International Journal of Luminescence and Applications (ISSN: 2277-6362)
Vol. 7, No. 3-4, October - December 2017. Article ID: 259. pp.507-512.

Extraction of Features from Dummy Face for Improving Biometrical Authentication of Human

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Abstract— *Most of the research work has been done so for using actual human-face image only for recognition and authentication of human. For recognition and authentication of dummy face image has been considered very less. The advantage of using dummy face is that they are free from wide variety of poses, expression, illumination gestures and face occlusion. The four important characteristic of face biometrics are uniqueness, universality, performance and collectability make it very potential biometric traits for identification and verification of human face. The main contributions of this paper are design and implementation of training database for dummy face image and development of algorithms for training and testing phase. The performance of developed algorithms is found satisfactory. The work has been carried out in two phases. In the first phase, formation of the dummy face model as a corpus and extraction of different features using dummy face images of the different subjects have been done. In the second phase dummy face model has been used at the back-end for biometrical authentication using a proposed algorithm.*

Keywords— *Artificial Neural Network (ANN), Genetic Algorithm (GA), ConnectedComponent(CC), Principal Component Analysis (PCA), Discrete Cosine Transform (DCT)*

1. INTRODUCTION

Human face recognition has attracted significant attentions because of its wide range of applications in public domain such as: border security system, credit card identification, criminal identification or verification, scene surveillance, entertainments, etc. In these applications, face recognition techniques are used on various source formats ranging from static, controlled format photographs to uncontrolled video sequences which have been produced in different conditions. Therefore, a practical face recognition technique needs to be robust to the image variations caused by the illumination conditions, facial expressions, poses or perspectives. However, “the variations of the same face images due to viewing different directions and illuminations are almost always larger than the image variations due to a change in face identity”. In case of large variation of the face images the face recognition encounter very difficult, especially when only one upright frontal image is available for each person and the training images are under even illumination and a neutral facial expression.

The face is our primary focus of attention in social life playing an important role in conveying identity and emotions. We can recognize many faces learned throughout our identify faces and lifespan at a glance even after years of separation. This technique is quite robust despite of large variations in visual stimulus due to changing, aging, distractions and condition such as glasses, beard or changes in hairstyle (Rohit Raja et al. 2015)

A detailed experimental study of face detection algorithms based on “Skin Color” was read and three color spaces, RGB, YCbCr and HSI are concern. They compared the face algorithms based on these color spaces and combined them to get a new skin-color based face-detection algorithm which can improves accuracy. The Experimental result of the proposed algorithm is good enough to localize a human face in an image with an accuracy of 95.18% (S. K. Singh, D.S. Chauhan, M. Vatsa, and R. Singh., 2003).

Another face detection algorithm uses color images in the presence of complex backgrounds as well as varying lighting conditions. The method detects skin regions over the entire image, and generates face candidates based on their spatial arrangement of the skin patches. The algorithm constructs boundary, eye, and mouth by using a transfer of color space from RGB to YCbCr maps for verifying each face candidate (Rein-Lien Hsuy, Mohamed Abdel Mottalebz and Anil K. Jain., 2002).

This gray-scale algorithm was suggested by Yang and Huang, who observed that when the resolution of a face image is reduced gradually either by sub averaging or sampling, macroscopic features will disappear of the face and that at low resolution, face region will become

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uniform (X. He, S. Yan, Y. Hu, P. Niyogi, and H. J. Zhang. 2005).

This method describes how human vision system sees both face and local features such as: nose, lips and eyes etc. Some of the examples in hybrid approach are modular eigenfaces and component-based methods (Wang, C., and Brandstein, M. S., 1998). Even though there are wide range of algorithms available for both face detection and recognition. Tuning of these algorithms on to our embedded systems is really a big challenge (J. Sobottka and I. Pittas., 1996)

Though many FRT have been proposed, robust face recognition is still difficult. The recent FERET test has revealed that there are at least two major challenges (H. Zhao, P.C. Yuen, and J.T. Kwok. 2006)

PCA coefficients are eliminated, PCA cannot capture even the simplest invariance unless this information is explicitly provided in the training data. Independent component analysis (ICA) can be considered a generalization of PCA, which aims to find some independent bases by methods sensitive to high-order statistics. However, reported that ICA gives the same, sometimes even a little worse, recognition accuracy as PCA. (Parul Jain et al 2015)

Linear discriminant analysis (LDA) seeks to find a linear transformation that maximizes the between-class scatter and minimizes the within-class scatter, which preserve the discriminating information and is suitable for recognition. However, this method needs more than one image per person as a training set; furthermore PCA can outperform LDA when the training set is small, and the former is less sensitive to different training sets. Kernalized PCA method performs better generalization when the training set is non-linearly separable and by performing a non-linear mapping, the algorithm is found to be suitable for our current approach as the technique works well with single face image per person(Tilendra Shishir Sinha et al 2013 and 2015).

From the literature, it has been observed that very little amount of work has been carried out using Neuro-Genetic approach for the biometrical study through Face. The schematic diagram for the formation of knowledge-based model, that is,

Dummy_Face_Model has been shown in figure 1, below.

From Fig. 1, it has been shown that a known image has been fed as input. Then it has been pre-processed for enhancement and segmentation. The enhancement has been done for the filtering any noise present in the image. Later on it has been segmented using connected component method [Rohit Raja et al 2015]. Discrete Cosine Transform (DCT) has been employed for loss-less compression. DCT has a strong energy compaction property. The main property is that it considers real-values and provides better approximation of an image with fewer coefficients. Segmentation is the fundamental step in any image processing work. This has been carried out for detecting the boundaries of the objects present in the image and also used in detecting connected components between pixels. Hence the Region of Interest (ROI) has been detected and the relevant dummy face features have been extracted. The relevant features that have been selected and extracted in the present paper are based on the physical characteristics of face Image of the dummy.. The relevant parameters are: mean, median, standard deviation, range of parameter (lower and upper bound parameter), power spectral density (psd), auto-correlation and discrete wavelet transform (DWT) coefficient, eigen_vector and eigen_value. The relevant feature based parameters that have been extracted are fed as an input to an Artificial Neuron (AN) as depicted in figure 2, below.

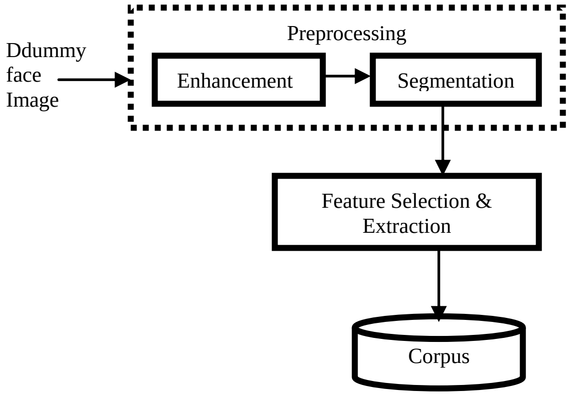

Fig. 1: Schematic diagram for Dummy_ Face_Model

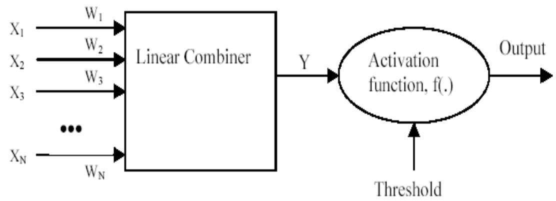

Fig. 2: An Artificial Neuron (AN)

From figure 2, each neuron has an input and output characteristics and performs a computation or function of the form, given in equation (1):

$$O_i = f(S_i) \text{ and } S_i = W^T X \quad (1)$$

where $X = (x_1, x_2, x_3, \ldots, x_m)$ is the vector input to the neuron and W is the weight matrix with w_{ij} being the weight (connection strength) of the connection between the j^{th} element of the input vector and i^{th} neuron. The f (.) is an activation or nonlinear function (usually a sigmoid), O_i is the output of the i^{th} neuron and S_i is the weighted sum of the inputs. A single neuron, as shown in figure 2, by itself is not a very useful tool for dummy_face_model formation.

The real power comes when a single neuron is combined into a multi-layer structure called neural networks. The neuron has a set of nodes that connect it to the inputs, output or other neurons called synapses. A linear combiner is a function that takes all inputs and produces a single value. Let the input sequence be $\{X_1, X_2, \ldots, X_N\}$ and the synaptic weight be $\{W_1, W_2, W_3, \ldots, W_N\}$, so the output of the linear combiner, Y, yields to equation (2),

$$Y = \sum_{i=1}^{N} X_i W_i \tag{2}$$

An activation function will take any input from minus infinity to infinity and squeeze it into the range –1 to +1 or between 0 to 1 intervals. Usually an activation function being treated as a sigmoid function that relates as given in equation (3), below:

$$f(Y) = \frac{1}{1+e^{-Y}} \tag{3}$$

The threshold defines the internal activity of the neuron. This has been kept fixed to –1. In general, for the neuron to fire or activate the sum should be greater than the threshold value.

The learning capability is a result of the ability of the network to modify the weights through usage of a learning rule. In the present work, feed-forward network has been used as a topology and backpropagation as a learning rule for the formation of corpus or knowledge-based model called Dummy_face_model.

This model has been optimized for the best match of features using Genetic Algorithm (GA) for Automatic Dummy face recognition (ADFR). GA has been adopted because it is the best search algorithm based on the mechanics of natural selection, crossover, reproduction and mutation. They combine survival of the fittest features with a randomized information exchange. In every generation, new sets of artificial features are created and are then tried for a new measure after best-fit matching. In other words, GA's are theoretically and computationally simple on fitness values.

The paper has been organized in the following manner, section II proposes the problem formulation and solution methodology, section III describes the experimental results and discussions, section IV gives the concluding remarks and further work and finally section V incorporates the references associated with the present work.

2. PROBLEM FORMULATION AND SOLUTION METHODOLOGY

In the present paper the problem has been formulated in five stages. The first stage of the problem is the detection of noises and its removal from the image for better performance of the system. The second stage of the problem is the detection of boundaries or contours of the image. The third stage of the problem is the selection and extraction of relevant features from the enhanced and segmented image. The fourth stage of the problem is framing of knowledge-based model as corpus. The fifth stage of the problem is the recognition problem, given an unknown face image; the goal is to formulate an algorithm that matches the best pattern stored in the knowledge-based model for classification. The objective of this paper is to investigate and develop a new method for Biometric authentication using Neuro-Genetic Approach (ANN and GA) within a single framework. The paper aims to analyse and discuss experimentally the aforesaid problem in the subsequent subsections.

2.1 Mathematical Preliminaries

Based on the assumption that the original image is additive with noise. To compute the approximate shape of the wavelet (i.e., Any real valued function of time possessing some structure), in a noisy image and also to estimate its time of occurrence, two methods are available, first one is a simple structural analysis and the second one is the template matching technique. For the detection of wavelets in noisy image, assume a class of wavelets, $S_i(t)$, I = 0,...N-1, all having some common structure. Based on this assumption that noise is additive, then the corrupted image has been modeled by the equation -:

$$X(m,n)=i(m,n)+Gd(m,n) \tag{1}$$

where i(m,n) is the clean image, d(m,n) is the noise and G is the term for signal-to-noise ratio control. To de-noise this image, wavelet transform has been applied. Let the mother wavelet or basic wavelet be $\psi(t)$, which yields to,

$$\psi(t)=\exp(j2\pi ft-t^2/2) \tag{2}$$

Further as per the definition of Continuous Wavelet transform CWT (a,τ), the relation yields to,

$$CWT\,(a,\tau) = (1/\sqrt{a}) \int x(t)\, \psi\{(t-\tau)/a\}dt \tag{3}$$

The parameters obtained in equation (3) has been discretized, using Discrete Parameter Wavelet transform, DPWT (m, n), by substituting a = a_0^m, τ = n $\tau_0 a_0^m$. Thus equation (3) in discrete form results to an equation (4),

$$\text{DPWT (m, n)} = 2^{-m/2} \sum_k \sum_l x(k,l)\, \psi(2^{-m}k - n) \quad (4)$$

where 'm' and 'n' are the integers, a_0 and τ_0 are the sampling intervals for 'a' and 'τ', x(k,l) is the enhanced image. The wavelet coefficient has been computed from equation (4) by substituting a_0 = 2 and τ_0 = 1.

Further the enhanced image has been sampled at regular time interval 'T' to produce a sample sequence {i (mT, nT)}, for m = 0,1,2, M-1 and n=0,1,2,…N-1 of size M x N image. After employing Discrete Fourier Transformation (DFT) method, it yields to the equation of the form,

$$\text{I(u,v)} = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} i(m,n) \exp\left(-j2\pi(um/M + vn/N)\right) \quad (5)$$

for u=0,1,2,…,M-1 and v = 0, 1, 2, ……..,N-1

In order to compute the magnitude and power spectrum along with phase angle, conversion from time domain to frequency domain has been done. Mathematically, this can be formulated as, Let R (u,v) and A(u,v) represent the real and imaginary components of I(u,v) respectively.

The Fourier or Magnitude spectrum yields.

$$|I(u,v)| = \left[R^2(u,v) + A^2(u,v)\right]^{1/2} \quad (6)$$

The phase angle of the transform is defined as,

$$\phi(u,v) = \tan^{-1}\left[\frac{A(u,v)}{R(u,v)}\right] \quad (7)$$

The power spectrum is defined as the square of the magnitude spectrum. Thus squaring equation (6), it yields,

$$P(u,v) = |I(u,v)|^2 = R^2(u,v) + A^2(u,v) \quad (8)$$

Due to squaring, the dynamic range of the values in the spectrum has been found very large. Thus to normalize this, logarithmic transformation has been applied in equation (6). Thus it, yields.

$$|I(u,v)|_{normalize} = \log(1 + |I(u,v)|) \quad (9)$$

The expectation value of the enhanced image has been computed and it yields to the relation,

$$\text{E[I(u,v)]} = \frac{1}{MN} \sum_{u=0}^{M-1} \sum_{v=0}^{N-1} I(u,v) \quad (10)$$

where 'E' denotes expectation. The variance of the enhanced image has been computed by using the relation,

$$\text{Var[I(u,v)]} = \text{E}\{[\text{I(u,v)} - \text{I'(u,v)}]^2\} \quad (11)$$

The auto-covariance of an enhanced image has also been computed using the relation,

$$C_{xx}(u,v) = \text{E}\{[\text{I(u,v)} - \text{I'(u,v)}][\text{I(u,v)} - \text{I'(u,v)}]\} \quad (12)$$

Then the power spectrum density has been computed from equation (12),

$$P_E(f) = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} C_{xx}(m,n) W(m,n) \exp(-j2\pi f(m+n)) \quad (13)$$

where C_{xx}(m,n) is the auto-covariance function with 'm' and 'n' samples and W(m,n) is the Blackman window function with 'm' and 'n' samples.

The data compression has been performed using discrete cosine transform (DCT), given below,

$$\text{DCT(u,v)} = \sum_{m=0}^{M-1} \sum_{n=0}^{N-1} I(m,n) \cos\left(\frac{2\pi T(m+n)}{MN}\right) \quad (14)$$

Further for the computation of principal components (i.e., Eigen values and the corresponding Eigenvectors), a pattern vector $\overline{p_n}$, which can be represented by another vector $\overline{q_n}$ of lower dimension, has been formulated using (5) by linear transformation.

$$\text{Thus } \overline{p_n} = [M]\ \overline{q_n} \quad (15)$$

where $[M]$ = $[I(m,n)]$ for m= 0 to M-1 and n = 0 to N-1.

and $\overline{q_n}$ = min([M]), such that $\overline{q_n}$ > 0

Taking the covariance of equation (15), it yields, the corresponding Eigenvector, given in equation (16),

$$\overline{P} = \text{cov}(\overline{p_n}) \quad (16)$$

And thus $\overline{P}\ .\ M_i = \lambda_i\ .\ M_i$ (17)

where 'λ_I' are the corresponding Eigenvalues.

Algorithm for formation of corpus (RTR database)

Algorithm 4.1: Algorithms for formation of Dummy_face_model (Dummy face model database or corpus)

Step1. Read the known 90-degree (perpendicular to surface plain) oriented face image.
Step2. Convert into grayscale image, say R
Step3. Filter the grayscale image using DCT
Step4. Set the counter for front-face = N
Step5. Do while front-face > 0
Select the region of interest (ROI) for each front-face
Locate ROI and Crop the face image
Scaled the cropped and selected face using 2D transformation techniques (Scaling techniques)
Segment ROI using connected component method
Employ flood filled algorithm for image rectification
Re-segment the filled object image
Compute the relevant geometrical features of the face image rectified and store in the form of human-face-model (RTR database)
front-face = front-face - 1
End do

3. RESULT AND DISCUSSIONS

The construction of the Dummy-face-model (knowledge-based model) consists of various steps as depicted in Figure 1. Framing of Dummy-face-model (knowledge-based) model starts with a preprocessing stage, which consists of two major phases: Enhancement phase and segmentation phase. The enhancement stage has been used to obtain the distortion free and compressed image for further processing. The noise free image has to be obtained by using filters. The compression of the noise free image has been obtained by using some compression techniques such that the information should not be lost. In this present work the discrete cosine transform (DCT) has been applied to compress the noise free image. After performing the loss-less compression over the image, Segmentation process has been done. This is performed in the present work for the detection of line and edge of the face image. In the present work the connected component method has to be used for segmentation of the image. During segmentation process, the unwanted portion of the face image has been found highlighted. These unwanted portions have been removed or neglected using a process called cropping of an image portion. The next step in formation of the face model (knowledge-based model) is feature selection and extraction. From the segmented image the relevant geometrical features has been extracted which are required for the present work. By using the methods of artificial neural network (ANN) and the relevant geometrical features a computer algorithm has been developed, for the face model

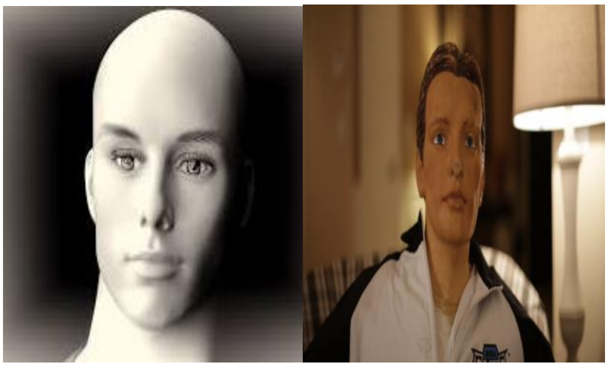

Fig 3: Example of Dummy face images

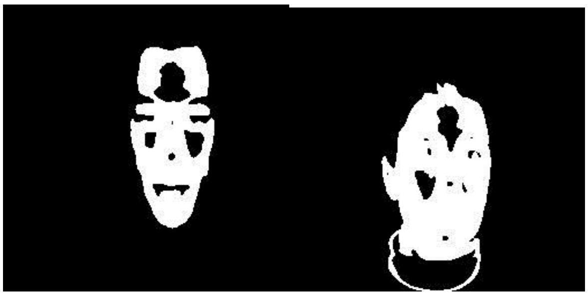

Fig 4. Segmented Dummy face Image

Table 1: Camparision interms of Accuracy compare with different standered algorithms and Standered database with Dammy face model

	ATT	*FERET*	*YALE*	*DFM*
PCA	93.1	69.7	57.2	96.5
LDA	96.3	70.6	66.7	97
SVM	96.9	70.6	70.9	94
Developed Algorithm	94	95.4	93.3	97.56

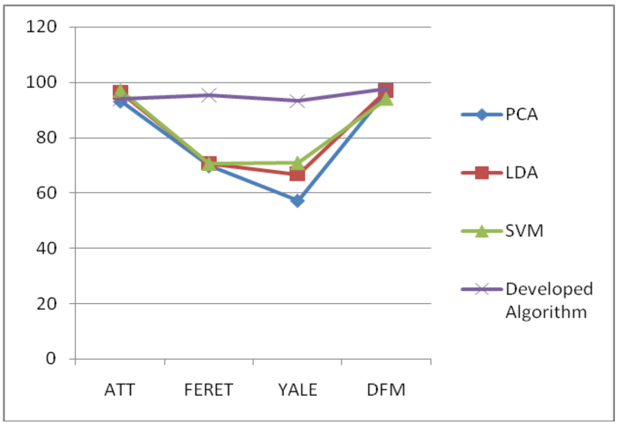

Fig 4: Performace Measurment of Developed Algorithms

4. CONCLUSION

In order to increase the performance of Automatic Face recognition method of any dummy face image with different orientation and lighting conditions without carrying any weight a thorough mathematical analysis have been carried out in the present paper. Limited number of face features has been extracted. Few more features have to be extracted for achieving better results. Other environments like lighting condition, Gender and with soft biometrics, so on have to be considered for further study and analysis.

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