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Automated Age Prediction Using Geometric Features of Facial Images and Neural Network

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ABSTRACT

Automated age estimation is an important processing task that serves many purposes such as surveillance monitoring, marketing of products, authentication systems, find out the fugitive or missing person and security control etc. Therefore, estimating age from still face images by using facial features is trending research topic from past few years. An automated age group prediction system using geometric features of facial images and neural network is proposed in this paper. Three age groups including child, young, and old, are considered in the classification system. The prediction process is divided into three phases: image accumulation from different real-life photo or website, geometric feature extraction using image processing technique, and age classification using Neural Network. Using this process, we can predict the age group of a face of a person with satisfactory accuracy.

Keywords: Age Prediction, Geometric Feature, Wrinkles, Image Processing, Artificial Neural Network, Classification

INTRODUCTION

Face is a prolific information source. People can effortlessly extract many kinds of useful information from a face image, such as identity, expression, emotion, gaze, gender, age, etc. Since human faces provide a lot of information, many topics have drawn lots of attentions and thus have been studied intensively. Human facial image processing has been an active and interesting research issue for years. Human being can easily predict the age of any person by looking at their facial features as we have been in the environment with them for a long time. So our brain can easily predict their approximate age but, a computer can't do it. So, it is very interesting to design an expert system which can at least estimate or predict the approximate age of a person by scanning its image automatically. Age estimation is an important processing task that serves many purposes which are given as follows.

- In marketing, companies may increase their profits by measuring the demographics of groups interested on their billboard or street advertising through age estimation.
- In security control and surveillance monitoring, an age estimation system, with the input of a monitoring camera, can warn or stop under-age drinkers from entering wine shops; prevent minors from purchasing tobacco products from vending machines; refuse the aged when he or she wishes to try a roller coaster at an amusement park; and deny children access to adult websites or restricted films.
- In addition, estimated age also provides a type of soft biometric information which provides ancillary parameters for user identity. It can be used to complement primary biometric features, such as face, fingerprint, iris, and hand geometry, to improve the performance of a primary (hard) biometrics system.
- Face-based authentication systems which typically compare age separated face images are also bound to benefit from facial ageing models and from faces.
- It can also help to find out the fugitive or some missing person locates at remote place.

Thus, estimating age automatically from still face images is trending research topic from past few years. A lot of approaches and models [1-8] came forward as the research progressed. The process of age estimation attempts to label a face image automatically with an age group of the individual face. Age prediction is concerned with the use of a training set to train a model that can estimate the age of the facial images. The training dataset consist of facial

features for different persons with different age group. The model is any of well-known artificial intelligent classifiers which can learn from the data and able to take decision.

Ageing is the process of becoming older. In the narrow sense the term refers to biological ageing of human beings, animals and other organisms. From studying the aging process of adult humans, one can observe that the facial skin of an older person is not as taut as in a younger adult or baby. These unique changes are known as the facial features based on which age of a person can be estimated. There are several face features [9-10] which are already known like geometric feature and wrinkle features. Geometric features, precisely on the basis of two-dimensional facial images. Facial characteristic points can be defined as a standard reference points on human face used by scientists. For baby the shape of face is almost circular in 2D. But as the baby grows, the distance between eyes, distance between eye and nose, distance between nose and mouth etc. are changed; consequently, facial features are also changed. The second type of facial feature is adulthood. During adulthood, the main changes in this stage are changes in skin texture. Skin becomes thinner, darker, less elastic and leatherier. Also, wrinkles, under chin, sagging cheeks and lowered bags under the eyes appear. Wrinkles features [24] are a good indication of the loosening skin with respect to age (although, in general, these aging-wrinkles must not be confused with creases formed from facial expressions). However, in this work, we have selected geometric feature as the classification parameters.

There are various popular artificial intelligence methods [11-12] for classification problem such as Artificial Neural Network [13-15], Decision Tree [16-18], Bayesian Network [19-21] etc. These intelligent systems help computer to take the decision after training or learning. However, Artificial Neural Network (ANN) derives its origin from the working of human brain [22]. ANN is an information processing model which consists of multiple single processing units (neurons), these neurons are massively parallel in nature which performs highly complex computations. The sole goal of ANN is to make a computer learn something so that network would adapt to a given dataset. ANN, like people learn by example. These abilities make ANN [25] suitable for pattern recognition, speech recognition or data classification problem. Therefore, in this work, we have chosen ANN for classification or prediction of age group.

Here, geometric features and Neural Network have been used to predict the age group of facial images. This paper is organized in following way. In next section, we revise some theoretical concept of some topic related with this project. Next, proposed approach and results are discussed. Finally, future work and conclusion is given followed by references.

METHODOLOGY

This automated age prediction methodology is divided into three phases: image acquisition from different website or real-life, geometric feature extraction using image processing technique, and age prediction using neural network. Therefore, the stepwise process of the proposed methodology can be written as:

Step -1
Collect original colour images for different age groups (i.e. child, young, old) from the real-life photo or website. Input these image to Matlab and cropping of face portion (manually or automatically)

Step -2
Find out the coordinates of eyes, forehead, nose-tip, mouth and chin from the cropped image also calculate different important distance among them. Geometric features extraction by taking different combination of ratio of different distances. Repeat these processes for all images and make a database

Step -3
Use this database for training Artificial Neural Network. Choose new image of person and predict age output of the image using ANN model and check the accuracy.

Now, the above mentioned process is elaborated in following way:

Image Acquisition
Initially, for this project, we select the range of ages to classify them in different age groups. Following table shows three age groups (child, young, old) and corresponding range of ages for classification purpose. We have searched and saved different images with different age groups from several websites or real-life pictures. 10 images per age group are collected by this method. During acquisition of images following points must be considered.

- Facial images should be expressionless (no crying or laughing etc.). During laughing or crying, extra lines are included into the facial images. Therefore, extraction of wrinkle features from these images will be erroneous.
- The images should be makeup less as much as possible. Because if any face is covered with some makeup then the wrinkle lines may not be properly visible and extraction of wrinkle features from this images will also be erroneous.

- Presence of spectacles, any kind of head gadget, hats, etc. are not acceptable as they will cover a certain portion of faces and that may lead to inaccurate results.
- The faces that have hair fringes on forehead, beard on face etc. should be avoided as much as possible for the same reason.

Table -1 Age Groups and Corresponding Ages

Age group	Range (years)	No of images
Child	0 to 20	12
Young	21 to 40	12
Old	41 and above	12

Following figures shows a sample of facial images which consists of three initial facial images for each of age groups i.e. child, young and old respectively.

Fig. 1 A sample of true color images for different age groups

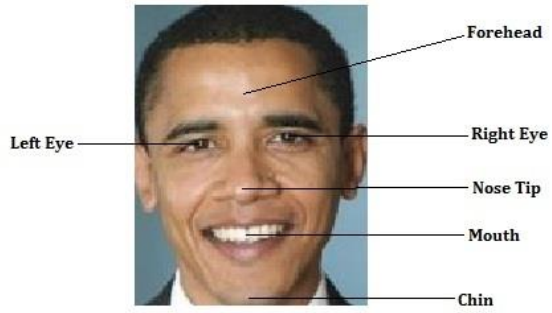

Fig. 2 Different reference points for calculation of geometric features

Feature Extraction and Database Preparation

Next for each of input true color images, the pre-processing is required i.e. to crop the face portion from a whole image. It may be done manually or some automated process using Computer Vision Toolbox. The pre-processing is required to remove unwanted portions of an image except facial portion which is area of our interest.

Now, to extract the geometrical features from a facial image, it is necessary to find out few reference points (see Fig. 2) of face based on which geometrical features would be calculated. Initially, we have located six regions of a facial image (i.e. reference points) like centre of left eye, centre of right eye, mid-forehead, nose-tip, middle point of mouth and end point of chin (using MATLAB Image processing Toolbox) and corresponding coordinates (x, y) of these points are noted down.

Following table shows a truncated table (6 cases only) corresponding to the location of the points. We repeat this process for all 36 images that we have acquired.

Next, we have calculated four different distances between these points namely: a) distance between left eye & right eye (L_{ee}), b) distance between forehead & nose-tip (L_{fn}), c) distance between forehead & mouth (L_{fm}) and d) distance between forehead & chin (L_{fc}). The distance between these points can calculated using conventional formula for calculation of Euclidean distance. Let's consider that the coordinated of left eye and right eye are given by (x_l, y_l) and (x_r, y_r) respectively. So, the distance between left eye & right eye (L_{ee}) can be calculated by:

$$L_{ee} = \sqrt{(x_l - x_r)^2 + (y_l - y_r)^2} \quad (1)$$

Similarly, L_{ee}, L_{fn}, L_{fm} and L_{fc} can be calculated easily. Table 3 shows different reference distance of a facial image.

Now, geometric feature can be calculated by taking the different ratio of these different distances. In this work, total five geometrical features are being considered for automated age prediction. These geometrical features are denoted F1, F2, F3, F4 and F5 respectively which can be defined as following way:

$$F1 = \frac{L_{fn}}{L_{fm}} \quad (2)$$

$$F2 = \frac{L_{ee}}{L_{fn}} \quad (3)$$

$$F3 = \frac{L_{ee}}{L_{fc}} \quad (4)$$

$$F4 = \frac{L_{ee}}{L_{fm}} \quad (5)$$

$$F5 = \frac{L_{fn}}{L_{fc}} \quad (6)$$

In the next phase of this work, we create a database to store the extracted information about number of geometrical features and age groups. This database consists of seven columns and 36 numbers of rows. Table 5 shows the sample of database consists of information regarding geometrical features where first five columns denote five different geometric features and last column denotes age groups. Here we consider child as 1, young as 2 and old as 3. Following table shows a portion of the data base. This data base is used for training and testing of Neural Network model for age prediction.

Table -2 Sample for Coordinates of Important Locations for Six Different Images

Name	Coordinates of Important Locations											
	Right Eye		Left Eye		Fore head		Nose Tip		Mouth		Chin	
	x	y	x	y	x	y	x	y	x	y	x	y
CHILD1	130	329	307	333	212	287	213	423	218	505	223	575
CHILD 2	95	197	239	205	171	147	168	275	160	346	157	410
YOUNG1	32	61	73	66	55	43	51	86	48	109	74	135
YOUNG2	81	190	239	180	154	102	172	300	176	368	175	487
OLD1	25	66	81	62	47	44	48	97	51	125	55	161
OLD2	50	69	93	84	84	58	65	110	57	125	46	149

Table -3 Sample for Different Important Distances for Six Different Images

Name	Distances			
	L_{ee}	L_{fn}	L_{fm}	L_{fc}
CHILD1	177.0	136.0	218.1	288.2
CHILD 2	144.2	128.0	199.3	263.4
YOUNG1	41.3	43.2	66.4	93.9
YOUNG2	158.3	198.8	266.9	385.6
OLD1	56.1	53.0	81.1	117.3
OLD2	45.5	55.4	72.2	98.6

Table -4 A sample of Database Consist of Information Regarding Geometrical Features

F1	F2	F3	F4	F5	Age Group
0.62	1.30	0.61	0.81	0.47	1
0.64	1.13	0.55	0.72	0.49	1
0.65	0.96	0.44	0.62	0.46	2
0.74	0.80	0.41	0.59	0.52	2
0.65	1.06	0.48	0.69	0.45	3
0.77	0.82	0.46	0.63	0.56	3

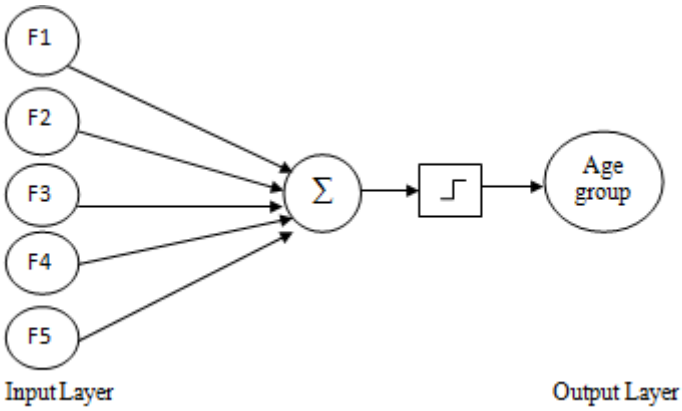

Fig. 3 Neural Network (Single-Layer Feed Forward) modeling of age prediction problem

Construction of Neural Network

In the next phase of this work, a feed forward neural network is constructed for age group classification problem which will use the wrinkle features to classify the image into any one of three age groups. The database which was created after the extraction of facial features from the images is used for training of neural network. For age classification using neural network, the five geometric features and age group are acted as input nodes and output node respectively.

We have used MATLAB 7.6 for construction and training of Neural Network. After the training of NN, machine can learn optimal values of weights, bias, and thresholds by minimizing the training error during iteration. 80% of the obtained database is used for training. After training of neural network, it is necessary to validate the proposed model for age classification problem. Rest of 20% data is used for testing new cases which were not used during training.

EXPERIMENTAL RESULTS AND DISCUSSION

So, using above mention process we can identify the number of geometric features from six different important reference regions of a facial image. By extracting and storing the geometric features and age group information, the database is generated. The initial database consists of geometric features information for 36 images. Among these 36 images, 30 images (10 images from each age group) are used for training and construction of Neural Network. Rests of 6 images are used validation purpose. Initially we consider a single-layer feed forward neural network that contains no hidden layer. Next we consider, we introduce multi-layer feed forward neural network for better accuracy. The *accuracy* (*AC*) is the proportion of the total number of predictions that were correct.

However, for each case, two types of validation are performed to observe the accuracy of the model. First one is cross validation and another one is testing new cases. In case of cross validation, we apply or test the trained neural network model on training data itself i.e. trained neural network is used to predict the age group of input images. In second case, we test the new data (6 images which is not used during training) by trained neural network i.e. the model is used to predict the age group of new images.

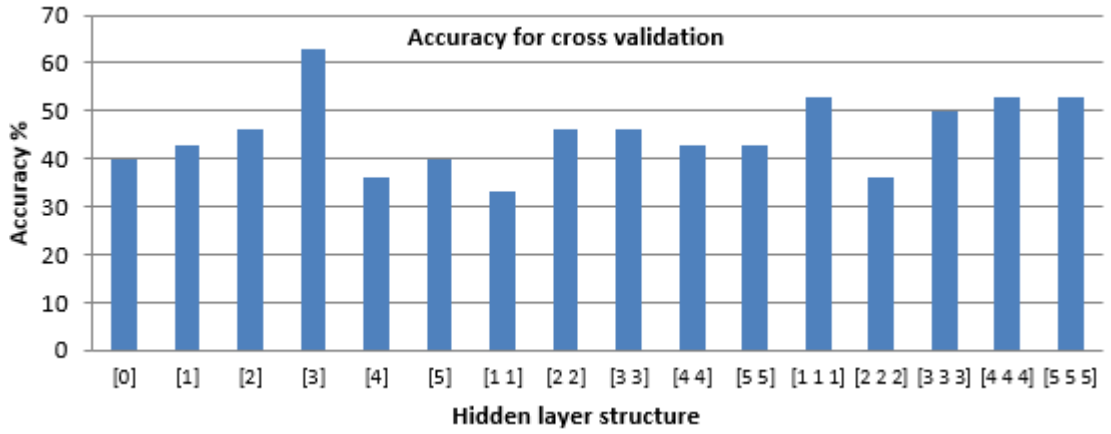

Fig. 4 Classification accuracy for cross validation

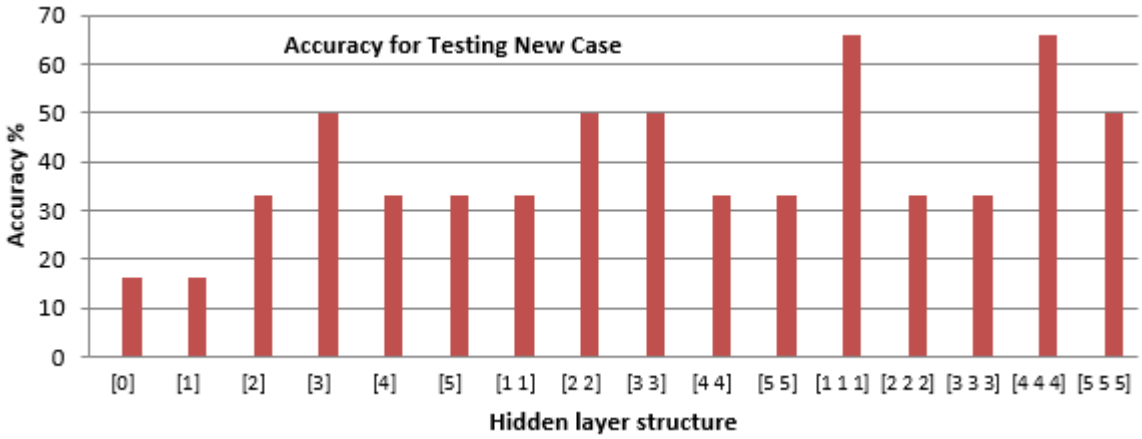

Fig. 5 Classification accuracy for testing new cases

Figure 4 and 5 shows the classification accuracy for cross validation and testing new cases respectively for different hidden layer structure. As an example, [0] corresponds to no hidden layer and [2 2] corresponds to a NN which has2 hidden layer along with two nodes on each layer. It has been observed that classification accuracy for cross validation and testing new case is 40% and 16% respectively. Due to non-linear relationship among the geometric features of faces classification is small. Therefore, hidden layer is introduced to deal with the non-linearity.

However, if we increase the number of hidden layer in case of cross-validation, we get maximum accuracy of 63% for the hidden layer structure of [3] i.e. 1 hidden layer with three nodes. Moreover, if we increase the number of hidden layer in case of testing new case, we get maximum accuracy of 66% for the hidden layer structure of [1 1 1] and [5 5 5]. It is expected that if ample amount of data is provided then classification accuracy (without hidden layer) would be improved.

CONCLUSION

Since human faces provide a lot of information, many topics have drawn lots of attentions and thus have been studied intensively. Due to various potential applications and uses, research related to age estimation using face images has become important. Estimating age from still face images by using facial features is trending research topic from past few years. A lot of approaches and models came forward as the research progressed.

With age, the human face is going through several changes which are called features. These features are may be either wrinkles (become prominent with ages) or shape of the faces (size of faces is changed with ages). Using facial features like wrinkle or geometric features and supervising classification tools such as Neural Network, it can be possible to predict the age group using image processing and artificial intelligence technique.

In this paper, we presented an automated age classification system that can able to predict the age group of a person from the facial image of it. Here, we have considered geometric features for age classification and the features are extracted using MATLAB. We have only considered three age groups i.e. is child, young and old. The facial images were obtained from different real-life photos and websites. Here faces detection is done by cropping which is manual process. Next, five geometric features are extracted based on the ratio of the distances between some important locations of faces such as left eye, right eye, forehead, nose-tip, mouth and chin. The generated database for geometric features information is used to train the Neural Network which is a very popular artificial intelligence technique for classification of data. For age classification problem using Neural Network, the five geometric features and age group are acted as input nodes and output node respectively. Two types of validation technique are used: cross validation and testing new cases. For both cases we achieved satisfactory classification accuracy. Moreover, accuracy can be improved by incorporating different number of hidden layer and nodes in the Neural Network structure. However, classification accuracy can't be improved above 66% in spite of using Multilayer Feed Forward Neural Network. This is due to similar geometric features of young and old aged faces. Moreover, the number of training data should be more for training of the model.

In future, we will try to incorporate the automated face detection technique to crop the faces from a group of photo. Moreover, wrinkles features must be included as inputs to the Neural Network to improve the accuracy, robustness and efficiency of the proposed model.

REFERENCES

[1] H Fukai, Y Nishie, K Abiko, Y Mitsukura, M Fukumi and M Tanaka, An Age Estimation System on the AIBO, *International Conference on Control, Automation and Systems*, **2008,** 2551-2554.
[2] X Geng, Z Zhou and KS Miles, Automatic Age Estimation Based on Facial Aging Patterns, *IEEE Transaction on Pattern Analysis and Machine Intelligence*, **2007,** 29(12), 2234-2240.
[3] X Geng, KS Miles and Z Zhou, Facial Age Estimation by Nonlinear Aging Pattern Subspace, *16thACM International Conference on Multimedia*, **2008,** 721-724.
[4] W Horng, C Lee and C Chen, Classification of Age Groups Based on Facial Features, *Journal of Science and Engineering*, **2001**,4(3), 183-192.
[5] WL Chao, JZ Liu and JJ Ding, Facial Age Estimation Based on Label-Sensitive Learning and Age Oriented Regression, *Pattern Recognition*, **2013,** 46(3), 628-641.
[6] SE Choi, YJ Lee, SJ Lee, KR Park and J Kim, Age Estimation using a Hierarchical Classifier Based on Global and Local Facial Features, *Pattern Recognition*, **2011**,44(6), 1262-1281.
[7] S Thakur and L Verma, Identification of Face Age Range Group using Neural Network, *International Journal of Emerging Technology and Advanced Engineering*, **2012,** 2(5), 250-254.
[8] MZ Lazarus, K Srilakshmi and VM Sandeep, Age Classification: Based On Wrinkle Analysis, *International Journal on Recent and Innovation Trends in Computing and Communication*, **2013**,1(3), 119-124.

[9] E Gose, R Johnsonbaugh and S Jost, *Pattern Recognition and Image Analysis*, 1st Edn, Prentice Hall, Upper Saddle River, New Jersey, **1996**.
[10] S Gutta and HWecheler, Gender and Ethnic Classification of Human Faces using Hybrid Classifiers, *International Joint Conference on Neural Networks*, **1999**, 6, 4084-4089.
[11] S Mandal, G Saha and RK Pal, A Comparative Study on Disease Classification Using Different Soft Computing Techniques, *The SIJ Transactions on Computer Science Engineering & its Applications*, **2014**,2(3), 59-66.
[12] J Han and M Kamber, *Data Mining; Concepts and Techniques*, Morgan Kaufmann Publishers, **2000**.
[13] JE Dayhoff, *Neural-Network Architectures: An Introduction*, 1st Edn Van Nostrand Reinhold Publishers, New York,**1990.**
[14] S Mandal and I Banerjee, Cancer Classification Using Neural Network, *International Journal of Emerging Engineering Research and Technology*, **2015,** 3(7), 172-178.
[15] S Mandal, G Saha and RK Pal, Neural Network Training Using Firefly Algorithm, *Global Journal on Advancement in Engineering and Science*, **2015,** 1(1), 7-11.
[16] F Esposito, D Malerba and G Semeraro, A Comparative Analysis of Methods for Pruning Decision Trees, *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **1997**, 19(5),476–491.
[17] WN Haizan, W Mohamed, M Najib, M Salleh and AH Omar, A Comparative Study of Reduced Error Pruning Method in Decision Tree Algorithms, *International Conference on Control System, Computing and Engineering*, **2012**,23- 25.
[18] SS Mandal, G Saha and RK Pal, An Approach towards Automated Disease Diagnosis & Drug Design Using Hybrid Rough-Decision Tree from Microarray Dataset, *Journal of Computer Science and System Biology*,**2013**,6(6), 337-343.
[19] S Mandal, G Saha and RK Pal, Reconstruction of Dominant Gene Regulatory Network from Microarray Data Using Rough Set and Bayesian Approach, *Journal of Computer Science & Systems Biology*, **2013**, 6(5), 262-270.
[20] N Friedman and M Goldszmidt, Learning Bayesian Networks with Local Structure, Kluwer Academic Publisher, **1998**.
[21] N Friedman, M Linial, I Nachman and D Pe'er, Using Bayesian Network to Analyze Expression Data, *Journal of Computational Biology*, **2000**, 7(3-4), 601-620.
[22] M Rocha, P Cortez and J Neves, Evolution of Neural Networks for Classification and Regression, *Neurocomputing*, **2007**,70(16-18), 2809-2816.
[23] D Svozil, VK. Eka and J Pospichal, Introduction to Multi-Layer Feed-Forward Neural Networks, *Chemometrics and Intelligent Laboratory Systems*, **1997**, 39(1), 43-62.
[24] S Mandal, C Debnath and L Kumari, Automated Age Prediction using Wrinkles Features of Facial Images and Neural Network, *International Journal of Emerging Engineering Research and Technology*, **2017**, 5(2), 12-20.
[25] S Jain, SS Jain and GV Jain, Artificial Neural Network Based Development of Pavement Depreciation Models for Urban Roads, European *Journal of Advances in Engineering and Technology*, **2017**, 4 (5), 343-351.