Abstract—In this correspondence, we proposed an intelligent faces classification method for the robust face recognition. All the face recognition algorithms introduced till yet are computationally very expensive and situation become more critical when search space is large (Large Population). Proposed technique reduced the search space instead of feature space in the off line mode by classifying the data set using self organizing maps unsupervised neural networks and then face recognition algorithm is applied on reduced search space. More than 6X10^4 Histogram equalized (HE) front face cropped images are used for experiments. HE enhances the facial features and reduces the illumination effects. As for recognition any robust algorithm can be used on the reduced search space so recognition rate for that used algorithm will be considered. For proving the Histogram Equalized Intelligent Classification using Self Organized Maps (HEIC SOM) robust in throughput traditionally used PCA based face recognition algorithm is used and about 98% accuracy in terms of classification is achieved with improved efficiency of about 24 times in execution timings (for recognition). As much as the data set would be large this efficiency in time will be increased. Error in terms of false classification is discussed in results.

Index Terms—face recognition, SOM, PCA, neural networks, large population face recognition

I. INTRODUCTION

In the past two decades face recognition (FR) has become a very popular biometric way for recognition. With the passage of time FR has different challenges i.e. facial appearance variations due to intrinsic and extrinsic features, Intrapersonal and interpersonal features which includes aging, expression, hairs, glasses, cosmetics, illumination effects, scale, pose, resolution and noise etc. Sirovich and M. Kirby [1] used the statistical approach and utilized the Principal component analysis. M. Turk and A. Pentland [2] provide that projections along eigen pictures can be used to classify features to recognize face.

With the passage of time, Increase in the size of search space becomes major issue for FR. The more the search space large, more the computation required and takes more time for calculating the output decision because almost in all the techniques it is common practice that for every input face, algorithm has to compare/match with all the faces or their reduced features in data set and decision has been taken on the bases of matching score. The concept of parallel processing has covered this problem partially, but of course in the cost of increased hardware. Offline classification of data base is a good approach to reduce the search space. Feature space reductions have been a hot area of research in FR but it produces inaccuracy in results especially in large data sets. Neural networks are good classifiers and are used for classification in economic and statistical research fields.


With the success of Neural networks algorithms in the field of face recognition, the arising issue has been the computational expensiveness of neural networks especially when the few training samples are available for one subject. For this purpose researchers started worked for the computation relaxation in neural networks. A. Sagheer [7] introduced the one dimensional Self Organizing Maps for decreasing the computation complexity and in [8] SVM is used to reduce the complexity of SOM and claimed the results are achieved on the large data base. All of classification methods are computational expensive and situation become more critical when the database is very large. The only solution left is the pre classification or offline classification of the search space and input face is firstly estimated for its class and then search is established in corresponding class only.

Proposed HEIC SOM firstly prepare the database suitable for the classification, for this purpose fully automated face detection and face cropping is done using [9] on the image containing face. SOM is sensitive to the illumination variance so before going to classification it is

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necessary to use the illumination invariant features of face. To make HEIC SOM more robust histogram equalization is used which is not only enhances the facial features but also more effective against illumination.

SOMs have been used as a method of dimensionality reduction and feature selection for face space representations [10] and [11]. In proposed technique SOM is used to make the classes of Histogram Equalized faces and SOM training is applied on the complete database presented as a search space.

We describe the proposed system description in Section II. The experiments are reported in Section III and Section IV contains the conclusions.

II. SYSTEM DESCRIPTION

Proposed HEIC SOM can be described into two phases
- Passive phase or preparing phase.
- Active Phase or Recognition phase.

Passive phase of the system runs only once and needs high level of processing and memory consumption while Active phase always run whenever new face is given to the system to recognize. System flow chart is defined in Fig. 1.

Figure 1. System flow chart.

A. Passive Phase or Preparing Phase

As described earlier this phase runs only once. The input for this stage is the complete database of faces i.e., database of the employees of a company or all the residents of a colony etc. This is the beauty of the implemented system that its performance becomes more efficient with increasing the size of database. So the system is very suitable for the application where large scale number of faces needs to be processed and multiple images of the subject are available. Pre processing steps for this phase involves face detection, cropping, and gray scale face extraction as defined in Fig. 2. More the face detected face is aligned to the center of image; the results would be more accurate. At the cropped face histogram equalization [12] is applied to enhance the contrast preserving the brightness using following set of equations

\[
p(x = i) = \frac{n_i}{n}, \quad 0 \leq i \leq L
\]

\[
cdf_x(i) = \sum_{j=0}^{i} p_x(j)
\]

\[
cdf_y(i) = iK
\]

\[
Y = T(x) = cdf_x(x)
\]

\[
\hat{y} = y \cdot (\max\{1\} - \min\{1\}) + \min\{1\}
\]

where $n = \text{no. of pixels in the image}$

![Figure 2. Pre classification processing of face](image_url)
\( n_i \) = no. of occurrences of gray level \( i \)  
\( p_r(i) \) = probability of a pixel of level \( i \)

After pre processing, data containing HE faces matrix is given to the SOM artificial neural network for training and classification. The number of classes is pre decided, and depends upon the application requirement. Decision for the number of classes is taken on the bases of size of data base and hardware specs of the next phase of the system i-e real time processing.

Unlike other artificial neural networks SOM unsupervised learning produce a low dimensional and discrete form of input training samples space and uses a neighborhood function to preserve the topological properties of input. Neurons located in the nodes of two dimensional grids with hexagonal cells can interact with each other and distance between the neurons on the map lattice decide the degree of interaction. Initially a random vector is chosen from initial data set and the best matching neuron (or best matching unit) coefficient vector is identified, which is called as winning neuron. This winner neuron is the most similar to the input vector. Step by step this process is given in the following set of equations

\[
\|X - W_c\| = \min(\|X - W_l\|) \tag{6}
\]

\[
w_i(t + 1) = w_i(t) + \Delta w_i(t) \tag{7}
\]

\[
\Delta w_i(t) = \alpha(t) h_{c_i}(t)(x(t) - w_i(t)) \tag{8}
\]

\[
\alpha(t) = \alpha_0 \exp^{-\frac{t}{\tau}} \tag{9}
\]

\[
h_{c_i}(t) = \exp^{-\frac{d(i,c)^2}{\sigma^2}} \tag{10}
\]

where, \( X \) = input at a particular instant  
\( W_c \) = weight of the winning node  
\( W_i \) = weight of the node under consideration.  
\( h_{c_i}(t) \) = Neighborhood function  
\( d(i,c)^2 \) = Euclidean distance from node i to the winning node  
\( \alpha(t) \) = monotonically decreasing learning coefficient  
\( \beta(t, c)^2 \) = neighborhood size at time t.  
\( t \) = time Step  
\( \alpha_0 \) = learning rate at \( t_0 \)  
\( \tau \) = time constant

Training of neural network is a high processing and time taking process, on each iteration Map converges itself up to the given number of iterations. Once the SOM training is completed, it cannot update itself but can classify the inputs which are given to it [4]. This special property of the SOM is used to design the proposed the system as SOM network can be saved and useable to classify the data. In the proposed system this saved network is the input for the next phase and it will be used to classify the all incoming faces.

B. Active Phase or Recognition Phase (Run Time) of System

This phase is the run time and active phase of the system and required two inputs to run. First one is the saved SOM network trained in the passive phase (defined in II.A) and second one is the input Image from any source i-e camera or from testing dataset.

During run time face, system takes the input image and all pre processing steps involved in section II.A and defined in Fig. 2 are applied to it. This pre processing is necessary because it makes the input face image ready to give to the saved SOM network. As defined in II.A, these pre processing contains face detection, face cropping, resizing the cropped face at the desired value for which SOM net is trained etc. In the next step, processed face is given to the saved SOM network. Prepared network simulate the given face using the set of equations (6)–(10) and classify the face for the specific class.

After the classification is done, any Face Recognition (FR) technique can be used in the reduce search space i-e in the specified class to recognize the exact face. In our case we used conventional PCA [2] as FR technique. This is another good feature of the proposed technique that it provides the flexibility to use any FR algorithm inside the classified group to search the exact face i-e the hardware/software applications introduced till yet can be used without any modification and HEIC SOM will provide the reduced search space for them

III. RESULTS

Dataset of Facial Images by Computer Vision Science Research Projects [13] is one of the difficult data set for the FR which contains about 7000 images of 395 individuals in variable lighting and luminance environment with different facial expressions and complex back grounds. Experiments performed on the cropped faces with the different sizes of images 8x8, 16x16, 32x32 and 64x64. These resizing were carried out before the SOM classification as defined in Fig. 2.

For the experiments firstly data set is divided into two parts testing images and training images. 10% of data base is used as testing images. For different sizes of faces separate SOMs were trained with 500 epos. For each experiment SOM size is fixed to 4X4 which results into 16 groups. As defined in system flow chart Fig. 1, Sub classification is also implemented inside the classes which have the number of samples greater than ¼ of full data samples. After the unsupervised classification is done simple PCA is used to get the results. As conventional PCA [2] is used so 5 level of PCA recognition is tested to reduce the PCA error because in this correspondence classification is targeted i-e reduction in search space.

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Image Size</th>
<th>PCA with HEIC SOM</th>
<th>PCA Without HEIC SOM (Image size 64x64)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Recog. Rate</td>
<td>Time (Sec)</td>
</tr>
<tr>
<td>1.</td>
<td>8x8</td>
<td>95.42</td>
<td>3.24</td>
</tr>
<tr>
<td>2.</td>
<td>16x16</td>
<td>96.28</td>
<td>3.66</td>
</tr>
<tr>
<td>3.</td>
<td>32x32</td>
<td>97.85</td>
<td>4.12</td>
</tr>
<tr>
<td>4.</td>
<td>64x64</td>
<td>98.28</td>
<td>4.88</td>
</tr>
</tbody>
</table>

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During system run, testing image is given to the system. At the first phase HEIC SOM finds its class number (From class 1 to class 16 and for sub class A–D if any) and then PCA searches the match in the corresponding class. Results for 10% of full dataset are used for randomly selected samples and calculated results are given in Table I and in the form of Fig. 3 and Fig. 4.

Figure 3. Time required for one processing

Figure 4. Recognition rate

Different sizes of faces are only used for SOM training and classification but 64X64 faces are used for recognition in all the experiments. Using the small size of face for PCA is not recommended because it affects the recognition accuracy very badly. In Table I, Column PCA without HEIC SOM has different recognition rates because for each experiment different sample sets was collected randomly for testing.

Results clearly show that HEIC SOM is robust in terms of Recognition rate as well as efficient in processing time which is the major advantage of the proposed system. PCA works on the bases of eigen value and eigen vectors, as much as the data matrix is large, system has to calculate the more eigen faces in online search which increases the processing time. Increasing the number of samples in the data matrix for PCA, squares the size of matrix and hence required more time to process. More over proposed technique improves the PCA performance as Fig. 4 clearly shows because by increasing the data set PCA error increases so reducing the data set increased the accuracy of PCA. Fig. 4 also shows that by increasing the size of image HEIC SOM is more robust than conventional PCA. The more the image size is large the more accurate classification would be leads to the good recognition rate but with increasing the image size increases the HEIC SOM and requires more processing in preparing phase but its only for ones but it gives robust results in run time processing so large image size is preferred for making the structure of system. SOM is very sensitive for illumination variances as illuminations dominates the features of the face specially in our case when small sizes of the face are used to reduce the processing. This is why False classification is also observed in the faces where large illumination variance has been present because histogram equalization remove the small illumination variances but not much robust for large variance.

IV. CONCLUSION

Proposed technique can be summarized in this way that it reduces the search space efficiently by convert the large population data base into small data sets which decreases the error for recognition and requires very less time to search the required face in reduced search space, requires less memory and less processing obviously. Results improved specially in terms of processing time. As in the preparing phase most of the work i-e. SOM making and training is performed. System allows adding the more faces at any time which does not required to run the preparing phase again. Classification is improved at the CVSRP’s data set which has very less illumination variance. Large variance in Illumination may affect the classification badly. So the results may be collected with the data set having large illumination variance and results can be improved by using robust illumination invariance technique in pre processing phase of the system, HEIC SOM will support that technique.

REFERENCES


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