Automated Age Group Classification Using Facial Characteristics

Rajiv Saini, Deepak Malik, Pratibha Thakur, Amanpreet Kaur, Kavita Sharma & Sahil Mehta
*ÿPanjab University, Chandigarh, India

ABSTRACT

Most of the facial features recognition, say for an example, character, gender and expression has been broadly envisioned. Programmed age assessment and prediction of future expressions have once in a while been examined. With the increase in age of human beings, we can see some gradual changes in their facial features. This paper aims to give a procedure to gauge age gathering that makes use of facial features. This procedure takes account of three stages: 1. Location, 2. Feature Extraction and 3. Classification. The geometric components of face pictures such as face edge, wrinkle topography, left eye to right eye separation, eye to nose separation, eye to jaw separation and eye to lip separation are calculated. By considering the surface and shape data, age grouping is done making use of K-Means bunching calculation. Age features are further ordered progressively based on the gathered data making use of K-Means bunching calculation. The acquired results are pretty vast and efficient. This paper can further be utilized for anticipating future confronts, arranging gender orientation, and expression recognition from images of the various faces.

KEYWORDS: Age estimation, eyeball recognition, face detection, wrinkle features.

INTRODUCTION

Facial features of respective faces can be used to identify individuals. The study of features of a face is known as "FACE RECOGNITION", which is one of the important biometric methods used in the current scenario. As compared to conventional authentication strategies, Biometric methods are considered as highly significant and advantageous, because biometric features are unique individual to individual. This issue of individual verification and identification is a vast area for researchers. Commonly utilized validation strategies involve face, voice, fingerprint, ear, iris and retina and research in those areas are going on from over the last two decades. Conventionally, face recognition is used especially for the resolution of identification in several areas. It is also utilized for identifying several reports like land enrollment, travel papers, driver's licenses and finding out any person within a security range. Pictures capturing facial features are progressively used for verification in high safety zone applications. As the age of an individual increases it results in the change of facial features, so the database needs to be upgraded as per these changes and to update the database is a challenging task. So our aim is to address the problem of facial ageing and to develop a mechanism that will identify any person with an accuracy of 100%. This paper aims successful age bunch estimation by utilizing facial components such as surface and shape from the image of the persons face.

For efficient results, computation of geometric elements of facial picture like wrinkle geology, face point, left to right eye separation, eye to nose separation, eye to jaw separation and eye to lip separation is performed. For the composition and shape data, classification of age has been done by making use of K- Means clustering algorithm. Age extents are organized progressively based on the gathered data utilizing K- Means clustering algorithm [1]. For quite a long time, human facial image processing is one of the vibrant and intriguing exploration issues. As human faces give a considerable amount of data, numerous themes have drawn heaps of considerations and hence concentrated completely. Majority of them falls under "face recognition" [3]. Few of the research focus on feature faces [4], remaking faces from some of the suggested features [5], collaborating the gender orientation, races, and expressions from facial images [6], and so on. Also, not that many studies have been done on age classification till now. Kwon and Lobo [8] initially started researching on the age classification issue. They talk about the craniofacial research, dramatic cosmetics, plastic surgery, and discernment to find out the actual elements that changes as age increases. They divided gray scale facial pictures to three age groups i.e. babies, young adults and senior adults. In the beginning, they connected deformable formats [9] and also snakes [7] to find out the essential elements, (like eyes, nose, mouth and so on) from a facial image, and based on that judged if it is a baby or adult by finding out the distance between these components.

Initially, they made use of snakes to find out wrinkles on particular areas of the face in order to break down the facial image so as to decide the category like young or old. Known and Lobo declared that their results were promising and efficient. Their information set was having just 47 images, and the results that identified the images as baby was beneath 68%. Moreover, the routines they utilized for this area, i.e. deformable layouts and snakes, are computationally extravagant, but the framework won't be suitable for ongoing research.

LITERATURE SURVEY

Traditional face recognition incorporates various methods like Eigen face or principal component analysis (PCA), fisher face or linear discriminate analysis (LDA) in [10], [11]. These strategies extricate facial features from an image and after utilizing them look as a part of the face database for pictures with coordinating elements. Skin composition examination strategy [3], [4] utilizes the visual subtle elements of the skin, as caught in standard computerized or filtered images, and turns the remarkable lines, details and spots evident in a man's skin into a scientific space. There are two fundamental reasons for studying ageing effects in human computer interaction: (1) automatically estimating age for face image, and (2) Automatic age progression for face recognition. A framework has been produced to characterize face pictures into one of the three age bunches: babies, youthful grown-ups and senior grown-ups in [5]. In this paper, key historic points were mined from face pictures and separations between those milestones are calculated. At that point, proportions of those separations were utilized to characterize face pictures as that of new born children or grown-ups. This paper likewise proposes a strategy for wrinkle recognition in predetermined in face pictures to further arrange grown-up images into youthful grown-ups and senior grown-ups. The primary genuine human age estimation hypothesis was proposed in [15], [16]. Those utilized a ageing function (quadratic function) taking into account a parametric model of face pictures and performed undertakings, for instance, programmed age estimation, face recognition, crosswise over age progression. 3-D method utilizes 3-D sensors to catch data about the state of a face in [17], [18]. This data is then used to recognize particular elements on the surface of a face, for instance, the eyes shape attachments, nose and jaw. This system is strong to change in lighting and survey edges. [19], [20] added to a Bayesian age contrast classifier that characterizes face images of people in light of age contrasts and performs face check crosswise over age progression. Those utilized direction change and distortion of nearby facial element points of interest. Be that as it may, males and females may have diverse face maturing patterns relying upon nature impacts. The AGES (Aging example Sub-space) technique for programmed age estimation is proposed in [21]. It demonstrates the maturing pattern in a 2D sub-space and after that for a concealed face image to develop the face and calculate the age. A 3D maturing displaying system which consequently creates some missing pictures in diverse age gatherings is proposed in [13]. Feature extraction based face recognition, age orientation, and age order is proposed in [23],[24],[25], [26] recommended that the frontal face perspective create an isosceles triangle joining the two eyes and mouth. This isosceles triangle is very helpful for face recognition and estimation of age range. The face triangle is unique for each and every individual and this face triangle can be utilized for face recognition with age. In order to estimate the age facial global features, Active Appearance Model (AAM) is applied. The AAM is a generative parametric model that contains both the shape and appearance of a human face, which it demonstrates utilizing the principal component analysis (PCA), and has the capacity to create different occurrences utilizing just a little number of parameters. In this way, an AAM has been broadly utilized for displaying face and facial element point extraction. AAM, which is the expansion of Active Shape Model, discovers the component points utilizing the enhanced Least Mean Square method. At that point support vector machine system is made functional to make hyper planes that will go about as the classifiers utilizing the outcome, the individual is named youthful or grown-up. Two separate maturing capacities are produced and used to discover the age as proposed by K. Luu et al. [27] and Choi et al. [32]. The system proposed by K. Ricanek et al. [28] can be considered as the expansion of K. Luu et al. [27], with the special case that Least Angle Regression (LAR) strategy is utilized to build the exactness of discovering the feature points in the image utilizing AAM. In LAR strategy, every one of the coefficients are initially assigned 0. Then from feature point X1, LAR moves persistently towards minimum mean square estimation until it achieves the proficiency. Worldwide elements, for example, separation, point and proportion are additionally considered for order of age gathering. MerveKilinc et.al. [29] Utilize another system for having covered age gatherings and a classifier that consolidates geometric and textural components. The classifier scoring results are added to deliver the assessed age. Relative investigations demonstrate that the best execution is gotten utilizing the combination of local Gabor Binary patterns and geometric elements. From the geometric elements, the cross-proportion is figured out, which is the proportion of separation between the facial elements like nose closures, head, and mouth. The part of geometric qualities of appearances is considered, as portrayed by an arrangement of historic point focuses on the face, in the view of age. The relative changes used to estimate change in the subjects posture. Sub spaces can be distinguished as points on a Grassmann manifold. The twisting of a normal face to a given face is evaluated as a speed vector that changes the normal to a given picture in unit time.at that point Euclidean space regression strategy is made functional. This paper apprehensions with giving a technique to gauge age gatherings utilizing face features. This system depends on the face triangle which has three direction coordinate points between left eyeball, right eyeball and mouth point. The face edge between left eyeball, mouth point and right eyeball appraises the age of a human. On human trial, it functions admirably for human ages from 18 to 60 as talked about by P. Turaga et al. [30] and R. Jana et al. [31].

Choi et al. [32] examines about the age identification utilizing age feature classification joined as a part of request to enhance the general execution. In feature extraction, they talked about local, global and hierarchical features. In nearby elements, for example, wrinkles, skin, hair and geometrical components are extracted utilizing Sobel filter system. In worldwide components AAM technique, Gabor Wavelet transform methods are utilized. Various leveled is the mixture of both the neighborhood and worldwide elements. In the proposed model they utilized Gabor channel to extricate the wrinkles and LBP system for skin identification. This enhances the age estimation execution of neighborhood elements.

C.T. Lin et. Al [33], assessed the age by global face elements taking into account the blend of Gabor wavelets and orthogonal locality preserving projections. The Gabor wavelet transformation is utilized to build effectiveness of SVM development. Hu Han et. Al [34] examined about the face pre-preparing, facial part restriction, feature extraction and hierarchical age estimation. They utilize SVM-BDT (Binary Decision Tree) to achieve age group classification. A different SVM age repressor is prepared to anticipate the final age.

PRELIMINARIES

Under this section, representations, descriptions and methods of digital image processing has been used in this paper is described briefly. For further details in depth, readers can refer to conventional image processing books [3], [4].

Let N be the group of natural numbers, (p,q) representing the three-dimensional coordinates of a digitized image, and R representing the set of positive integers i.e. R= {0,1,…. I-1} that indicates the grey levels. Hence image function can be defined as the mapping

F: N ×N → R

The pixel brightness have the coordinates as (p.q) that can be represented as f (p,q). The center is located at the upper left corner of an image with the x-axis horizontal and the y axis vertical.

Let us suppose, R be a threshold, Bi = {b0, b1} that indicates a pair of binary gray levels. Also B0, b1 ∈ R. the value of applying threshold on an image function f(x,y) at grey level t is a binary image function.

Ft: N ×N → B

Such that fi (p,q) = b0 if f(p,q)<th, and b1 otherwise.

Also the gray level histogram of an image function f (p,q) with grey levels in G is a discrete function.

Hg: R→ N

Such that hg (k) = nk, where k ∈ G, and nk represents the number of pixels in the image with gray level k.

let C = {c0c1,…. cm} be a subset of R, where m<l, ci ∈ R, for i=0,1,…..,m, and cj+1 –cj =1, for j = 0,1,….m-1. That is [c0, cm] is a sub range of [0, l-1].

Range normalization of an image function f (p,q) on C is a mapping

G: N ×N → c

Such that

$$G(p,q) = \frac{f(p,q)-fmin}{fmax-fmin}\text{cm-c0+c0}$$

Where fmax and fmin stands for the minimum gray levels of image function f(x,y).

The horizontal projection of a binary image function is a discrete function

P: N →N

Such that p(y) = ny, where y is an y axis coordinate, and ny is the number of pixels at y axis coordinate y in the binary image with gray level b0.

A smoothing of equally weighted moving average of a horizontal projection p(y) is a transformation

Q: N →N

Such that

$$q(y) = \frac{1}{2R+1}\sum_{i=-R}^{K} p(y+i)$$

Where R>0 is a smoothing range.

The gradient of an image function f (p,q) at coordinates (p,q) is defined as the vector.

s

$$\nabla f(p,q) = \left[\frac{\partial}{\partial x} f(p,q), \frac{\partial}{\partial y} f(p,q)\right]$$

Sobel operators are having this property that they are utilized for approximating the magnitude of the gradient. These masks can be used so as to find out the edges in both the horizontal and vertical directions. The definition of masks is defined below and are convoluted with an image function f (p,q):

−1	−2	−1
0	0	0
1	2	1

−1	0	1
−2	0	2
−1	0	1

Two numbers are attained at every pixel having coordinates (p,q) : s_p indicates the output from the right mask, and s_q from the left mask.

IMPLEMENTATION

Under this section, the implementation strategies used for the age group classification is going to be discussed. Implementation process is comprised of three stages, namely, location, feature extraction and age classification as outlined in figure 1.

In the location phase, we will be using the Viola Jones face detection algorithm. Further this algorithm is divided into three basic steps. These steps involve feature extraction, boosting and multi scale detection. For the purpose of classification, geometric and wrinkle features are utilized in the system. In the second phase i.e. feature extraction phase, two geometric features will be calculated. These geometric features are the ration of separations between eyes, noses, and mouths. For evaluating the degrees of facial wrinkles, it is necessary to describe these three distinctive wrinkle features. Classification is achieved by K-means clustering algorithm.

LOCATION PHASE

Flow chart shown in figure 1 depicts, the input image is made to pass through the location phase. Location phase makes use of the Viola – Jones algorithm which is based on the principle that a sub window is scanned that is capable of recognizing faces over a given input image. The standard image processing methodology is to rescale the input image to a particular size and after that run a fixed size locator through these images. This methodology is somewhat tedious because of figuring the diverse size images. Despite of this, viola jones rescale the indicator rather than the input image and run the finder commonly through the image – every time with an alternative size. Both approaches can be suspected as equally time consuming, but viola jones have contrived a scale invariant finder that requires the same number of computations for variable size of the pictures. This finder is built based on integral image and some straightforward rectangular components reminiscent of Haar wavelets. The next section further elaborates on this locator.

In general, Viola Jones face detection algorithm is categorized into three basic steps. These steps have feature extraction, boosting and multi scale detection. Let us discuss each one of them in depth.

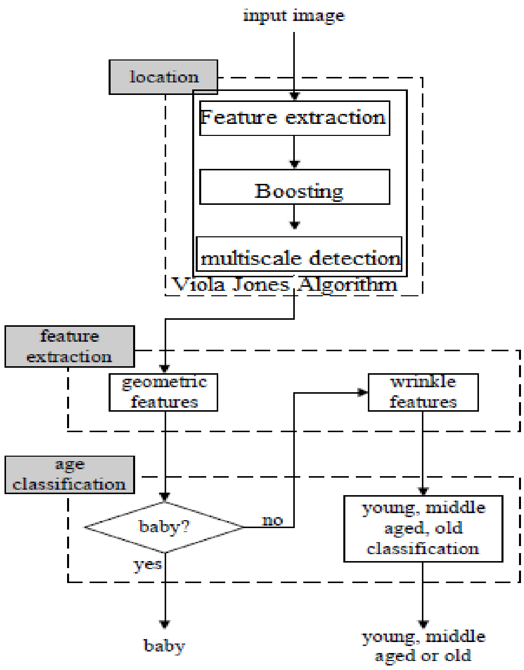

Figure 1. Process of the System

FEATURE EXTRACTION

Surely, feature is extremely important to any entity detection algorithm. For the purpose of face detection, we can utilize a lot of features such as eyes, nose, the topology of eye and nose. While detecting face using Viola Face, an extremely basic and straight feature has been utilized.

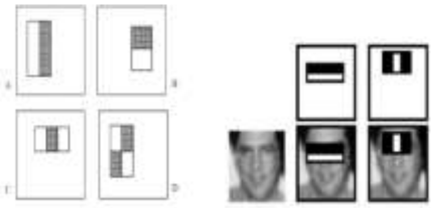

Figure 2. Four basic features in Viola Jones Algorithm

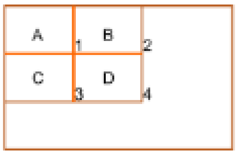

Figure 3. Calculation of Pixel sum within a rectangle

Figure 2 depicts four diverse features calculated using Viola Jones algorithm. Each of them can be achieved by deducing white zone from the black zone. The word ‘zone, reflects the summation of all the gray valued pixels inside the rectangle. One uncommon demonstration that is integral image has been used for the calculation of these features. The sum of the pixel values which are above and to the left side of (x,y) gives rise to integral image of a location (x,y). Figure 3 depicts the quick approach to evaluate the pixel sum inside a rectangle. The figure 2 indicates that the value of integral image at location 1 (V1) is the total sum of pixels in rectangle A; while as the value at location 2 (V2) is the total sum of pixels in rectangle A and B. the value at location 3 (V3) is the sum of pixels in rectangle A and C, while as the value at location 4 (V4) is the sum of pixels in rectangle A,B,C and D. As per this collected information, it is easy to find out the sum of pixels from V4+V3-V2-V1. By making use of this principal, it is easy to get the sum of pixels of any rectangle located at any point.

BOOSTING

Boosting, in Viola Jones face detection algorithm, is the grouping of a numerous powerless classifiers. This boosting process makes the procedure of learning more effective and well organized. In particular the boosting works as follow as:

1. From a given dataset, first take a solitary and straight forward classifier and after that find out the errors it make.
2. The second step is to reweight the dataset and after that provide the data where it made errors.
3. Take the second straight forward classifier into consideration based on the previously weighted dataset.
4. Consolidate the first and the second classifier, reweight the whole data and check where the data make errors.
5. Continue learning unless T classifier is obtained.
6. The last classifier will be the mixture of every one of those T classifiers.

Figure 4 shows point of interest of the guideline of boosting.

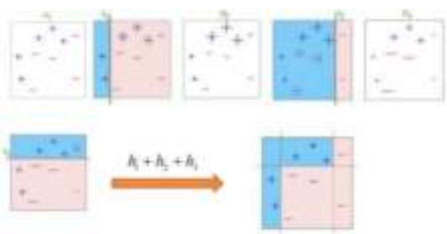

Figure 4. Process of Boosting with 3 simple classifiers

MULTI SCALES DETECTION ALGORITHM

Another step involved in the Viola Jones Face detection algorithm is multi scale detection. Before doing face detection, it is clear that we have no idea with the size of face in an image. Hence, for detecting face of any size, multi scale detection needs to be performed. Learning and testing are based on the rectangle, hence it is necessary to estimate the features for all the different scales.

FEATURE EXTRACTION PHASE

The key issue of any characterization frameworks is to locate an arrangement of reliable features on the basis of classification. As per the investigations of facial representation [9] and emotional cosmetics [12], a lot of changes in the facial features occur as the age keeps on increasing. In this phase, global features in combination with the grid features are extracted from the face images. The global features include the distance between two eye balls, chin to eye, nose tip to eye and eye to lip. These features are estimated as shown in figure 4. In general these features can be classified into two categories i.e. wrinkle features and geometric features. Let us discuss each one of them in detail.

WRINKLE FEATURES

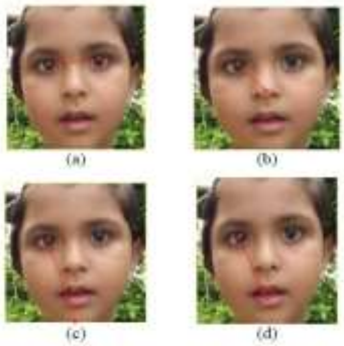

Figure 5.Distance between (a) twoeyeballs (b) eye to nose tip(c) eye to chin (d) eye to lip

By making use of four distance values, there occurs calculation of four features namely F1, F2, F3 and F4 as mentioned below:
F1 = (distance from left to right eye ball) / (distance from eye to nose).
F2 = (distance from left to right eye ball) / (distance from eye to lip).
F3 = (distance from eye to nose) / (distance from eye to chin).
F4 = (distance from eye to nose) / (distance from eye to lip).
F5 can be estimated by making use of the grid features of face image that is completely dependent on the wrinkle geography in face image. The grid features includes forehead portion, eyelid regions, upper portion of cheeks and eye corner regions as shown in figure 3(a).

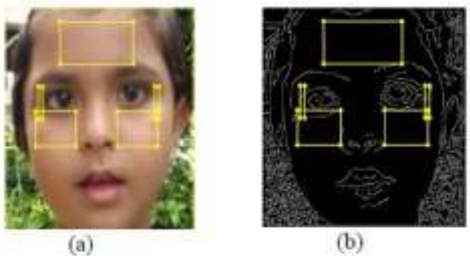

Figure 6. Grid features region of face image (b) canny edges of face image

For the estimation of F5 features, a few steps have to be followed as discussed below:
Transformation of the color face image occurs to the gray scale image. After this, the gray scale face image further undergoes canny edge detection technique. It gives rise to a wrinkle edged binary face image as represented in fig 6(b). The white pixels of the wrinkle regions in Fig. 6(b) give wrinkle information of the face image. It is clear from the figure that while using binary image white pixels are represented by 1 and black pixels are represented by 0. When the density of wrinkles on the face is more, then accordingly the sum of wrinkle area in binary face image is more as shown in figure 7.

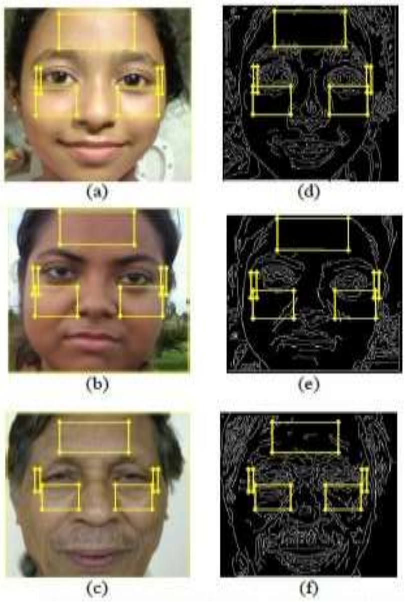

Figure 7. (a)(b)(c)wrinkle region features of face(d)(e)(f)canny edges of respective face

The most important thing of wrinkle features is that it determines the age of a person. Estimation of feature F5 can be done as follows :

F5= (sum of pixels in forehead region / number of pixels in forehead region) + (sum of pixels in left eyelid region / number of pixels in left eyelid region) + (sum of pixels in right eyelid region / number of pixels in right eyelid region) + (sum of pixels in left eye corner region / number of pixels in left eye corner region) + (sum of pixels in right eye corner region / number of pixels in right eye corner region).
Feature F6 can be defined as the angle between the right eyeball, mouth point and left eyeball in face image as shown in figure 7.

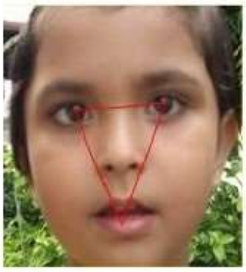

Figure 8. Image of face angle

GEOMETRIC FEATURES

It is clear from above figure 8 that new born babies have a number of wrinkles on their faces as the bone structure in new born ones is not fully grown. Moreover the ration of primary features is highly different from those in other life spans. Hence we can say that geometric features are more reliable to use as compared to wrinkle features when it comes to judging whether an image is of a baby or not.

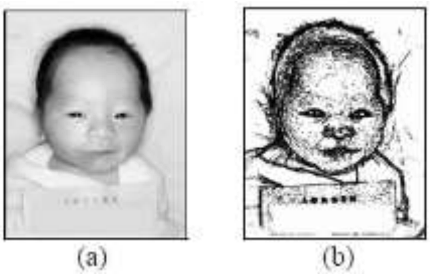

Figure 9. (a)baby(b)result after the sobel operator

In case of infants, the head is near a circle. The distance between two eyes is almost equivalent to the distance from eyes to mouth. As the head bone grows with age, the head becomes oval shaped and accordingly there is a sudden increase in the distance from the eyes to the mouth. Above and beyond the ratio between baby's eyes and noses is equivalent to the distance between noses and mouths which in turn are approximately equal to 1, while in case of adults it is larger than 1, as shown in figure 9(a) and (b).

CLASSIFICATION

Classification makes use of K-means clustering algorithm. The classification of various age ranges is done with dynamism depending on the number of groups. On the basis of six features from F1 to F6, classification of age is done into 2,3 and 4 age range clusters as illustrated in table 1.

Table I: Age group classification using features F1 to F6

No. of group	Group No.	Age Range In years	No. of faces actually in this group	No. of faces falling in this group	Correct percentage
2	1	1-40	27	21	60%
	2	41-80	23	9	
3	1	1-30	22	15	50%
	2	31-45	8	3	
	3	46-80	20	7	
4	1	1-20	22	9	36%
	2	21-40	5	3	
	3	41-50	9	2	
	4	51-80	14	4	

By making use of five features i.e. F1 to F5 classification of age is done into range of 2,3 and 4 age groups as illustrated in table II

Table II: Age group classification using features F1 to F5

No. of group	Group No.	Age Range In years	No. of faces actually in this group	No. of faces falling in this group	Correct percentage
2	1	1-30	29	27	90%
	2	31-80	21	18	
3	1	1-30	17	15	72%
	2	31-50	22	4	
	3	51-80	11	7	
4	1	1-20	14	10	64%
	2	21-30	15	6	
	3	31-50	14	10	
	4	51-80	7	6	

Wrinkle features F5 is utilized for age classification into range of 2,3 and 4 age groups as illustrated in table III.

Table III: Age group classification using features F5 only

No. of group	Group No.	Age Range In years	No. of faces actually in this group	No. of faces falling in this group	Correct percentage
2	1	1-40	34	32	96%
	2	41-80	16	16	
3	1	1-30	29	27	84%
	2	31-45	10	5	
	3	46-80	11	10	
4	1	1-18	14	9	62%
	2	19-40	15	9	
	3	41-80	13	13	
	4	Mixed	8	Mixed	

CONCLUSION

This paper aims to define a strategy for age group estimation altogether. So the proposed system gives a powerful strategy that confirms the age gathering of people from an arrangement of distinctive aged face images. Critical components, for example, separations between different parts of face, study of wrinkle topography and count of face edges are analyzed. Every one of these ways are contrasted to locate the most ideal approach to figure age range of the face images in the database. After watching aftereffects of all features discussed above, face images are bunched into 2, 3, and 4 gatherings utilizing K-Means grouping calculation. It has been detected that wrinkle topography feature i.e., F5 gives the best result to gauge human age range in contrast with different components. The above result drives us to the conclusion that wrinkle topography Analysis has been the best strategy to find human age range of a person.

REFERENCES

[1] Ankit Kumar Soni et. al "Estimation of age groups based on facial features" Applied and Theoretical Computing and Communication Technology (iCATccT), 2015 International Conference on *21 April 2016, IEEE,*
[2] Jana, Ranjan, DebaleenaDatta, and RituparnaSaha. "Age Group Estimation using Face Features." *International Journal of Engineering and Innovative Technology (IJEIT)* 3.2 (2013): 130-134.
[3] Horng, Wen-Bing, Cheng-Ping Lee, and Chun-Wen Chen. "Classification of age groups based on facial features." *Tamkang Journal of Science and Engineering*4.3 (2001): 183-192.
[4] Chellappa, R., Wilson, C. L. and Sirohey, S., "Human and machine recognition of faces: A Survey," *Proc. of the IEEE*, Vol. 83, pp. 705-740 (1995).
[5] Choi, C., "Age change for predicting future faces," *Proc. IEEE Int. Conf. on Fuzzy Systems*, Vol. 3, pp. 1603-1608 (1999)
[6] Shepherd, J. W., "An interactive computer system for retrieving faces," *Aspects of Face Processing*, Ellis, H. D. et al. Eds, MartinusNijhoff International, Dordrecht, The Netherlands, pp. 398-409 (1986).
[7] Gutta, S. and Wecheler, H., "Gender and ethnic classification of human faces using hybrid classifiers," *Proc. Int. Joint Conference on Neural Networks*, Vol. 6, pp. 4084-4089 (1999).
[8] Kass, M., Witkin, A. and Terzopoulos, D., "Snake: active contour models," *Proc. First Int. Conf. on Computer Vision*, London, England, pp. 259-268 (1987).
[9] Kwon, Y. H. and da Vitoria Lobo, N., "Age classification from facial images,"*Proc. IEEE Conf. on Computer Vision and Pattern Recognition*, Seattle, Washington, U. S. A., pp. 762-767 (1994).
[10] Yuille, A. L., Choen, D. S. and Hallinan,*192 Wen-Bing Horng et al.*P. W., "Feature extraction from facesusing deformable templates," Proc.IEEE Conf. on Computer Vision and Pattern Recognition, San Diego,
[11] M. A. Turk and A. P. Pentland, "Eigen faces for recognition", Journal of Cognitive Neuroscience, 3(1): 71–86, 1991.
[12] Sahoolizadeh, Hossein, and YounessAliyariGhassabeh. "Face recognition using eigen-faces, fisher-faces and neural networks." *Cybernetic Intelligent Systems, 2008. CIS 2008. 7th IEEE International Conference on*. IEEE, 2008.
[13] B.D., Zarit, B.J., Super, AND F.K.H. Quek, "Comparison of five color models in skin pixel classification", Int. Workshop on Recognition, Analysis, and Tracking of Faces and Gestures in Real-Time Systems, pages 58-63, Corfu, Greece, Sep. 1999.
[14] R.L., Hsu, M., Abdel-Mottaleb, and A.K.Jain, "Face detection in color images", IEEE Trans. on Pattern Analysis and Machine Intelligence, 24(5):696-706, May 2002.
[15] Y.H.Kwno and N.daVitoria Lobo, "Age Classification from Facial Images", Computer Vision and Image Understanding, vol.74, no.1, pp.1-21, 1999.
[16] A.Lanitis and C.J.Taylor, "Towards Automatic Face Identification Robust to Ageing Variation", IEEE Trans. on Pattern Analysis and Machine Intelligence, vol.24, no.24, p.442-455, 2002.
[17] A.Lanitis, C.Draganova, and C.Christodoulou, "Comparing different classifiers for automatic age estimation", IEEE Trans.Syst.Man, Cybern.B, Cybern, vol34, no.1, pp.621-628, Feb.2004.
[18] V. Blanz and T. Vetter, "Face recognition based on fitting a 3D morphable model", IEEE Transactions on Pattern Analysis and Machine Intelligence, 25(9):1063 –1074, September 2003.
[19] R. Kimmel A. M. Bronstein, M. M. Bronstein, "Three-dimensional face recognition", Intl. Journal of Computer Vision, 64(1):5–30, August 2005.
[20] N.Ramanathan and R. Chellappa, "Face verification across age progression", in Proc. IEEE Conf. Computer Vision and Pattern Recognition, San Diego, CA, 2005, vol.2, pp.462-469.
[21] N.Ramanathan and R. Chellappa, "Modeling Age Progression in young faces", in Proc. IEEE Conf. Computer Vision and Pattern Recognition (CVPR), vol.1, pp.387-394, 2006.

[22] X.Geng, Z.H. Zhou, and K. Smith-Miles, “Automatic age estimation based on facial aging patterns”, IEEE Trans. on Pattern Analysis and Machine Intelligence, vol.29, pp.2234-2240, 2007.
[23] A. K.Jain, “Age Invariant Face Recognition”, IEEE Trans. on Pattern Analysis and Machine Intelligence, 2010
[24] Ramesha K, K B Raja, Venugopal K R, and L M Patnaik, “Feature Extraction based Face Recognition, Gender and Age Classification”, International Journal on Computer Science and Engineering (IJCSE), Vol. 02, No.01S, pp. 14-23, 2010.
[25] Chiunhsiun Lin, Kuo-Chin Fan, “Triangle-based approach to the detection of human face”, Pattern Recognition Journal Society, vol.34, pp.1271-1284, 2001.
[26] R. Jana, H. Pal, A. R. Chowdhury, “Age Group Estimation Using Face Angle”, IOSR Journal of Computer Engineering (IOSRJCE), Volume 7, Issue 5, PP 35-39, Nov-Dec. 2012.
[27] K. Luu, K. Ricanek , T. Bui, and C. Suen. “Age Estimation Using Active Appearance Models and Support Vector Machine Regression”. In IEEE BTAS, 2009.
[28] K.Ricanek, Y. Wang, C. Chen, and S. Simmons. “Generalized Multi-Ethnic Age Estimation. In IEEE BTAS”, 2009.
[29] MerveKilinc, Yusuf SinanAkgul, “Human Age Estimation via Geometric and Textural Features”, 2009.
[30] P. Turaga , S. Biswas and R. Chellappa"The role of geometry in ageestimation",Proc. 2010 IEEE Int. Conf. AcousticsSpeech and Signal Processing (ICASSP),pp.946 -949 2010.
[31] R. Jana, H. Pal, A.R.Chowdhury “Age group Estimation using Face Angle”,IOSR Journal of Computer Engineering, pp. 35-39, 2012.
[32] 32[9] Choi, YounJoo lee, Sung Joo Lee, Kang Ryoung Park, Jaihie Kim, “Age estimation using a hierarchical classifier based on global and local facial features”, ELSEVIER, pp.1262-1281, 2011.
[33] C.T. Lin, D.L. Li, J.H. Lai, M.F. Han, J.Y. Chang, “Automatic Age Estimation System for Face Images”, International Journal of Advanced Robotic Systems, 2012.
[34] Hu Han, Charles Otto and Anil K. Jain “Age Estimation from Face Images: Human vs. Machine Performance”, IAPR International Conference on Biometrics, 2013.