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ORIGINAL ARTICLE

Ensemble of texture descriptors and classifiers for face recognition

Alessandra Lumini [a], **Loris Nanni** [b,*], **Sheryl Brahnam** [c]

[a] *DISI, Università di Bologna, Via Venezia 52, 47521 Cesena, Italy*
[b] *DEI, University of Padua, viale Gradenigo 6, Padua, Italy*
[c] *Computer Information Systems, Missouri State University, 901 S. National, Springfield, MO 65804, USA*

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Abstract Presented in this paper is a novel system for face recognition that works well in the wild and that is based on ensembles of descriptors that utilize different preprocessing techniques. The power of our proposed approach is demonstrated on two datasets: the FERET dataset and the Labeled Faces in the Wild (LFW) dataset. In the FERET datasets, where the aim is identification, we use the angle distance. In the LFW dataset, where the aim is to verify a given match, we use the Support Vector Machine and Similarity Metric Learning. Our proposed system performs well on both datasets, obtaining, to the best of our knowledge, one of the highest performance rates published in the literature on the FERET datasets. Particularly noteworthy is the fact that these good results on both datasets are obtained without using additional training patterns. The MATLAB source of our best ensemble approach will be freely available at https://www.dei.unipd.it/node/2357.

* Corresponding author.
E-mail addresses: alessandra.lumini@unibo.it (A. Lumini), loris.nanni@unipd.it (L. Nanni), sbrahnam@missouristate.edu (S. Brahnam).

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1. Introduction

Face recognition has been an area of intense study since the 1960s. Innovative applications making use of this technology are continuously being developed at a rapid pace. Contemporary face recognition applications can be divided into three areas that depend on the goal of the face recognition task: (1) face verification, where the goal is to authenticate the identity of a face image with a corresponding template; (2) face identification, where the goal is to find a match in a database of face images; and (3) face tagging (a relatively new variation of face identification), where the goal is to label face images based on identification when matched. Face recognition is now an essential component in biometric security, access management, criminal identification, and image sorting and retrieval.

The main goal of face recognition is to compare two images of faces and solve the problem of determining whether both images are of the same person or of two different people. This problem is difficult because two images of the same person can vary considerably in time, pose, facial expression, illumination conditions, occlusions, and image quality. Most state-of-the-art face recognition techniques perform well when facial images are captured in optimal (laboratory) conditions where lighting is controlled and samples provide full frontal views, but when facial images are captured in the wild – where pose, age, and facial expressions change and where environmental conditions such as lighting are less than ideal – performance deteriorates. The difficulty lies in teasing out the specific features indicative of identity from the mass of features expressing other conditions. Even the best classifier will fail if an insufficient number of features indicative of identity are isolated. One way to tackle this problem is to use *multibiometrics*, which recognizes individuals via biometric fusion [1], whether multimodal, multi-instance, multisensorial [2], or multialgorithmic. Of particular importance to both single trait biometrics and multibiometrics is the identification of face descriptors that are discriminative yet insensitive to information having nothing to do with identity, such as pose variations, changes in facial expression, and lighting conditions.

Some of the most notable face recognition techniques developed the last five decades [3] include Principal Component Analysis, Elastic Template Matching, Discriminant Analysis, Local Binary Patterns (LBPs), Algebraic moments, Gabor Filtering [4], and Neural Networks [5]. One way to categorize face recognition techniques is to look at how a face is represented [3]. *Appearance based approaches* utilize global texture features such as Eigenfaces [6] or some other linear transformation. In addition to the information found in the texture of a face image, *Model based approaches* take into account the shape of the face, whether 2D [7] or 3D. *Geometry or template based approaches* compare an input image with a set of templates constructed using either statistical tools or by analyzing local facial features and their geometric relationships [8]. *Neural Networks* include approaches based on "deep learning" where the representation of faces is learned during the training process [5]. This last class includes approaches that are often referred to as "*deep*

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