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Gender Classification Using Hybrid of Gabor Filters and Binary Features of an Image

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ABSTRACT

Face is one of the most important biometric of human and contains lots of useful information such as gender, age, race and identity. Gender classification is very easy for human but it considers a challenge for computers. Gender classification through face images has recently been considered so much. Gender recognition can be useful in interaction between human and computer like identifying individual's identity. It is also applicable in TV networks in order to study the rate of viewers. Various algorithms have been designed for this issue and each of them has unraveled that to some extent. The last obtained rate to identify gender was through article written by Mozaffari who obtained mean rate of 83% for identification. It is the proposed method of the present study which has brought identification rate to 92.5. in this method we draw out face features based on Gabor filters and local binary patterns. These features are resistant against noise and they select proper features against bottleneck of images. In order to obtain a proper classification, we use self-organized map (SOM) (type of artificial neural network). This neural network finds the proper weights for each gender with very little error. Obtained results are compared with existing datasets and therefore, superiority of the proposed method would be evident.

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1. INTRODUCTION

One of the important issues which are proposed beside identification systems based on face images is determining individuals' gender through their face image. Until now, proposed methods to recognize individuals by face image have had different algorithms. Most of the methods proposed to recognize a face are based on learning process and using several images for each individual such as neural network and SVM. Using learning-based methods of recognition requires series with several different images for each individual which preparing them would be difficult. From other side, it is not possible to provide several images from one by real applications such as Video Surveillance. Therefore, today, single-sample face recognition methods have been changed to an important research issue.

Gender classification is the most important task in applications such as monitoring, business profile of regulatory issues and so on. The present article has proposed a new method to estimate gender. In addition, it is a new method to classify gender based on extracting switching features and binary patterns of each image and based on weights of Self-organized map. In the proposed method, we use general obtained faces to apply face image of each gender averagely. Input image is compared by input image of a man and a woman. Local apparent differences are then defined. In order to increase accuracy of gender classification, the proposed system can extract the most significant radius of a face which is in fact the distinguishing features

of each face based on LBP and Gabor features and by segmenting face based on triangular method and it can obtain a better result in compare with other segmentations (Square or circular). After extracting binary and Gabor features and with consider to the differences between general images of each gender, we proceed to cluster them. This clustering is conducted based on self-organized map and finally, gender is recognized based on location of the image in clusters.

2. A REVIEW ON THE PREVIOUS ATTEMPTS

Various methods have been proposed to classify gender until now. In addition, there are several methods to extract features in order to classify gender so that they can be divided into several approaches. In the present article, we have used proposed method of Dr. Mozaffari which is based on using general images of man and woman and utilizing average of these images and applying Euclidean distance to recognize gender.

2.1 Appearance-based Approaches

Features are extracted from general data of a face in appearance-based approaches. At first, in this method we locate data of the image successively in a row or column. We then use statistical method to reduce dimension and data resolution. For example, using ICA, LDA, PCA and … methods can be noted.

2.2 Geometric Features-based Approaches

In these approaches, face image is divided into different areas such as eyes, mouth, nose and … and geometric features of each areas of the face such as length of the nose, distance between eyes and … are determined. In fact, in these methods, shape and location of face components such as mouth, eyes, eyebrows and nose are determined and feature's vector is extracted from all areas of the face.

2.3 Model-based Approaches

In model-based approaches, the based model uses from data of different components of the face. In fact, these approaches aims to construct a model of human face based on face changes and features, therefore this model is able to receive face changes. From these kinds of methods, Elastic Bunch Graph Model and Active Appearance Model can be noted.

2.4 Hybrid Approaches

These approaches combine two or more approaches mentioned above.

3. THE PROPOSED METHOD

The base of our method is using single image of an individual's face and gender classification is based on features of Gabor filter and LBP utilizing triangular segmentation of the face. The method of extracting features is based on Gabor filter and local binary features and classification conducted based on self-organized map. This neural network contains 50 internal layer so that accepts images of dimensions 64×64 as input. In order to test this method, images of AR database have been used. Diagram of gender classification system is shown in Figure 1.

3.1 Extracting Features

Algorithm of gender classification is based on two features of Gabor filter and Local Binary Patterns.

3.1.1 Applying Gabor Filter

After extracting features of a face and preprocessing stage of the face, it is turn to apply Gabor coefficients on area of the face. This area of the face is created based on triangular segmentation on the face as Figure 2. Gabor filter is as follow. Logarithmic wavelet of Gabor has been known as the most effective method to segment a texture so that it can easily separate data related to the texture from intermediate frequency bands and apply it for algorithm of segmenting. As extracting features to recognize a face through Gabor filter contributes to good results, technic of feature extraction based on Gabor filter has been used here. Relation 1 shows Gabor filter relation:

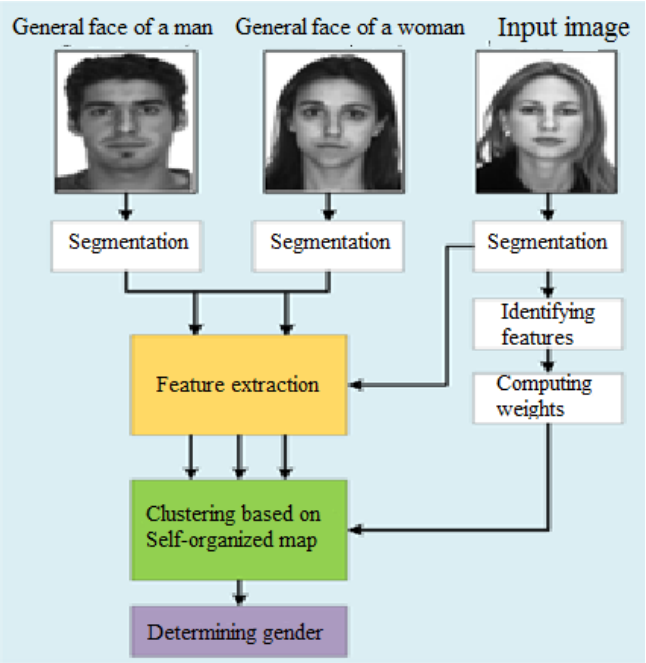

Figure 1. Block of the proposed gender classification system diagram or using from full-view image of a face

Figure 2. Triangular segmentation of an image

$$\begin{Bmatrix} W(x,y,\theta,\lambda,\varphi,\sigma,\gamma) = \exp(-)\cos(2\pi\frac{x'}{\lambda}+\varphi) \\ x' = x\cos(\theta)+y\sin(\theta) \\ y' = -x\sin(\theta)+y\cos(\theta) \end{Bmatrix} \quad (1)$$

(x,y) are spatial index and σ,λ,γ,Ø,m are parameters of wavelet. By the help of Wiskott, we use similar parameters.

$$(U,V) = \left(\frac{2}{N}\right)^{\frac{1}{2}}\left(\frac{2}{M}\right)^{\frac{1}{2}}\sum_{i=0}^{N-1}\sum_{j=0}^{M-1}A(i)A(j). \quad (2)$$
$$\cos\left[\frac{\pi.u}{2.N}(2i+1)\right].\cos\left[\frac{\pi.v}{2.M}(2j+1)\right].f(i,j).$$

In which:

$$A(i) = \begin{cases} \frac{1}{\sqrt{2}} & for\ i=0 \\ 1 & other\ wise \end{cases} \quad (3)$$

In order to extract features of a set of images, Gabor filters with 5 spatial frequencies and 8 orientations of separate angle is used which create 40 different Gabor filters. It has shown in figure 3. These features are spatially implemented on face images.

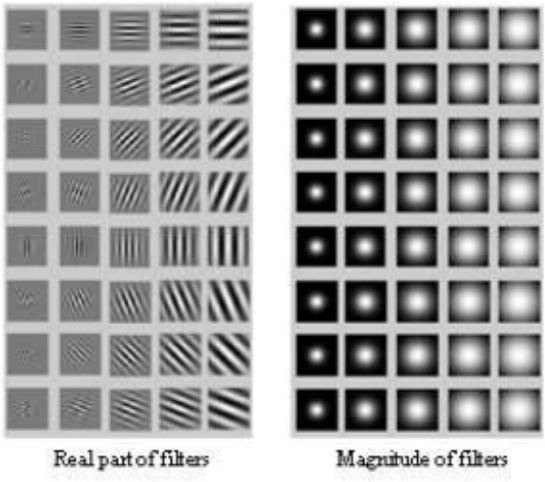

Figure 3. Gabor filter with 5 spatial frequencies and 7 separate orientation

For input image of figure 4, Gabor filter is implemented as the following stages:

Figure 4. Input image to Gabor filter

Gabor coefficient with different angle of rotation is as the following figure:

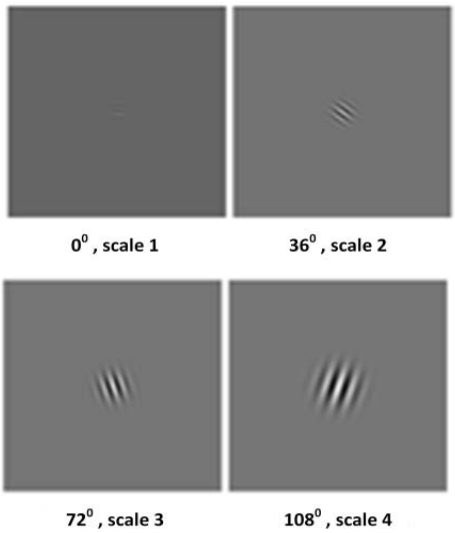

Figure 5. Gabor filter with rotation angles of 144, 0, 36, 72, 108 degrees respectively

After creating Gabor coefficient and multiplying by input image, figure 6 is obtained:

Figure 6. Output obtained from implementing Gabor filter with different angles on input image

As it could be seen in the figure 6, these figures show good samples of a face and other shapes of the face so that it enables us to take different texture from different angles and extract locations of eyes, mouth and forehead. Proposed method of the present article is used to extract the related weights of each face image through general average of Gabor filter of each individual.

3.1.2 Local Binary Patterns

LBP operator tags label to pixels of an image through thresholding a neighborhood of 3×3 in each pixel so that it is resulted in a binary number. LBP feature has been frequently used to classify gender.

$$S(f_p - f_c) = \begin{cases} 1 & f_p \geq f_c \\ 0 & f_p < f \end{cases} \quad (4)$$

$$LBP(f_c) = \sum_{p=0}^{7} S(f_p - f_c) 2^p \quad (5)$$

In relations 4 and 5, f_c is the value of pixel center and ⟦f⟧_p is the value of center pixel for a neighborhood. The value of LBP in center pixel is obtained from relation 5. Symbol of ⟦LBP⟧_(P,R)^u is used for uniform LBP operator which usage of LBP operator for neighborhood of P points is sampled on a circle of radius R.

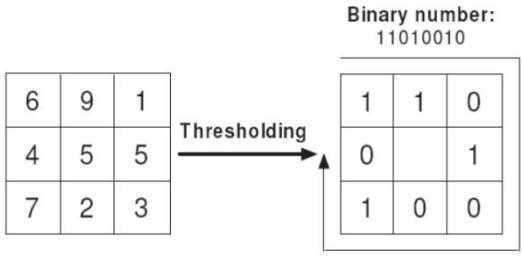

Figure 7. Usage of LBP operator in neighborhood (1, 8)

Figure 8. Implementing LBP operator on face images with parameters R=1 & P=8

3.2 Construction of General Face Image

As the proposed algorithm is not based on training procedure, a general image is used to recognize gender of input image. General image of man and woman is obtained through linear combination of images. The following figure is a sample of general images of man and woman.

Figure 9. A sample of general images of man and woman. (a): AR database, (b): Ethnic database

3.3 Segmentation

Segmenting face image into several areas contributes to extract distinctive features between men and women. Based on figure 2, each image of database is segmented in 8 sections so that it has 9 sections computing with the main image.

3.4 Determining Features of Face

All of the features of face do not have the same importance in gender classification. In order to determine important features of face, input image is filtered through using Sobel and LOG operator. Two output images have different information obtained by combining wavelet. Some features of face like eyes and mouth which is more important in gender classification will be apparent in considered images. Figure 10 shows detection of face features.

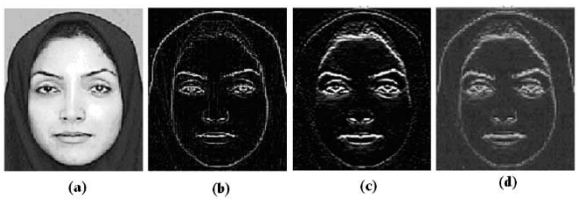

Figure 10. Detection of face features (a): Input image. (b): Implementing Log actor. (c): Implementing Sobel actor. (d): Combining actors of Log and Sobel

3.5 Computing Weights

Image entropy is used to determine which section of the proposed image that has endured feature extraction has more weight in process of gender recognition. Those sections with higher entropy, it means having more weight, are considered as more important blocks.

3.6 Learning Algorithm of Self-organized Maps

Learning algorithm of self-organized maps is a type of unsupervised learning. Basically, unsupervised learning algorithm can be specified by first order equations. These equations describe how network weights become compatible to time or repetition of discrete mode. In order to adjust weights, scale of similarity or sharing pattern is used to conduct learning process which leads us to some correlation forms, clustering or competitive behaviors of the network. Generally, learning algorithm of self-organized maps are based on selecting winning neuron and movement of the mentioned neuron and some of its neighbors toward the considered input data.

3.6.1 Early Stage:

In this stage, weight of each neuron is created based on the previous stage of weight extraction through non-linear features. In the present article, weights are implemented based on separating low-level features and also extraction of adjusted Gabor and Local Binary features and an input pattern of general images to the network.

3.6.2 Specifying the Winning Neuron:

In this stage, winning neuron is specified based on similarity of network. Different similarity criteria can be applied in self-organized maps but the most common criterion which is applied in these networks is Euclidean distance. The relation of Euclidean similarity is as follow:

$$\|X - W\| = \left(\sum_{i=1}^{d} (X_i - w_i)^2\right)^{\frac{1}{2}} \quad (6)$$

Now, at the same time, input is compared with all existing elements inside the network. Winning neuron is a neuron with the minimum distance among all reference patterns of input data.

$$\|X - m_c\| = \min_i\{\|X - m_r\|\} \quad (7)$$

So that m_c is the winning neuron and m_r is reference vectors. A sample of selecting winning neuron among reference patterns is shown in figure 11. These winning neurons identify images with the same content and adjust their neighboring neurons in order to obtain better results.

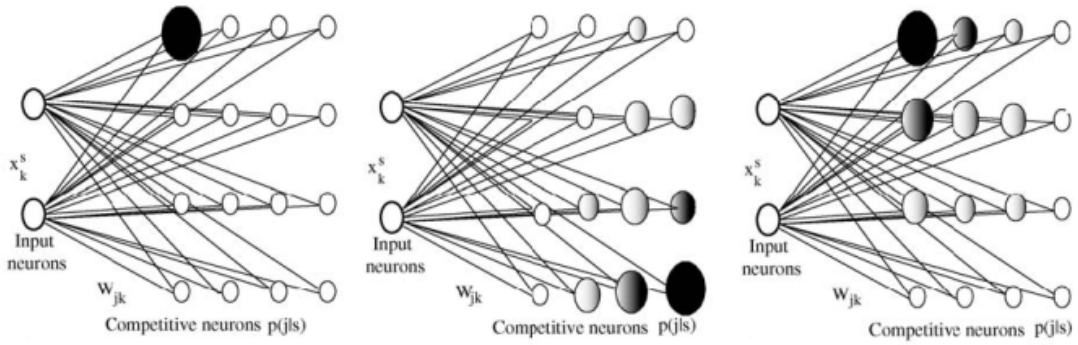

Figure 11. Selecting winning neuron among reference patterns in self-organized maps

3.6.3 Determining Neighboring Neurons

After specifying winning neuron, a set of neighboring neurons of the winning neuron which should be changed in value are determined. Changing related values to neighboring neurons is generally done in two ways: In the first method, a specified neighboring radius is selected around the winning neuron. In this method, all neurons of the network which are in the specified distance of the winning neuron move toward input with a constant coefficient. In the second method, all existing neurons in the network move toward input with unequal coefficient. This unequal coefficient has the maximum value in the winning neuron and it decreases when recedes from the wining neuron.

3.6.4 Weights Modification

At the end, weights related to the winning neuron and its neighbors should be modified based on input of network. These changes are conducted based on the relation 8:

$$m_r(t+1) = m_r(t) + \alpha(t).h_{cr}(t)[x(t) - m_r(t)] \quad (8)$$

So that x is input vector in time t, m_r is r^{th} reference pattern in time t, α is rate of learning in time t and h_{cr} is neighborhood function which is defined based on Kernel function as follow:

$$h_{cr}(t) = \exp\left(-\frac{\|k_c - k_r\|^2}{2\sigma(t)^2}\right) \quad (9)$$

So that k_c represents winning neuron and k_r is its neighbor's reference pattern and σ is radius of Kernel function in time t. result of the above issues is modification of weights and movment of the mentioned neurons toward training sample. It is a parameter which is applied in order to control convergence of the algorithm and it is depended on repetition. It is necessarily according to t as a steady decrease. Unsupervised training is generally and inevitably more complicated than supervised method, therefore, it requires more time to learn training patterns.

3.7 Clustering & Gender Recognition

After extracting images' features and determining weight of the considered image, we cluster inputs of feature extraction (Self-organized map) and then deal with recognizing gender of the individual based on location of the image in the determined clusters.

4. Experimental results

In order to evaluate the proposed method, we used AR database related to face images. AR database are composed of 56 different women and 70 men (totally 126 people). With regard to the proposed algorithm and the method of Dr. Mozaffari's article, results of table 1 show superiority of the proposed method.

Table 1. General results of comparing the proposed method and Dr. Mozaffari' article

Name of the Method	Percent of man recognition	Percent of woman recognition	General percent
Mozaffari	80.9	86.50	83.7
The proposed method	92.5	92.5	92.5

5. CONCLUSION

Recognizing gender is one of the import issues in statistic and psychology which is necessary in computer systems when surveyed data are increased. The present article uses Gabor filter and Local Binary Patterns to extract distinctive features of face images which are not sensitive to noise of the images and are also able to separate patterns with high difference. This system contributes to gender recognition through clustering neural network (self-organized map) so that the obtained results show the superiority of the method.

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