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THE DESIGN ASPECTS OF FACE IDENTIFICATION SYSTEM WITH SVMs

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The person identification systems are increasingly becoming popular in modern society. The producers of security systems are interested in the new technologies for the automation of the person identification process. This fact is due to rise the level of these systems reliability because of depreciation of the components of used hardware in the designing and the construction of ones.

The range of the biometric systems identification is wide enough, there're the identification on the fingerprints, the iris identification, the face recognition methods and etc. All these technologies are different by the algorithms, methods and techniques that used for the system development. The considerable quantity of solutions are proposed in the field of face recognition and in the sphere of the person identification by photo. Nowadays the development of the automatic personal identification system is a very important issue because of the wide range of applications in different spheres, such as video surveillance security systems, control of documents, forensics systems and etc.

It is necessary to mark that the process of pattern recognition in the field of image processing consists of several required stages before the reception of final result. There are the preprocessing of the source patterns (the image data processing such as the readjustment of light conditions, the detection of region of interest, the image resizing), the dimension reduction of source data space by data transformation (to data approximation and to remove the noise), the selection and the implementation of techniques for the data classification.

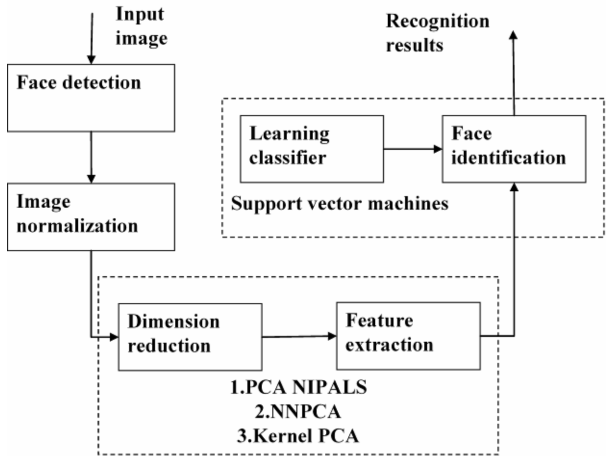

Figure 1 - Structure of the system

In this paper we describe the experimental face identification system based on support vector machines (SVM) [1] and we consider some more interesting aspects with designing and constructing of the person system identification by photo. Our system consists of several typical modules (see figure 1) that are characteristic for the systems of this type such as block of the region of interest (face) detection, block of the image normalization (with the functions of improvement of brightness and contrast characteristics), the features' extraction block for the dimension reduction of source data space, the module of face recognition (identification) with the functions for the training SVM-classifier and the functions of classification of the processed pattern by the definition of the test image to the defined class.

At the stage of the system development we have realized some experiments and established that the face detection procedure is more important and must be executed at first.

The image normalization module should work at the second stage. The results and the level of performance efficiency of these procedures in that order are displayed in a figure 2. There is effect of the occurrence of the background and of the equalization of histogram for additional parts of photo. Application of the image enhancement unit on the detected region of interest (face in particular) allows receiving the more contrasting images that suitable for the further procedure of reduction of the original data space and the pattern recognition process.

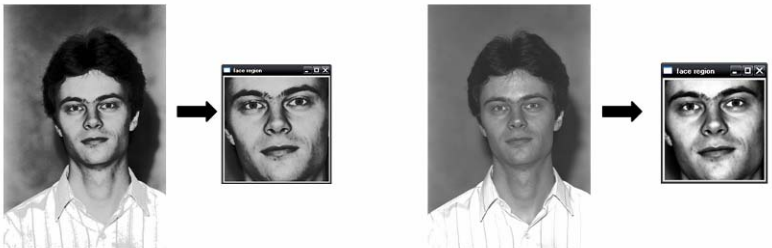

Figure2 – Samples of image normalization: left – "normalization-detect", right – "detect-normalization"

The location of the face region performs the unit of face detection with the known algorithm of Viola-Jones [2]. This effective face detection method based on simple features trained by the adaboost algorithm, integral images and cascaded feature sets have been used. However, the results of usage of initial algorithm during the experiments execution are shown in figure 3 and we can observe a lot of noised data such as the background, the hair, the clothes.

Figure 3 – The face region with the noised data

These elements of image are not interested for the further pattern recognition process. It's necessary to obtain a narrower region of interest to achieve a higher level of reliability at the stage of the recognition process. We have developed the technique to detect region of face based on anthropometric data of the person to extract the face features only without any noised data. The results of application of the presented algorithm are shown on figure 4.

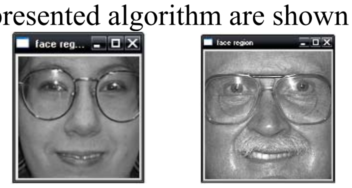

Figure 4 – The face region only

Our approach is based on application on discrete adaboost [3] to select simple classifiers based on individual features drawn from a large and over-complete feature set in order to build strong stage classifiers of the cascade. This technique executes the iris area only, not whole face as the previous method. The input image for iris detection procedure is the result from the previous stage of image processing that contains the parts of the clothes, the hair etc. At first we execute the search of the left eye area only. After that (if the previous stage was finished successfully) the procedure of the right eye search is starting. In case of obtaining the positive result we calculate distance between pupils in pixels. At the next step we compute the left upper point of region of interest coordinates. The face region is limited by squared boundaries. The computation is performed with usage of the distance between pupils from the previous stage. The length from the left iris to upper boundary is calculated as $0{,}55 \cdot D$ and the length from the left iris to the left boundary of the region of interest is equal $0{,}47 \cdot D$, where D is the distance between pupils in pixels. Thus the length of the side of square of face region is calculated as $2 \cdot 0{,}47 \cdot D + D = 1{,}94 \cdot D$. These estimated coefficients were obtained experimentally.

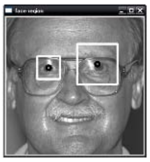

Figure 5 – The face with eyeglasses

Figure 6 – The face with pair eyes

Our approach allows finding the specified face region on the majority tested images. If this problem has not been solved successfully we used follow technique. In that case the algorithm performs the search of eyeglasses area and the iris in particular for each eye using the adaboost strategy described above. The results of search of eyeglasses are represented in figure 5. In case of unsuccessful attempt the search of region of pair eyes starts (see figure 6 with results). Our algorithm has found the face regions of interest on all tested images. However, we provide for every eventuality when nothing found at the proceeded image and the original entry image is used as region of interest.

At next stage our system performs the procedures of image normalization. We perform an expansion of pixels values to the whole intensity range and the equalization of histogram. The first approach maps the values in intensity image to new values such that values between low and high values in current image map to values between 0 and 1. Thus the new pixel values allocate to whole intensity range. The histogram equalization enhances the contrast of images by transforming the values in an intensity image so that the histogram of the output image approximately matches a specified histogram. After use these methods the image contains some distortions as sharp face lines. That's why we apply the median filter for dither the face features. Using median filter performs median filtering of the input image in two dimensions. Each output pixel contains the median value in the 3×3 neighborhood around the corresponding pixel in the input image. This part of image processing removes significantly the illumination changes among the images. The figure 7 illustrates the results of introduction the image pre-processing methods described above.

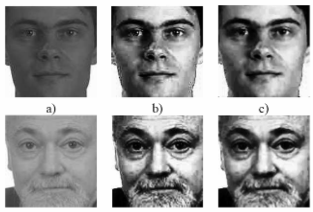

Figure 7 - Examples of normalized images: a - input images, b - after application adjusting image intensity values and histogram equalization, c - after using median filter.

Most classification-based methods have used the intensity values of window images as the input features of classifier. However, using directly the values of intensity values of image pixels are dramatically increases the computation time. On the other hand the huge capacity of data contains many waste data being overfull. In our system, we extract direction features via method of principal component analysis. We use three techniques for implementation of this approach. There are the algorithm NIPALS (non-linear iterative partial least squares) [4] for compute the principal components, the neural network PCA (NNPCA) [5], and the kernel principal component analysis[6].

The features extracted vector is presented as the sequence of more significant coefficients of the principal components. In our work the size of face region extracted in face detection block is 169×169 pixels. Thus the original data dimension counts 28.561 features. Using the most important values of image for feature extraction we form the sequences with 169 coefficients only. The second part of data (less significant coefficients) is rejected.

Thus we use three different approaches to extract the features vector from the original data set (region of interest that contains a facial image).

The Support Vector Machines (SVMs) [1] present one of kernel-based techniques. SVMs based classifiers can be successfully apply for text categorization, face identification. A special property of SVMs is that they simultaneously minimize the empirical classification error and maximize the geometric margin; hence they are also known as maximum margin classifiers. SVMs are used for classification of both linearly separable and unseparable data. For multi-class classification we use the "one-against-one" approach in which $k(k-1)/2$ classifiers are constructed and each one trains data from two different classes.

Basic idea of SVMs relative to the Nearest Neighbor approach is creating the optimal hyperplane and calculating the decision function for linearly separable patterns. This approach can be extended to patterns that are not linearly separable by transformations of original data to map into new space due to using kernel trick.

Our system contains two basic blocks. There are training SVM-classifier module and face identification unit based on SVM-classifier. At first we have to create the model for following pattern recognition. At this stage we train our SVM-classifier by the algorithm proposed Jones C.Platt. In our system we used the libsvm implementation [7] of this algorithm. The one type input feature vector containing the significant coefficients from PCA is used both for train and classification.

For testing our face recognition system based on support vector machines we used the sample collection of images with size 512-by-768 pixels from database FERET [8] containing 100 classes (unique persons). This collection counts 300 photos. Each class was presented by 3 images. So, to train SVM-classifier we used 200 images where 2 photos introduced each class. 100 images were used to test our system. Note, that any image for testing doesn't use in training process. The results of realized experiments are shown in the table 1.

Table 1 – Results of testing person identification system

	Recognition rate, percent	Feature extraction time for each vector, s	Training time, s
PCA NIPALS	80	0.6	28.4
NNPCA	84	12	28.8
Kernel PCA	81	0.8	28.3

In this paper we proposed an efficient face identification system based on support vector machines. This system performs several algorithms for ensuring the full process of pattern recognition. Thus, our system is intended for face identification by processing the image even low quality. The face detection region procedure without any noise is a very important stage of the person identification process. The angle of inclination and the rotation angle of head influence on the level of reliability of recognition. These factors are the most significant in person identification system.

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