Indian Journal of Science and Technology, *Vol 8(14), IPL 022, July 2015*
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Multiple Hierarchical Technique to Predict the Gender of a Person based on 3 Sigma Control Limits on Neural Network

M. R. Dileep[1*] and Ajit Danti[2]

[1]Department of Computer Science, Alva's College, Unit of Alva's Education Foundation, Moodbidri, 574227, Karnataka, India; dileep.kurunimakki@gmail.com
[2]Department of Computer Applications, Jawaharlal Nehru National College of Engineering, Shimoga, 577204, Karnataka, India; ajitdanti@yahoo.com

Abstract

Objective: Gender Classification is one of the most important applications in Artificial Intelligent Systems. The objective of this research work is to classify the human gender based on multiple level decisions. Since many years, a great deal of effort has been made to gender recognition from face images. It is not straightforward to achieve the same accuracy level in real-world environment. The proposed approach can give solution to these problems. **Methods:** In this paper, multiple levels hierarchical techniques based on 3 Sigma control limits on Neural Network is applied for gender recognition to get the desired objectives. In order to achieve this, the proposed algorithm considers the Artificial Neural Network as basic classifier. Here, in Initial Level Hierarchy, facial features are given as input to the Neural Network. Then, the output represents the gender classification from the Neural Network is extracted. The next level of classification can be done in Core Hierarchical Decision. **Findings:** This paper provides an effective approach that classifies human gender in computer vision applications. In the proposed research, a Feed Forward Neural Network works at the primary level, based on the outcome of the primary level, the further classification is done in the next higher level hierarchically. In this research, there are 1000 gray-scale with 256 gray levels facial images used for experiment. Each image size is normalized to 64×64. Among the 1000 experimental images, 800 images are used as training data, and the remaining are used as test images. Prediction of the gender is more accurate and effectively achieved the success rate of 95 percent. **Applications:** The proposed algorithm can play an important role in many computer vision based applications such as human-computer interaction, surveillance, biometrics, demographic studies and targeted advertising.

Keywords: Multiple Hierarchical Technique, Neural Network, Prediction of Gender, 3 Sigma Control Limits

1. Introduction

Human facial image processing has been an active and interesting research issue for years. Since human faces provide a lot of information, many topics have drawn lots of attentions and thus have been studied intensively. Automatic human facial expression recognition, Human mood analysis system are the thrust research area in video surveillance and law enforcement applications as a prerequisite for face recognition. In the last several years, various feature extraction and pattern classification methods have been developed for gender classification. Emerging applications of computer vision and pattern recognition in mobile devices and networked computing require the development of resource limited algorithms. Perceived gender classification is a research topic with a high application potential in areas such as surveillance, face recognition, video indexing, and dynamic marketing surveys.

Gender classification is important visual tasks for human beings, such as many social interactions critically depend on the correct gender perception. As visual surveillance and human-computer interaction technologies evolve, computer vision systems for gender classification

*Author for correspondence

will play an increasing important role in our lives. Gender classification is arguably one of the more important visual tasks for an extremely social animal like us humans many social interactions critically depend on the correct gender perception of the parties involved. Arguably, visual information from human faces provides one of the more important sources of information for gender classification. Not surprisingly, thus, that a very large number of psychophysical studies has investigated gender classification from face perception in humans.

Until now much research work has been done on detecting the human faces based on templates and example-based techniques. However, some of these methods are computationally expensive and also complex.

Information technology, a neural network is a system of programs and data structures that approximates the operation of the human brain. A neuron is a basic information processing unit. A neuron consists of a cell body called Soma, a number of fibers called Dendrites, and a single long fiber called Axon. Soma fires at different frequencies, Dendrites receives electrical signals affected by chemical processes. A perceptron is a simplest form of neural network. The connections between neurons are called Synapses. Neurons in a network are connected by directed, weighted paths. The weights may be Positive (Excitatory) or Negative (Inhibitory). Figure 1 shows a typical structure of a Neuron.

Gender Classification is one of the promising research areas since the couple of decades. Many of the researchers developed hundreds of algorithms in this area of research and got success. H. Ai and G. Wei[1], proposed a method Face Gender Classification on Consumer Images in a Multiethnic Environment. In this approach the classification of the faces is done on facial features. J. Bekios-Calfa et al.[2] invented an algorithm Revisiting Linear Discriminant Techniques in Gender Recognition, that recognize the gender of the person. Changqin Huang et. al.[3] proposed

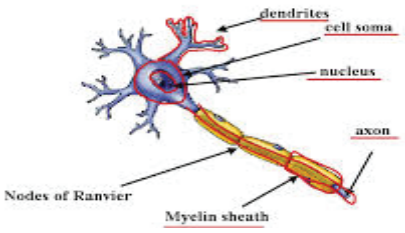


Figure 1. Structure of a Neuron.

a methodology on Gender Recognition with Face images based on PARCONE Mode. Chu W.S et al.[4] introduced a method for Identifying gender from unaligned facial images by set classification. Dileep M.R. and Ajit Danti[5], invented an approach of Prediction of Human Gender based on two level decision on 3 Sigma Limits on Neural Network. Farhad Soleimanian Gharehchopogh et al.[6] invented A New Approach in Bloggers Classification with Hybrid of K-Nearest Neighbor and Artificial Neural Network Algorithms. X. Geng et al.[7] introduced an algorithm of Automatic Age Estimation Based on Facial Aging Patterns. Gudong Guo et al.[9] defined a problem based on Image-Based Human Age Estimation by Manifold Learning and Locally Adjusted Robust Regression. J. Hayashi et al.[10] developed a system on Age and Gender Estimation from Facial Image Processing. Hlaing Htake Khaung Tin[11], developed an algorithm on Facial Extraction and Lip Tracking Using Facial Points. Hlaing Htake Khaung Tin[12], given a solution to classify the gender based on images called Perceived Gender Classification from Face Images. Hlaing Htake Khaung Tin[13], given a method Subjective Age Prediction of Face Images Using PCA.W. B. Horng et al.[14] defined a methodology on Classification of age groups based on facial features. Jinli Suo et al.[15] developed a model on Compositional and Dynamic Model for Face Aging. Their study was based on geometric ratios and skin wrinkle analysis. Their method was tested on a database of only 47 high resolution face images containing babies, young and middle aged adults. They reported 100% classification accuracy on these data.

Ji Zheng and Bao-Liang Lu[16], given an approach for Support vector machine classifier with automatic confidence and its application to gender classification, which classifies the gender based on SVM. Juan Bekios-Calfa et al[17], developed a methodology which describes Revisiting Linear Discriminant Techniques in Gender Recognition. Kwon, Y. H. and da Vitoria Lobo[18], introduced a technique for Locating Facial Features for Age Classification. B. Moghaddam and M. H. Yang[19], developed an algorithm for Learning Gender with Support Faces. Roberts T and Bruce V[20], defined an algorithm of Feature saliency in judging the sex and familiarity of faces. Ryotatsu Iga et al.[21] described a problem on Gender and Age Estimation System from Face Images. Sebe N et al.[22] explored an approach towards authentic emotion recognition. Syed Mustafa et al[23], given an approach for

Performance Evaluation of Web-services Classification. Y. Tian et al.[24] prepared a methodology for Evaluation of Gabor wavelet-based facial action unit recognition in image sequences of increasing complexity. A. J. O'Toole et al.[25] developed an application for the Perception of Face Gender: the Role of Stimulus Structure in Recognition and Classification. Yamaguchi MK et al.[26] developed an approach for the Judgment of gender through facial parts. A. Yuille et al.[27] extracted an algorithm for Facial feature extraction from faces using deformable templates. Y. Zhu and F. Cutu[28], introduced an approach for Face Detection using Half-Face Templates.

In these paper two categories of genders viz. Male and Female are considered. An algorithm has been proposed to predict genders of the different people using two level decision using 3 Sigma limits on Neural Network classifier. The accuracy of the proposed method is good compared to other methodologies. For implementation images from different databases and internet are considered.

The rest of this paper is being organized as follows. Section 2 presents the Proposed Methodology. Section 3 provides the Proposed Algorithm. Section 4 gives the Experimental Results. Finally, the conclusions are given in section 5.

2. Proposed Methodology

This paper proposes an effective method for human gender prediction/classification from facial images. Figure 2 shows the diagrammatic representation of the steps followed in achieving the proposed methodology.

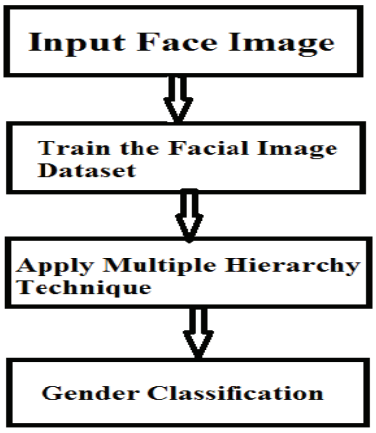


Figure 2. Representation of the steps of proposed Methodology.

Here, the classification of the facial images is done at two levels, namely

- Initial Hierarchy
- Core Hierarchy

The Proposed algorithm has been implemented to classify input images into one of two groups viz. Male and female using Feed-Forward ANN. In the Initial Hierarchy, the facial images are classified using Neural Network. The Core Hierarchical Decision includes, the classification based on the outcome of the Initial Hierarchy to improve the detection rate effectively. The proposed methodology is experimented on database of the face images. This dataset is used as the benchmark database for Performance Comparisons of Gender Prediction.

In this method, first the images containing the face will be read and intensity values of each of the image ranges from 0 to 255. In order to improve the efficiency of the performance, instead of considering all Neurons (64 x 64 = 4096 Neurons) into the Neural Network, the Mean of each of the image will be given as input to the Neural Network. Mean of each image is represented by 64 standard values.

2.1 Initial Hierarchy

In the Initial Hierarchical Decision, Neural Network classifies the faces based on the different genders viz. Male and Female. This outcome cannot be used as a conclusion as there may be the chances of mis-detection. To enhance the Initial Hierarchical Decision, an algorithm for Core Hierarchical Decision is proposed to reduce the misdetection rate and improve the success rate of detection as given in the next section. Figure 3 gives the diagrammatic representation of "Initial Hierarchical Decision".

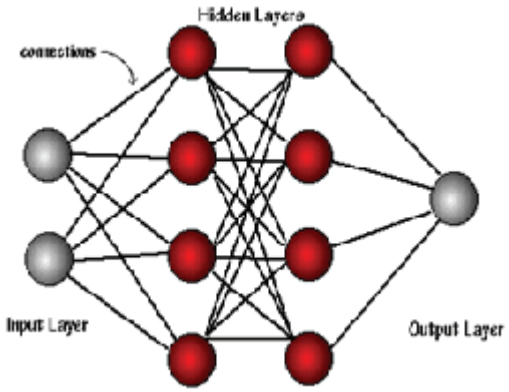


Figure 3. Initial hierarchical decision.

The output of the built in NN classifier is a standard value that predicts the gender of a person in the Initial Hierarchy. This can be represented by,

$$y = F(N, I) \tag{1}$$

Where y represents the predicted gender of a person in the Initial Hierarchical decision.

F is a function that represents the simulation of the Neural Network.

N is the vector that represents the trained value in the Neural Network.

I is the matrix that represents the testing image.

The output generated in the Initial Hierarchy, from the standard classifier ANN cannot be considered as the final output. It is not possible to rely on the output that is generated by the ANN since the conclusion should not be dependent on standard classifier. Based on the output generated from the Initial Hierarchy, again the classification is done in the Core Hierarchy by applying 3 sigma control limits on Neural Network. The application of 3 sigma control limits on Neural Network is so efficient that, it can classify the data with greater marginal levels in terms of range. The upcoming section describes the proposed Core Hierarchical Decision.

2.2 Core Hierarchy

In which, the gender of a person is identified by Core Hierarchical Decision using Neural Network. In which 3 Sigma Control limits are applied on the Neural Network classifier. 3 Sigma Controls cover more than 90 percent of the population of the dataset under consideration for decision making. Figure 4 shows 3σ limit describes how data are dispersed around their averages.

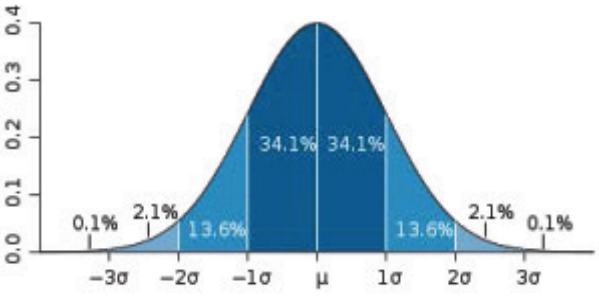


Figure 4. 3σ limit dispersed around their averages.

In the Core Hierarchical Decision, 3 sigma control limits are determined by their spread around the mean using the equation (2) and (3).

$$l_m = \bar{y}_m - 3\sigma_m \tag{2}$$

$$u_m = \bar{y}_m + 3\sigma_m \tag{3}$$

Where, l_m and u_m are the Lower Limit and Upper Limit of Male faces, respectively.

$\bar{y}_m$: mean of intensity values of male faces

σ_m : standard deviations of male faces

The Mean $\bar{y}_m$ of male face images is determined using the equation (4)

$$\bar{y}_m = \frac{\sum y_m}{n} \tag{4}$$

Where, y_m represents the predicted gender of male faces obtained in First level decision.

N is the number of Male faces.

The standard deviation σ_m of male face images is determined using the equation (5)

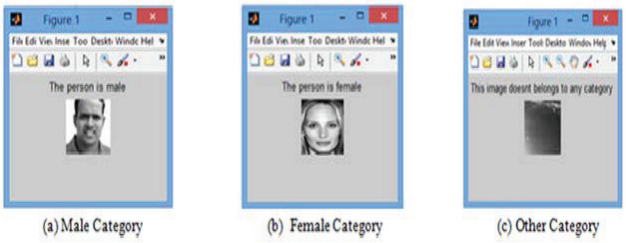
$$\sigma_m = \sqrt{\frac{\sum (y_m - \bar{y}_m)^2}{n-1}} \tag{5}$$

Similarly, l_f and u_f are determined for female faces. The reasonable threshold value is empirically determined by considering the face images of the database. The mean $\bar{y}_f$ and σ_f of female images are also determined using the similar Equations given in (4) and (5).

In testing the query image, gender y is determined using the Equation (1) as first level decision. The final decision on gender is determined using Equation (6) as Core Hierarchical Decision.

$$\begin{cases} male & if\ l_m < y < u_m \\ female & if\ l_f < y < u_f \\ misdetection & else \end{cases} \tag{6}$$

The experimental results of prediction of gender are shown in the Figure 5.



(a) Male Category (b) Female Category (c) Other Category

Figure 5. Sample experimental results of Proposed Methodology.

3. Proposed Algorithm

Proposed algorithm for gender prediction from the given image is as given below:

Input: Query face

Output: Determine Gender i.e. male or female

Step 1: To Train: Input all n face images to the Neural Network in the form of Dataset.

Step 2: Set the Target for the classification of Male and Female categories.

Step 3: Create & train the Neural Network, so that the invariant features of the face will be read.

Step 4: Determine the gender y_m and y_f for male and female using $y = F(N,I)$ in Initial Hierarchical Decision.

Step 5: The Mean $\bar{y}_m$ and $\bar{y}_f$ of Male and Female face images is determined using the equations,

$$\bar{y}_m = \frac{\sum y_m}{n} \text{ and } \bar{y}_f = \frac{\sum y_f}{n} \text{ respectively.}$$

Step 6: The Standard Deviation σ_m and σ_f of Male and Female face images is determined using the equation,

$$\sigma_m = \sqrt{\frac{\sum (y_m - \bar{y}_m)^2}{n-1}} \text{ and } \sigma_h = \sqrt{\frac{\sum (y_f - \bar{y}_f)^2}{n-1}} \text{ respectively.}$$

Step 7: Define lower and upper sigma control limits for Male and Female faces using the equations $l_m = \bar{y}_m - 3\sigma_m$ and $u_f = \bar{y}_f + 3\sigma_f$ and respectively.

Step 8: To Test the query image: Find the gender y using the equation $y = F(N,I)$ in Initial Hierarchy.

Step 9: Core Level Decision for gender classification is determined using the equation,

$$\begin{cases} Male \ \ if \ l_m < y < u_m \\ Female \ if \ \ l_f < y < u_f \\ else \ if \ l_{other} < y < u_{other} \end{cases}$$

Step 10: Based on the range to which y value belongs in Core Hierarchical Decision, the conclusion can be drawn that, the test image belongs to that specific category of the gender.

4. Experimental Results

In this research, there are 1000 gray-scale with 256 gray levels facial images used for experiment. Each image size is normalized to 64×64. Among the 1000 experimental images, 800 images are used as training data, and the remaining are used as test images. The male face images are trained using to neural network, and second level classification is done three sigma limits. The proposed Algorithm has shown good robustness and reasonable accuracy for the photos from our test set. The proposed system has a low complexity and is suitable for real time implementations, such as real time facial animation. The processing time may be seriously reduced by algorithms and their implementation optimization, which have not yet performed.

In the testing phase, among 200 images, 100 images were taken as Male images and remaining 100 images were taken as Female ones. Thus, the success rate for male and female is 94.00% and 96.00% respectively. Therefore, the overall success rate for test images is 95.00%. The average recognition time of each test image is 0.30 seconds on a Pentium Quad Core processor with 2 GB RAM.

However, proposed method fails to detect the side-view faces, occluded faces and partial face images. This is due to the fact that the proposed model is constrained to detect only the frontal view face. Figure 8 shows the sample images which has been mis-detected. Our proposed method is compared with the methods "A Support vector machine classifier with automatic confidence and its application to gender classification[14]", developed by Ji Zheng and Bao-Liang Lu, also "Identifying gender from unaligned facial images by set classification[4]", developed by Chu W. S., Rong C. and Song Chen C. and found higher success rate as shown in Figure 6 and Figure 7.

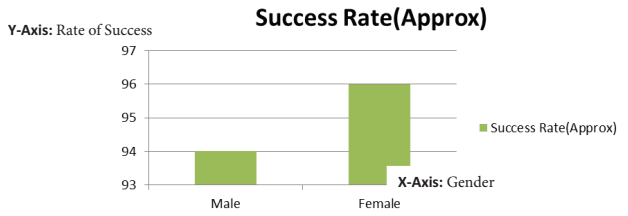


Figure 6. Success rate of the proposed Multiple Hierarchical Technique.

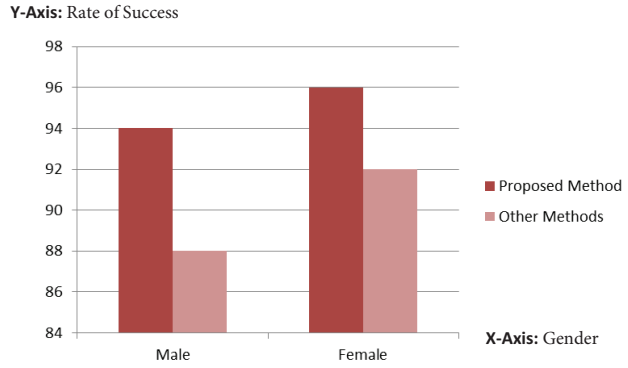


Figure 7. Comparing proposed Multiple Hierarchical Technique model with other models[15,21].

Figure 8. Images which has been mis-detected.

5. Conclusion

In this paper, a fast and efficient human gender classification system is proposed to classify a facial image into male and female using feed forward neural network. The final decision is made by employing validation based on three sigma control limits applied on the output of the neural network classifier. The proposed method is better in terms of speed and accuracy. Single frontal human faces with two gender groups are detected successfully with success rate of 95%.The proposed system has a low complexity and is suitable for real time implementations, such as real time facial animation. In future studies, misclassifications are reduced by using fuzzy logic approach for further improvement in the proposed system so that it becomes more pertinent to the design of a real-time video surveillance system.

6. References

1. Ai H, Wei G. Face gender classification on consumer images in a multiethnic environment. Proceedings Conference Advances in Biometrics; 2009. p. 412–18.
2. Bekios-Calfa J, Buenaposada JM, Baumela L. Revisiting linear discriminant techniques in gender recognition. IEEE Transactions on Pattern Analysis and Machine Intelligence. 2011; 33(4):323–30.
3. Huang C, Pan W, Lin S. Gender recognition with face images based on parcone mode. Proceedings of the Second Symposium International Computer Science and Computational technology (ISCSCT); 2009. p. 222–6.
4. Chu WS, Rong C, Song CC. Identifying gender from unaligned facial images by set classification. Proceeding of 20th IEEE International Conference on Pattern Recognition; 2010. p. 2636–739.
5. Dileep MR, Danti A. Prediction of human gender based on two level decision on 3 sigma limits on neural network. International Conference on Computing Algorithm; 2015 Mar. p. 1203–7
6. Gharehchopogh FS et al. A new approach in bloggers classification with hybrid of K-nearest neighbor and artificial neural network algorithms. International Journal of Science and Technology. 2015 Feb; 8(3):237–46.
7. Geng X, Zhou Z, Smith-Miles K. Automatic age estimation based on facial aging patterns. IEEE Trans Pattern Analysis and Machine Intelligence. 2007; 29(12):2234–40.
8. Gonzalez RC, Woods RE. Digital image processing. 3rd ed. Pearson Education; 2008.
9. Guo G, Fu Y, Dyer CR, Huang TS. Image-based human age estimation by manifold learning and locally adjusted robust regression. IEEE Transaction on Image Processing. 2008; 17(7):1178–88.
10. Hayashi J, Yasumoto M, Ito H, Niwa Y, Koshimizu H. Age and gender estimation from facial image processing. Proceedings of the 41st SICE Annual Conference; 2010. p. 13–8.
11. Tin HHK. Facial extraction and lip tracking using facial points. International Journal of Computer Science, Engineering and Information Technology (IJCSEIT). 2011 Mar; 1(1):945–52.
12. Tin HHK. Perceived gender classification from face images. International Journal of Modern Education and Computer Science. 2012; 1:12–8.
13. Tin HHK. Subjective age prediction of face images using PCA. International Journal of Information and Electronics Engineering. 2012; 2(3):1103–9.

14. Horng WB, Lee CP, Chen CW. Classification of age groups based on facial features. Tamkang Journal of Science and Engineering. 2001; 4(2):183–92.
15. Suo J, Zhu S-C, Shan S. A compositional and dynamic model for face aging. IEEE Transactions on Pattern Analysis and Machine Intelligence. 2010 Mar; 32(3):754–9.
16. Zheng J, Lu B-L. A support vector machine classifier with automatic confidence and its application to gender classification. International Journal of Neurocomputing. 2011; 74:1926–35.
17. Bekios-Calfa J, Buenaposada JM, Baumela L. Revisiting linear discriminant techniques in gender recognition. IEEE Transactions on Pattern Analysis and Machine Intelligence. 2011 Apr; 33(4):324–30.
18. Kwon YH, da Vitoria Lobo N. Locating facial features for age classification. Proceedings of SPIE-The International Society for Optical Engineering Conference; 1993. p. 62–72.
19. Moghaddam B, Yang MH. Learning gender with support faces. IEEE Trans Pattern Analysis and Machine Intelligence. 2002 May; 24(5):707–11.
20. Roberts T, Bruce V. Feature saliency in judging the sex and familiarity of faces. Perception. 1998; 17(4):475–81.
21. Iga R, Izumi K, Hayashi H, Fukano G, Ohtani T. A gender and age estimation system from face images. SICE Annual Conference in Fukui; 2003 Aug 4-6.
22. Sebe N, Sun Y, Bakker E, Lew M, Cohen I, Huang T. Towards authentic emotion recognition. International Conference on Systems, Man and Cybernetics; 2004. p. 1125–32.
23. Mustafa Set al. Performance evaluation of web-services classification. International Journal of Science and Technology. 2014 Oct; 7 (10):1674–81.
24. Tian Y, Kanade T, Cohn JF. Evaluation of Gabor wavelet-based facial action unit recognition in image sequences of increasing complexity. Proceedings of the Fifth IEEE International Conference on Automatic Face and Gesture Recognition; 2002 May. p. 218–23.
25. O'Toole AJ, Deffenebacher KA, Valentin D, McKee K, Huff D, Abdi H. The perception of face gender: the role of stimulus structure in recognition and classification. Memory and Cognition. 1998; 26(1).
26. Yamaguchi MK, Hirukawa T, Kanazawa S. Judgment of gender through facial parts. Perception. 1995; 24:563–75.
27. Yuille A, Cohen D, Hallinan P. Facial feature extraction from faces using deformable templates. Proceedings IEEE Computer Society Conference on Computer Vision and Pattern Recognition; 1998. p. 104–9.
28. Zhu Y, Cutu F. Face Detection using Half-Face Templates. p. 221–7.