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GENDER CLASSIFICATION FROM FACE IMAGES

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ABSTRACT

In this article, we study on gender classification which is one of the important issue in security, statistics and related commercial areas. In the study, FEI face data set has been used that has 200 female and 200 male frontal face images. Principal component analysis (PCA) has been used for feature extraction process. We use all part of the face images instead of taking some part of them. Support Vector Machine (SVM) and k-nearest neighbor algorithms used for classification test phases. We compare the results which obtained in our experiments and give them in tables and graphs. According to the experiments, defined as hybrid method principal component analysis with k-nearest neighbor method gives better recognition accuracy then defined as hybrid method principal component analysis with support vector machine method.

ÖZ

Bu makalede, günümüzde güvenlik, istatistik ve ilgili ticari alanlarda önemli yer tutan konulardan biri olan, yüz resimlerinden cinsiyet sınıflandırma üzerine bir araştırma yapılmıştır. Çalışmada, 200 bayan ve 200 bay olmak üzere 400 adet ön yüz resmi bulunan FEI yüz veri kümesi, resimlerden özellik çıkarımı için ise temel bileşen analizi (TBA) kullanılmıştır. Özellik (feature) çıkarımında yüzün belirli bölümleri yerine tamamı alınmıştır. Sınıflandırma ve test için destek vektör makineleri (DVM) ve en yakın k-en yakın komşu (k-nearest neighbor k-nn) algoritmaları kullanılmıştır. Deneysel çalışmalarda elde edilen sınıflandırma doğruluk oranları karşılaştırılmış ve sonuçlar analiz edilerek tablolar ve grafikler şeklinde sunulmuştur. Buna göre, elde edilen sonuçlara göre, temel bileşen analiziyle hibrit metot olarak kullanılan k-nn algoritmasının, destek vektör makineleri yöntemine göre cinsiyet sınıflandırmada daha iyi sonuçlar verdiği tespit edilmiştir.

Keywords: *Gender classification, face recognition, principal component analysis, k-nearest neighbor.*
Anahtar Kelimeler: *Cinsiyet sınıflandırma, yüz tanıma, temel bileşen analizi, k-en yakın komşuluk.*

1. INTRODUCTION

Pattern recognition is one of the sub-part of artificial intelligence and machine learning. It is described as recognition of patterns which has some special numbers, letters and shapes. For this purpose, this system makes classification process, using patterns' important features. It is used speech and speaker (voice) recognition, fingerprint recognition, character and digit recognition, DNA/RNA (microRNA) classification, micoarray data classification/clustering, military applications, robotics, fault detection systems, image and signal processing, classification and more application areas. It will be more common in the future. Customer detection and classification, churn analysis are also among this systems. Therefore, gender classification process is one of the important area in pattern recognition.

Although, many researchers publish many studies in pattern recognition area, there are quite little papers related with gender classification in the literature. This concept is also important for psychological effects. Especially, artificial neural networks, principal component analysis, support vector machines and k-nearest neighbor methods has been used in the literature. First study for gender classification had been made in 1991 by Jain and Huang [1, 17]. Next research had been studied with artificial neural networks [2, 17]. On the other hand, principal component analysis has also been preferred in machine learning and pattern recognition community [4,17]. It has been developed by Hetelling [3]. Chervonenkis et al used hyperplane kernels for nonlinear classification [1].

K-nearest neighbor method was proposed in order to classify patterns, by Fix and Hodges in 1951. In [6], local binary pattern (LBP) was used for gender classification to measure the performance and get 95% success. On the other hand, genetic algorithms, linear discriminant analysis and artificial neural networks methods also have been studied in the literature [6]. L. Lu et al used two stages principal component analysis and support vector machines algorithms and reached 94% accuracy [7]. H. Hassasnpour et al tried fuzzy logic classification on principal component analysis and they reached 87% accuracy result [8]. M. Hu et al also published successful

approach based on principal component analysis [9]. In 2014, convolutional neural networks and support vector machine hybrid approach have been applied to determine the gender. 84% accuracy has been obtained in this article using Matlab programming [10]. T. Bissoon et al tested principal component analysis and linear discriminant analysis hybrid approach in their study, in 2013 [11]. At the end, support vector machines, principal component analysis, k-nearest neighbor and Fischer discriminant analysis algorithms have been used in [12].

2. APPLIED METHODS

In this article, we use FEI face data set. It has been collected in Artificial Intelligence laboratory-Brazil, 2006. According to the publications in this field; chap, eyebrow and distance between eyebrows are important features for gender recognition [13]. Therefore, we remove other parts from face images. Hair parts of face images also removed from faces. These images is used for feature extraction process of principal component analysis. We use k-nearest neighbor and support vector machine algorithms and compare the recognition results.

2.1 Principal Component Analysis (PCA)

Principal component analysis is one of the most used algorithm in image processing. The purpose of this method decrases the size of data without harm it. This is also called Karheunen-Loeve transform or Hotelling transform [14]. In this method, the projection is used to extract features. The variance is calculated and chosen with that direction. So, we can summarize it with these basic steps:

Let $W=\{X_1,X_2,X_3,X_4,\ldots\ldots,X_k\}$ is a sample data set, with each element X_k is NxN dimension. Firstly, mean of X is calculated with these formulas:

$$\mu_{\times} = \frac{1}{n}\left(\sum_{i=0}^{n} X_i\right) \qquad (2.1a)$$

$$\mu_{W} = \frac{1}{k}\left(\sum_{i=0}^{k} \mu_{\times_i}\right) \qquad (2.1b)$$

After finding the mean of data set, the axis is shifted by subtracting each element with mean value. Then, covariance matrix of new values is calculated. For example, if we have X values with amount of K, then covariance values will be $K!/[(K-2)! * 2]$. The covariance matrix is a symmetric and its diagonals give the variance of data X. Obtained this matrix coordinates contains all combinations of covariances. After that, eigenvalues and eigenvectors of covariance matrix is calculated :

$$[C - \lambda I] = 0 \qquad (2.2)$$

All eigenvalues of C covariance matrix and their correspondent eigenvectors is calculated with below equation:

$$[C - \lambda_{1\to k} I]\begin{bmatrix} \propto_1 \\ \vdots \\ \propto k \end{bmatrix}_{k,1} = 0 \qquad (2.3)$$

All lenghts of each eigenvectors are 1 and after this stage less important parts can be removed from data set. For this purpose, obtained eigenvalues and eigenvectors is organized from largest values to small values. Moreover, very small parts can be removed completely. Here, the largest value is chosen as first principal component. This process will make computations easy for covariance and finding eigenvector. The eigenvector matrix is obtained with organizing them from the minimum one to

maximum one. In this stage, small eigenvectors can be removed. So, the matrix can be formed.

$$[W]_{KxN^2}([C]^T)^{-1} = [\overline{W}]_{KxN^2} \qquad (2.4)$$

After that, when we use Eq. (2.4), new space is obtained. Data is converted the axis which names called first component and second component. In principal component analysis, each image is shown as row or column vector. This process can be called vectorization. We make computations with row vectors. Obtained matrix can be seen in Fig. 1.

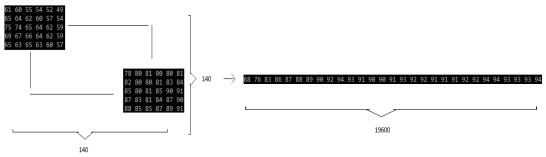


Figure 1. Forming a row vector with 140x140 size image
(Vectorization process)

After these conversion, data set wil be ready for implementing principal component analysis algorithm. Label is also ready for this process. After determining eigenvalues and eigenvectors, sample data is converted to new space. The largest 15 and 90 eigenvectors space has been chosen as two space.

2.2 Support Vector Machine (SVM) and k-nearest neighbor

In this study, we employ support vector machine and k-nearest neighbor classification algorithms. These are well known and widely used methods in machine learning area. Determining a line between two groups is main issue for support vector machine. It should be fitted according to data points. With this approach not only linear classification but also nonlinear classification can be implemented. On the other hand, k-nearest neighbor algorithm uses distance measures for classification with proper k

values [15]. But this method is very sensitive for distinct values. Classification is applied according to k values starting with 1 to other integer numbers. If the distance the same, in this condition one of class randomly selected [16].

3. EXPERIMENTAL RESULTS

We implement totally 400 faces from FEI face data set. k-fold cross-validation method is used to find error rate. We set this value as k=4. After reduction of dimension of data, we apply k-nearest neighbor algorithm. We show accuracy values for eigenvalues 15 and 30 in Table I. Mean recognition rates also can be seen from the table. We test the method 4 times and take their mean.

Figure 2. Organizing FEI face data set face images

The process on face images can be seen from Fig.2. Adjusting and preparing phases implemented on data set.

Experiments on k-nearest neighbor classifier show that 30 eigenvectors recognition is more successful than 15 eigenvectors. We can see this computations from Table 1.

k-fold cross validation method is also used for k-nearest neighbor algorithm to randomize the classification process and get their accuracies.

Table 1. The k-nearest neighbor accuracy rates for first 15 and 30 eigenvectors of FEI data set

KNN						
Eigenvector	k	TEST 1	TEST 2	TEST 3	TEST 4	MEAN
30	3	85	91	91	96	90.75
	4	85	89	86	93	88.25
	5	88	90	87	94	89.75
	6	86	85	83	93	86.75
	7	84	88	82	94	87
	8	86	87	82	92	86.75
	9	83	87	83	93	86.5
	10	84	86	83	91	86
	11	84	88	81	91	86
	12	83	88	81	92	86
	13	82	87	81	92	85.5
	MEAN	84.54	87.81	83.63	92.81	87.20
Eigenvector	k	TEST 1	TEST 2	TEST 3	TEST 4	MEAN
15	3	79	87	89	96	87.75
	4	77	85	86	93	85.25
	5	85	88	85	93	87.75
	6	83	85	85	92	86.25
	7	83	84	81	91	84.75
	8	83	82	81	90	84
	9	83	84	81	91	84.75
	10	83	84	82	92	85.25
	11	83	87	83	92	86.25
	12	81	85	83	91	85
	13	81	84	82	91	84.5
	MEAN	81.90909	85	83.45455	92	85.59

When we analyze the recognition results, number of eigenvectors is proportional to accuracies. But there is inverse proportion between k-values and accuracies. The highest accuracy is obtained for k=3. General recognition results reach their highest values at Test-4. At the end, we state that the recognition rate reach 85% for both eigenvector 15 and 30.

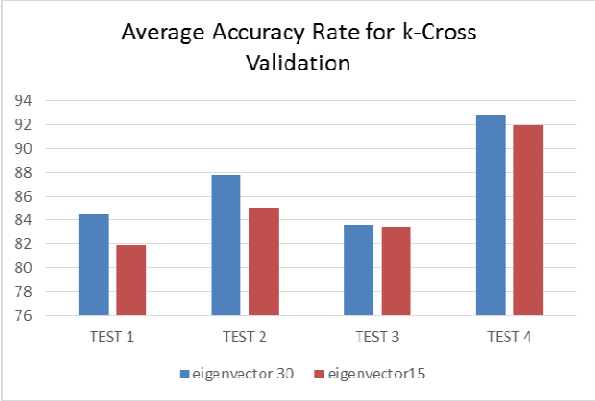
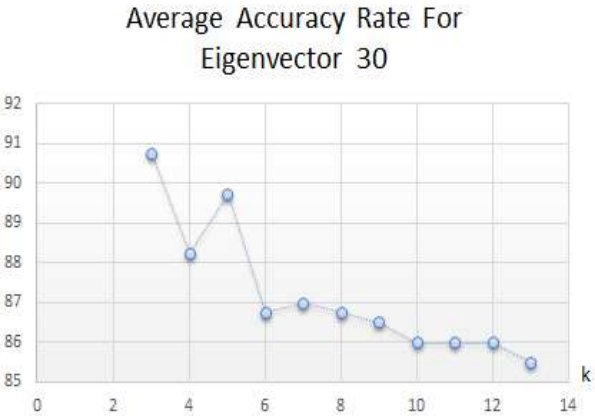


Figure 3. k-nearest neighbor classification rates graph for first 15 and 30 eigenvectors in FEI face data set.



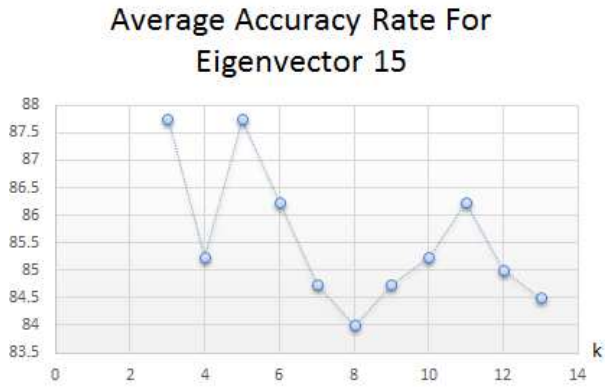


Figure 4. Classification accuracy rates according to k-values

Table 2. Support vector machine accuracy results for FEI face data set

Accuracy (%)				
0-80	80-160	160-240	240-320	320-400
85	85	75	77.5	82.5

Table 3. k-nearest neighbor and support vector machine accuracy results for FEI face data set

Accuracy (%)	
k-nearest neighbour	Support vector machine
86	80

When we compare the recognition performance of support vector machine and k-nearest neighbor, we can state k-nearest neighbor is more successful in accuracies about 6% (From Table 2 and Table 3).

5. CONCLUSION

In this article, we make gender classification to contribute image processing and machine learning research area. We analyze the advantages and disadvantages of techniques with previous published results. We focus

on determining gender on FEI face data set. Several conversions and pre-processing phases is used for the implementations. Some feature extraction and classification algorithms is tested on FEI. According to experimental results, we show that principal component analysis with k-nearest neighbor hybrid method is better than principal component analysis with support vector machine hybrid method. The main reason of this difference between two hybrid method is new space conversion of principal component analysis. The new places of converted data set via covariance matrix is more distinctive.

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