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Modifications to the Eigenphases Method for Face Recognition Based on SVM

Modificaciones del método de Eigenphases para el reconocimiento de rostro basado en SVM

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Abstract

This paper presents two modifications to the eigenphases method to increase its accuracy. In the first modification, called *Local Spatial Domain Eigenphases* (LSDE), the face image is first segmented into blocks of $N \times N$ pixels, whose magnitudes are normalized. These blocks are then concatenated before the phase spectrum estimation, and finally *Principal Component Analysis* (PCA) is used for dimensionality reduction. In the second modification, called *Local Frequency Domain Eigenphases* (LFDE), first the face image is segmented into blocks of pixels, whose pixels are normalized. The phase spectrum of each block is estimated independently. Next, the phase spectra of all the blocks are concatenated and then are applied to the PCA stage for dimensionality reduction. The proposed approaches are evaluated using open-set and closed-set face identification, as well as identity verification, using the "AR Face Database." The evaluation results show that the proposed modifications, using the Support Vector Machine as the classifier, perform fairly well under different illumination and partial occlusion conditions.

Keywords:

- eigenphases
- gabor transform
- discrete wavelet transform
- principal components analysis
- support vector machine

Resumen

Este trabajo presenta dos modificaciones del método de eigenphases para aumentar su precisión. En la primera modificación llamada Local Spatial Domain Eigenphase (LSDE), la imagen del rostro se divide en bloques de N × N píxeles, cuyas magnitudes se normalizan. Estos bloques se concatenan antes de que el espectro de fase y el PCA se estimen. En la segunda modificación llamada Local Frecuency Domain Eigenphase (LFDE), después de la segmentación de la imagen en bloques de N x N píxeles, las magnitudes de los pixeles de dichos bloques se normalizan y se calcula el espectro de fase en forma independiente. Una vez que se obtiene el espectro de fase de todos los bloques, se concatenan y se procede a la aplicación del análisis de componentes principales (PCA) para reducir la dimensionalidad del problema. Las modificaciones propuestas se evalúan en la modalidad de identificación, tanto en "open set" como en "closed-set", así también en verificación de identidad. En ambos casos se empleó la base de datos AR Face Database. Los resultados experimentales muestran que las modificaciones propuestas presentan un funcionamiento adecuado bajo diferentes condiciones de iluminación y oclusión parcial.

Descriptores:

- *eigenphases*
- *filtros de gabor*
- *transformada discreta*
- *transformada discreta wavelet*
- *análisis de componentes principales*
- *máquina de vector de soporte*

Introduction

Face recognition is a widely used biometric technology because it is non-intrusive and can be performed with or without the cooperation of the person being analyzed. Thus, face recognition is one of the biometric technologies that has gained higher acceptance among users (Kung *et al*., 2005; Li and Jain, 2011). This technology can be used for either identity verification or person identification, depending on the way in which the system parameters are estimated during the training task. Hence, it is convenient to mention the differences between these two tasks. In the identity verification task, the system is asked to determine whether the person is who he/she claims to be, whereas during the person identification task, the system is asked to determine, among a set of persons whose facial characteristics are stored in a database, the person who most closely resembles the image under analysis. Thus, the recognition task encompasses both identification and verification (Chellappa *et al*., 2010).

Variable illumination and occlusions are some of the relevant problems that must be solved in face recognition because these factors alter the perception of face images, which significantly decreases the accuracy of face recognition performance (Ruiz and Quinteros, 2008). In particular, improving the performance of face recognition algorithms under varying lighting conditions has attracted researchers' attention during the last several years, because changes in lighting conditions occur during the transition between indoor and outdoor environments, as well as within both indoor and outdoor environments, due to the 3D shape of the face, which produces shadows depending on the direction of illumination (Ruiz and Quinteros, 2008). Accordingly, several approaches have been proposed for reducing the variable illumination effects (Ruiz and Quinteros, 2008), which can be divided into two groups. The first group, which employs illumination plane subtraction with histogram equalization (Ramírez *et al*., 2011), contrast-limited adaptive histogram equalization (CLAHE) (Benitez *et al*., 2011), processes the input image to reduce the illumination changes, thereby improving the face image quality. The second approach for addressing variable illumination conditions is the development of face recognition algorithms that are able to provide robust performance under varying illumination conditions. To this end, several methods have been proposed which simultaneously provide small intraperson and large interpersonal variability under varying illumination conditions. Among them, the eigenphases approach, which uses the phase spectrum (Zaeri, 2009), together with *principal component analysis* (PCA) and the *support vector machine* (SVM) (Benitez *et al*., 2011; Zaeri, 2009; Olivares *et al*., 2009; Benitez *et al*., 2012), appears to be a desirable approach because it provides recognition rates of over 95%. The use of other frequency transformations, such as the discrete cosine transform (Dabbaghchian *et al*., 2010; Ajit *et al*., 2014), discrete Gabor transform (Olivares *et al*., 2007; Thiyagarajan *et al*., 2010; Qin *et al*., 2012), discrete wavelet transform (Hu, 2011; Eleyan *et al*., 2008) and discrete Haar transform (Gautam *et al*., 2014), has also been proposed. These approaches, under controlled conditions, achieve recognition rates of over 90%. Additional methods proposed in the literature include the Eigenfaces approach