Profile Face Recognition using Local Binary Patterns with Artificial Neural Network

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***Abstract*—Face recognition is a process of identifying a person based on facial features. It is one of the most popular and widely used biometrics technique today. However, there are challenges regarding robust, rotation-invariant, real-time face recognition systems. Few challenges can be listed as changes in illumination, rotations of the face, different head poses and occlusion etc. This study mainly consists of four parts, namely face detection from the image, feature extraction, training the neural network and recognition. Face detection algorithm is used to detect the face from the given image. The most useful and unique features of the face image are extracted in the feature extraction phase. The face area is first divided into K^2 sub regions from which Local Binary Pattern (LBP) histograms are extracted and concatenated into a single feature vector which is used to train the Neural Network. In the recognition phase, face recognition is done by trained Neural Network. The system is trained and tested on Ondokuz Mayis University database.**

***Index Terms*—Face recognition; Local Binary Pattern; Artificial Neural Network.**

I. Introduction

The humans establish their identity based on their face. Face not only conveys the identity of the people also conveys the information about human behavior such as emotions [1]. Face recognition became active field of research as the technological power advanced. Face recognition is used in the fields of Identity Recognition, Surveillance and Law Enforcement [2]. Unlike other fingerprint and iris biometrics systems, face recognition has distinct advantages because of its non-contact process. Face images can be captured from a distance without being in contact with the person being identified, and the identification does not require interacting with the person.

In this active research field number of face recognition systems are available. Despite these achievements, face recognition continues to be an active topic in computer vision research. This is due to the fact that current systems perform well under relatively controlled environments but tend to suffer when variations in different factors (such as pose, illumination etc.) are present [3]. Objective of the ongoing research is to develop more reliable systems against the factors.

First step of the face recognition is the detection of the face from the image. Face detection is process of detecting the face image from the images or video frames. Detecting face can be challenging too. Because of images and video frames can contain complex background, different head poses and occlusion (such as wearing glasses or scarf).

II. Proposed Algorithm

In this paper two algorithms are proposed for the Face recognition. The Local Binary Patterns (LBP) and Artificial Neural Network (ANN).

A. Local Binary Patterns

Local Binary Patterns was introduced by the Ojala et al. [4] as powerful texture descriptor. The LBP operator labels the pixels of an image by comparing the 3x3 neighbourhood of each pixel with the central pixel value and interpreting the result as a binary number. Then the histogram of the labels can be used as a texture descriptor. General form of LBP operator is given in Eq. 1. In this work texture descriptors were used as a feature vector of the face.

$$\mathrm{LBP}_{N,R} = \sum_{i=0}^{N-1} s\left(n_i - n_c\right) 2^i, \quad s(x) = \begin{cases} 1 & x \geq 0 \\ 0 & x < 0 \end{cases} \tag{1}$$

Where n_c is the gray value of the central pixel, n_i is the i^{th} gray value of the neighboring pixel. N is the total number of the neighboring pixel (sampling points), R is the neighborhood radius, determining the distance of pixels located away from the central pixel.

The original LBP operator with radius of 1 pixel and 8 sampling points is $\mathrm{LBP}_{8,1}$. Another important extension is the definition of "uniform patterns". An LBP is defined as uniform if it contains at most two 0-1 or 1-0 transitions when viewed as a circular bit string. Thus the 8-bit strings 00110000 and 00000000 are uniform, while 01010100 and 10011010 are not. Figure 1 shows the patterns of the LBP operator.

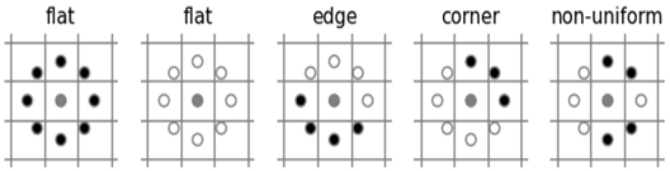

Fig. 1. LBP patterns

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Ojala et al. noticed that in their experiments with texture images, uniform patterns account for a bit less than 90 % of all patterns when using the (8,1) neighborhood and for around 70 % in the (16,2) neighborhood. Therefore, little information is lost by assigning all non-uniform patterns to a single arbitrary number. Since only 58 of the 256 possible 8 bit patterns are uniform, this enables significant space savings when building LBP histograms. R = 1, N = 16, Uniform LBP operator is noted as $LBP_{16,1}^{u2}$.

B. Artificial Neural Network

Artificial Neural Network (ANN) is inspired by the human biological nervous system. ANN uses the processing of the brain as a basis to develop algorithms that can be used to model complex patterns and prediction problems. As they have the ability to learn and model non-linear and complex relationships, which is really important because in real-life, many of the relationships between inputs and outputs are non-linear as well as complex. After learning from the initial inputs and their relationships, it can infer unseen relationships on unseen data as well, thus making the model generalize and predict on unseen data. The learning process of ANN is used with back propagation algorithm. Back Propagation is a feed forward supervised learning network [5]. The multilayered feed forward neural networks consist of the three layers as input layer, hidden layer and output layer. Nodes of the layers make independent computation of data and pass it to next layer up to the output layer. Computation of data on the layer nodes are the weighted sum of the input values and output of the nodes are pushed out by activation function such as threshold function, sigmoid function, hyperbolic function. Note that input layer does not use activation function.

The output is compared with the target value and the error is calculated which is processed back to the hidden layer to adjust its weights. The back propagation and adjusting weight process is carried out until the error falls below the tolerance level. This training iteration process is also called epoch.

III. DATABASE

For this research work, with the contributions of the students and academicians of Electrical and Electronics Engineering Department of Ondokuz Mayıs University, we created a face image database. Database consists of images with head poses ranging from -90° to +90° with 15° variations. There are total of 676 different images of 52 people with 13 different poses. Of the 52 people 39 were male and 13 were female.

The images were captured with the Sony the Alpha 77 camera with Sony E16-50mm f/3.5-5.6 lens. Figure 2 shows the experimentation setup that used to capture face images.

Fig. 2. Experimentation setup

Figure 3 shows the example of the database.

Fig. 3. Database images

This database can be used for further face recognition applications, as well as gender and age classification applications.

IV. PROPOSED METHOD

After creating the database only frontal images of 47 people were selected for this particular research work. Coding of this research work is carried on Python programming language using “OpenCV”, “PIL” and “scikit-image” image processing libraries. The phases of the proposed method are follows.

A. Face Detection

Haar cascade based Viola–Jones algorithm is used to detect the face from the input image [6]. Figure 4 shows the detected faces.

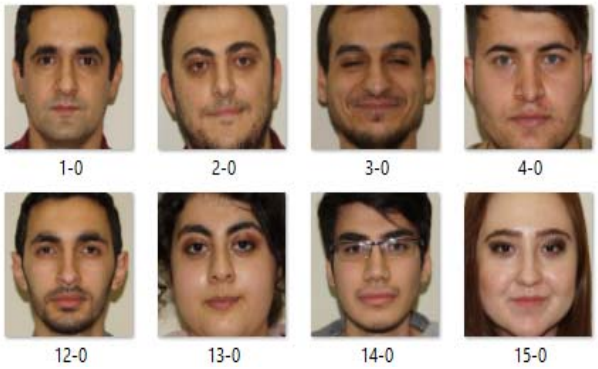

Fig. 4. Detected faces

B. Feature Extraction of the detected faces

Before extracting the features preprocessing of the faces is done to create training samples.

- Detected faces rotated clockwise (1º, 3º, 4º, 6º, 7º, 9º, 10º, 12º, 13º) and counter-clockwise (1º, 2º, 4º, 5º, 7º, 8º, 10º, 11º, 13º) creating 846 training samples.
- Face is divided into $K^2 = 9$ sub regions. LBP value for each sub region is calculated using uniform LBP operator.
- Using calculated uniform LBP values LBP histograms are constructed and concatenated into a single feature vector.

This histograms contain information about the patterns on pixel-level, sub region histograms are concatenated to build a global description of the face. This calculation process is carried out for all faces and stored in the database which is later used to train the neural network. For each sub region of the face image, when uniform LBP operator is used, histogram of 12 values were created. Total of 108 values were created for per face histogram. Creation of feature vector is show in Figure 5.

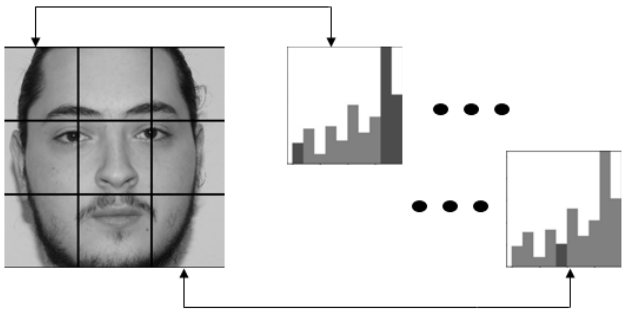

Fig. 5. Feature vectors of sub regions

C. Training of the ANN

Chi Square Distance dissimilarity measure is used to calculate the target values. Target values are calculated by comparing the detected face histograms with the training sample histograms. Lower Chi Square Distance value is considered better. Output of the network is compared with the target value to calculate the error and back propagated to adjust the weights.

Nodes of input layer was chosen 108, 80 nodes were chosen for the hidden layer so that the network can summarize only important features of the face, 47 nodes were chosen for the output layer as one node for each person. Learning Rate of neural network was set to 0.3 and initial weights were calculated randomly. As activation function Log-Sigmoid function was used. Training Epochs were set to 2000.

D. Face Recognition

Total of 1222 samples were derived from the frontal face images, of it 846 samples were used to train the network and 376 samples were used to test the network. 376 testing samples consisted of (2º, 5º, 8º, 11º, -3º, -6º, -9º, -12º) rotated face samples.

V. Results and Discussion

Table I. shows the training process of the ANN for each testing samples. Total run of 2000 epochs were achieved. Performance of the neural network increased from 17.03% at the 100 epoch to 91.75% at the 1300 epoch. After the 1300 epoch, performance stayed still around 90.76%. At the epoch of 1300, highest average performance of 91.75% was achieved. Recognizing highest at the 2° angle of 45 of 47 (95.7%) faces and lowest at the 11° angle of 40 of 47 (85.1%) faces. Total time taken to train the ANN was 7 minutes 01 seconds. From the results, it is seen that ANN can generalize the data and predict the unseen data (testing samples).

TABLE I. Performance Evaluation

Epochs	100	300	500	800
Tested				
2º	11/36 23.4%	18/29 38.3%	32/15 68.1%	37/10 78.7%
5º	9/38 19.1%	16/31 34%	28/19 59.6%	35/12 74.5%
8º	8/39 17%	17/30 36.2%	21/26 44.7%	32/15 68.1%
11º	6/41 12.8%	11/36 23.4%	20/27 42.6%	31/16 66%
-3º	10/37 21.3%	16/31 34%	31/16 66%	38/9 80.9%
-6º	7/40 14.9%	15/32 31.9%	26/21 55.3%	33/14 70.2%
-9º	7/40 14.9%	15/32 31.9%	23/24 48.9%	29/18 61.7%
-12º	6/41 12.8%	13/34 27.7%	23/24 48.9%	29/18 61.7%
TE(s)	20.85	20.99	20.86	21.01
AVG P%	17.03%	32.18%	54.26%	70.23%

Epochs	1100	1300	1600	2000
Tested				
2°	42/5 89.4%	45/2 95.7%	45/2 95.7%	44/3 93.6%
5°	39/8 83%	44/3 93.6%	44/3 93.6%	45/2 95.7%
8°	38/9 80.9%	42/5 89.4%	44/3 93.6%	45/2 95.7%
11°	37/10 78.7%	40/7 85.1%	40/7 85.1%	41/6 87.2%
-3°	41/6 87.2%	44/3 93.6%	43/4 91.5%	42/5 89.4%
-6°	40/7 85.1%	44/3 93.6%	45/2 95.7%	44/3 93.6%
-9°	37/10 78.7%	44/3 93.6%	42/5 89.4%	43/4 91.5%
-12°	36/11 76.6%	42/5 89.4%	39/8 83%	39/8 83%
TE(s)	20.95	22.21	20.97	20.94
TTE	7 min 01 sec			
AVG P%	82.45 %	91.75 %	90.95 %	91.21 %

RR = Recognition Rate = Correct/Missed, P% = Performance
TE = Time Elapsed in seconds
TT = Total Time Elapsed in minutes

VI. Conclusion and Future Scope

This paper proposed the use of LBP with ANN for face recognition. Database is created for this and future research works related to face recognition. LBP is used to extract the local features of the face after detecting the face from the given image. Extracted features later used to train the neural network and unseen testing samples are used to test the neural network. Highest average performance rate of 91.75% is achieved at the epoch of 1300. It is observed that the proposed method takes less than 15 seconds to calculate LBP code of 47 testing samples, create histogram and query the ANN. If ANN supposed to run again, its performance changes due to randomly calculated initial weights. For the future, accuracy of the system can be improved by training more samples. This method can be used to implemented head pose invariant face recognition system with more side face samples. All programming, training and testing ANN is run on laptop model of ACER Aspire E 15 with the properties of 4GB DDR3 RAM, AMD Quad-Core Processor A6-6310 (up to 2.4GHz), and AMD Radeon R4 Graphics.

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