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Automatic face recognition system based on the SIFT features ☆

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ABSTRACT

The main goal of this paper is to propose and implement an experimental fully automatic face recognition system which will be used to annotate photographs during insertion into a database. Its main strength is to successfully process photos of a great number of different individuals taken in a totally uncontrolled environment. The system is available for research purposes for free. It uses our previously proposed SIFT based Kepenekci approach for the face recognition, because it outperforms a number of efficient face recognition approaches on three large standard corpora (namely FERET, AR and LFW). The next goal is proposing a new corpus creation algorithm that extracts the faces from the database and creates a facial corpus. We show that this algorithm is beneficial in a preprocessing step of our system in order to create good quality face models. We further compare the performance of our SIFT based Kepenekci approach with the original Kepenekci method on the created corpus. This comparison proves that our approach significantly outperforms the original one. The last goal is to propose two novel supervised confidence measure methods based on *a posterior* class probability and a multi-layer perceptron to identify incorrectly recognized faces. These faces are then removed from the recognition results. We experimentally validated that the proposed confidence measures are very efficient and thus suitable for our task.

1. Introduction

Automatic Face Recognition (AFR) consists in identification of a person from an image or from a video frame by a computer. This field has been intensively studied by many researchers during the past few decades. Nowadays, it can be seen as one of the most progressive biometric authentication methods. Numerous AFR methods have been proposed and the face recognition has become the key task in several applications as for instance surveillance of wanted persons, access control to restricted areas, automatic annotation of photos in photo sharing applications or in social networks, and so on.

From the viewpoint of the image nature and quality, it is possible to divide this spectrum of applications to two groups: controlled and uncontrolled scenario systems. The image quality of the controlled systems is usually high, a face pose variation and other dissimilarities (lighting conditions, face tilt and rotation, etc.) are limited. Automatic face recognition is easier because the face detection and further image preprocessing are usually not necessary and the performance of current AFR approaches is often sufficient. Most of the current AFR systems belong into this group.

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However, few uncontrolled scenario systems exist. The main issue of these systems is that the face pose and position significantly differ and also the other dissimilarities within the images are common. A successful face recognition is thus much more challenging. This issue will be addressed in this paper and solved by the goals described next.

The first goal consists in proposing an algorithm to extract the faces from the photographs and to create a facial corpus as high quality as possible. The design and implementation of this algorithm is one important contribution of this paper. We will further show that the usage of this algorithm in our AFR system in the preprocessing step is beneficial.

It is necessary to identify an optimal face recognition approach to be integrated into our system. In our previous work [23] we proposed an efficient *SIFT based Kepenekci* face recognition approach and evaluated it on the standard ORL [15] corpus. We showed that this approach gives very good results using this small well controlled face dataset. The second goal thus consists in evaluation of our SIFT based Kepenekci on the other larger standard face corpora. We have chosen three large challenging face databases: FERET [33], AR [29] and LFW [17]. Our method is then compared with a number of very efficient AFR approaches in order to identify the most suitable one for the large data and for processing of the less controlled images. This method will be integrated into our system.

Face recognition in an uncontrolled environment is erroneous and it is beneficial to identify incorrectly recognized examples. The third goal of this paper thus consists in proposing and evaluating the confidence measure methods in order to identify such examples and remove them from the recognition results or propose them to the user for manual correction. Two novel supervised confidence measures based on *a posterior* class probability and a multi-layer perceptron are proposed.

The last goal of this paper is to introduce an experimental fully automatic face recognition system. This system will be used by the Czech News Agency (ČTK)[1] to annotate people in photographs during insertion into the ČTK database.[2] Its main strength is to successfully process photos of a great number of different persons taken in a totally uncontrolled environment. The original images have high resolution but the size of the faces varies substantially. There are also significant variances in lighting, ageing, face poses and angles. Moreover, another property is presence of more objects/faces in the images. The recognition of such images is thus very challenging. The system (with the source code) is available for research purposes for free. Note that the resolution of face images is strictly related to our proposed application. However, our face recognition approach is general enough to process images of different resolutions.

This paper is organized as follows. The following section summarizes successful approaches in the face recognition domain including confidence measure methods and face recognition systems. Section 3 describes the proposed corpus creation algorithm. Section 4 details the SIFT based Kepenekci method which we use for the face recognition. The next section details the proposed confidence measure methods which are used in order to detect and remove incorrectly recognized faces from the recognition results. Section 6 describes the architecture of our face recognition system. The performed experiments are presented in Section 7. This section describes the corpora which are used to evaluate the system. Furthermore, we compare our AFR module with the other efficient methods on these corpora. The performance of our system on the lower quality real ČTK data with the particular focus on the proposed corpus creation algorithm is shown further. In the last part of this section we evaluate our confidence measure methods. Section 8 briefly summarizes the main scientific contribution of this paper. In the last section, we conclude the results and propose some future research directions.

2. Related work

One of the first successful approaches in the AFR domain is the Principal Component Analysis (PCA), so called Eigenfaces [39]. This is a statistical method that takes into account the whole image as a vector. First, the image vectors are put together and the image matrix is formed. The eigenvectors of this matrix are calculated. The face images can then be expressed as a linear combination of these vectors. Each image is represented as a set of weights for the corresponding vectors. The PCA based approaches are still popular, as shown in [34].

Another method, the Fisherfaces [5], is derived from Fisher's Linear Discriminant (FLD). Similarly to Eigenfaces, Fisherfaces project an image into another, less dimensional, space. The original dimensionality, which is given by the resolution of the images, is reduced to the number of images (distinct classes). The projections of the facial images are then compared using a suitable similarity measure. The key point is maximization of the ratio of between-class scatter and within-class scatter. However, Eigenfaces maximize the total scatter across all images. According to the authors, this approach should be insensitive to variations in lighting conditions. A recent extension of this approach, called L-Fisherfaces, is proposed in [48]. Authors experimentally showed that this method achieves higher accuracy than four other evaluated methods on the three datasets.

Independent Component Analysis (ICA) can be also successfully used in the automatic face recognition field [11]. The main principle is to find a linear combination of non-Gaussian data that reconstructs the original data. Contrary to PCA, ICA uses higher order statistics. ICA thus provides more powerful data representation. ICA approach is still worthy of attention as shown in [10]. Authors further propose a Locality Pursuit (LP) approach, which uses locality preserving projections in

[1] http://www.ctk.eu.
[2] http://multimedia.ctk.cz/en/foto/.