference images into their red, green and blue (RGB) components following which each component is transformed into a contour image based on a specific signature [4]. Next, the phase-only filter (POF) for each contour component of the reference image is fabricated. Finally, these filters were independently correlated with the corresponding contour component of

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the target image. However, this method is not adequate to deal simultaneously with illumination and color changes. In addition, it leaves open the issue of detecting color spots in the image i.e. color stains on the face (facial bleeding). Thus, it is necessary to optimize this approach in order to deal with the following issues: (1) accommodate color information in the target image, (2) accurate face recognition and identification, (3) robustness for illumination variations, and (4) detect color stains of different dimensions on a given face. This work is a part of our current project on home video surveillance for the disabled and/or elderly patient monitoring [3]. In particular, our objective is to recognize faces and ascertain whether it contains color stains.

A note is in order. The present paper contains solution for detection of a face with a red colored stain which shows robustness against illumination variation and rotation. However, it is not adapted to analyze facial expressions. On the one hand, these expressions can be treated like noise, i.e. variation of the target image with respect to the reference image. In this respect, the correlator performances will be modified when this type of noise is present. Fortunately, this problem can be overcome [20–21], e.g. by adding a set of images with different facial expressions in the reference base and making use of a composite filter. On the other hand, recognizing the emotional state of a subject can be done by first decomposing the face in several areas (mouth, eye, eyebrow, and nose), and then calculating and comparing some metrics characterizing these areas.

Recently, several research projects on color pattern recognition have been reported in the literature [20–33]. This work generated significant interest and represents very important stepping stones toward the development of technological applications. However, these techniques generally suffer from poor sensitivity to the illumination and/or color detection [20–36,29–33]. The primary objective of our method is to study the effect of shape and color for object recognition by examining its robustness with respect to image saturation, illumination variation, background change, and size of stain color. At first, we summarize the steps leading to the two-level optimization of the proposed method. In the first level, devoted to object identification, the face is decomposed using red, green and blue (RGB) and also hue, saturation, and value (HSV) color spaces [16] and each color is processed with an independent correlator. Based on various test results obtained using RGB, normalized RGB ($R_N G_N B_N$), HSV, and normalized HSV ($H_N S_N V_N$), the normalized HSV representation was adopted for the first level. The merging of these three components implemented through three parallel correlations outperforms the correlator's performance for making a decision [5]. In the second level, numerical preprocessing of the input image was performed using a novel coding of the color images. Each color is associated with a specific pattern based on the type of color and intensity [4]. The RGB color space was employed in the second level to improve the correlation sensitivity to the changes in the target images. These signatures are then fused to fabricate one correlator thus eliminating the need for making three correlations in parallel.

The layout of the remainder of this paper is as follows. In Section 2, we briefly discuss early face recognition studies to fully justify the use of correlation. In Section 3, we describe the two-level correlation technique for making a decision. To overcome the problems associated with illumination changes, a new method is

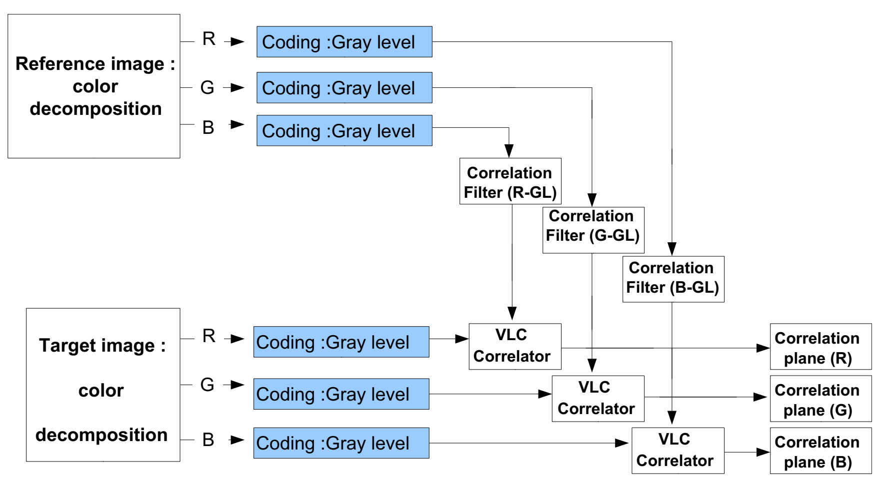

Fig. 1. Illustrating the principle of separated correlation (RGB decomposition).

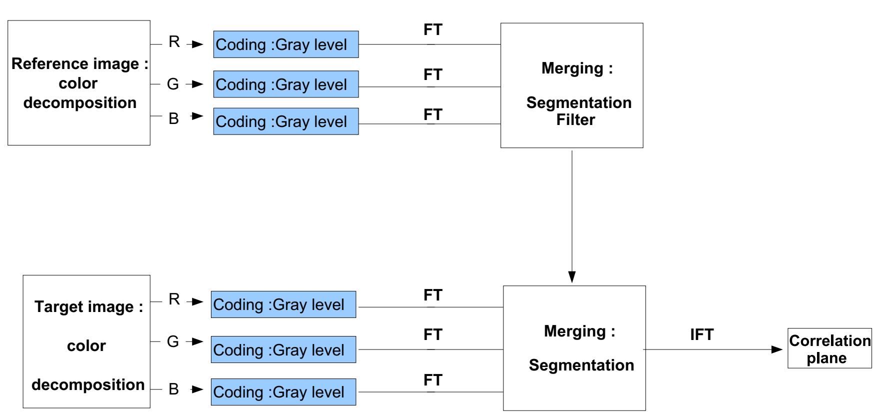

Fig. 2. The synoptic diagram corresponding to color correlation based on a segmented filter, IFT denotes the inverse FT.