Application of Modified Anthropometric model in Facial Age Estimation

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Abstract - Aging process affects the appearance of people in different ways. One of the changes caused by aging are changes in craniofacial morphology of individuals. Different models of facial aging exist and this paper will apply anthropometric model of facial aging on pictures of 20 people at different ages of their lives to show the similarities between craniofacial morphology of people at the same age. FGNet database that contains two-dimensional faces of people from childhood to adulthood will be used for analysis.

Keywords - Biometrics; Age estimation; Anthropometric model; Craniofacial morphology;

I. INTRODUCTION

There have been many studies related to craniofacial morphology (CM) of individuals. One of these studies was one conducted by Coleman and Grover [1] which refers to changes in the three-dimensional human face geometry during the aging process. Ricanek et al. [2] researched the craniofacial characteristics of aging in terms of building more robust systems for face recognition in biometrics. A study conducted by Gao and Ai [3] refers to the use of Gabor filters and fuzzy LDA method to classify individuals into groups: baby, child, adult and elderly persons.There have been many other studies related to the analysis of CM: Lanitis [4] studied CM in terms of face recognition or authentication of individuals based on facial images. Ramesh et al. [5] proposed a new algorithm for face recognition and classification of people according to sex and age, which gives very good results with a relatively small set of images for learning. Patterson et al. [6] suggest the use of an ageing function based on an Active appearance model that uses the principal component analysis (PCA) method. Olle Pettersson uses the learning vector quantization (LVQ) method for classification of faces regarding age in his Master of Science Thesis [7]. Kwon and Lobo [8] proposed a theory and practical calculations for age classification of facial images in 1994. Their calculations are based on CM of individuals and wrinkle analysis.

The aim of this paper is to analyze the images of both minors and adults, and to demonstrate the similarity in the proportions of the face of different people at the same age.

There are several different models of aging face. Some of those models were recognized by Geng et al. [9] (anthropometric model, active appearance model, aging pattern subspace and appearance feature model). The base for this paper is anthropometric model mentioned earlier. Anthropometric model for facial age estimation was proposed by Kwon and Lobo [8] and is based on geometric ratios of faces.

First step of this research is to define facial landmarks needed for calculation of ratios. After that, Euclidean distances between those landmarks are calculated. Next step is determining ratios important for age estimation. Last step is presentation of research results and encountered problems.

II. ANTHROPOMETRIC MODEL

As mentioned earlier, anthropometric model was proposed by Kwon and Lobo [8] and is based on geometric ratios of human face. These ratios are given in Fig. 1.

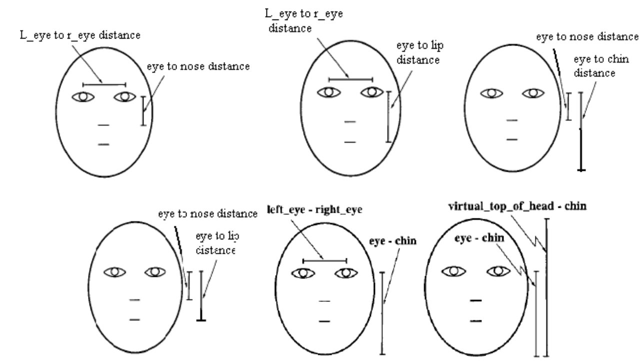

Figure 1. Ratios of human face as defined by anthropometric model [3]

III. FACIAL LANDMARKS

In order to calculate the ratios on human face, important facial landmarks need to be calculated.

Based on previous research, 43 facial landmark points are defined [10]. Five more points were added to these 43 (numbered 44-48 in Fig. 2) that were not recognized by Demayo et al. [10]. These five points are needed for later calculations of ratios. All of these landmark points are shown in Fig. 1.

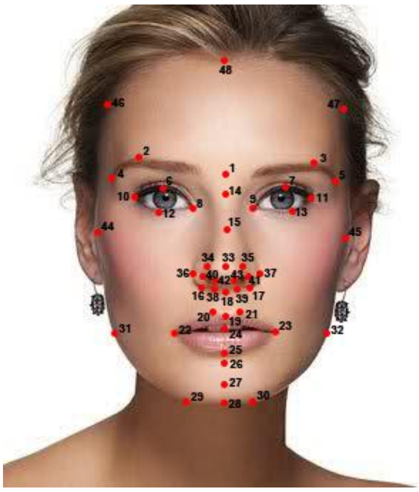

Figure 2. Facial landmark points [9]

TABLE I. FACIAL LANDMARKS AND THEIR ABBREVIATIONS

Landmark No.	Description	Abbreviation
1	Midpoint of the nasofrontal suture	MNS
2	Highest point on the upper margin of the midline portion of the eyebrow (left)	HUMEL
3	Highest point on the upper margin of the midline portion of the eyebrow (right)	HUMER
4	Most lateral point of the eyebrow(left)	LEBL
5	Most lateral point of the eyebrow(right)	LEBR
6	Highest point of the eyelid (left)	HEL
7	Highest point of the eyelid (right)	HER
8	Medial hinge of the eyelid (left)	MEL
9	Medial hinge of the eyelid (right)	MER
10	Lateral hinge of the eyelid (left)	LEL
11	Lateral hinge of the eyelid (right)	LER
12	Lowest point in the middle of the margin of the lower eyelid (left)	LMLEL
13	Lowest point in the middle of the margin of the lower eyelid (right)	LMLER
14	The deepest point of the nasofrontal angle	DNA
15	Nose bridge	NB
16	Most lateral point of the nose (left)	LNL
17	Most lateral point of the nose (right)	LNR
18	Most inner point between the nose tip and the upper lip	INTUL
19	The midpoint of the vermilion border of the upper lip	MVUL
20	Highest point of the upper lip (left)	HULL
21	Highest point of the upper lip (right)	HULR
22	Most lateral point where the upper and lower lip meet (left)	LULML
23	Most lateral point where the upper and lower lip meet (right)	LULMR
24	Midline point where the upper and lower lip meet	MULLM
25	Midpoint of the lower margin of the lower lip	MLLL
26	Midpoint of the pogonion and lower lip	MPLL
27	Most anterior point of the chin	AC
28	Lowest point in the midline on the lower border of the chin	LMLC
29	Protrusion of the mental tubercle (left)	PMTL
30	Protrusion of the mental tubercle (right)	PMTR
31	Most lateral point at the angle of the mandible (left)	LAML
32	Most lateral point at the angle of the mandible (right)	LAMR
33	Most protruded point of the nasal tip	PNT
34	Medial point of the nasal ala outer margin (left)	MNAOL
35	Medial point of the nasal ala outer margin (right)	MANOR
36	Most lateral point on the nasal ala (left)	LNAL
37	Most lateral point on the nasal ala (right)	LNAR
38	Lowest lateral point of the nasal ala inner margin(left)	LNAIL
39	Lowest lateral point of the nasal ala inner margin(right)	LNAIR
40	Highest point of the nasal ala inner margin (left)	HNAIL
41	Highest point of the nasal ala inner margin (right)	HNAIR
42	Medial point of the nasal ala inner margin (left)	MNAIL
43	Medial point of the nasal ala inner margin (right)	MNAIR
44	Most portruded point of the head (left)	PHL
45	Most portruded point of the head (right)	PHR
46	Middle point of the forhead (left)	MFL
47	Middle point of the forhead (right)	MFR
48	Highest point of the head	HH

Since all of these points are not necessary for calculation of ratios defined by anthropometric model and added ratios [9], purified characteristic points are shown in Fig. 3 and table II. These characteristic points were defined by Farkas [11].

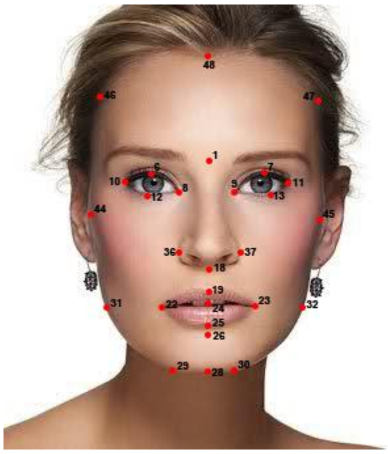

Figure 3. Purified facial landmark points[11]

TABLE II. FACIAL LANDMARKS AND THEIR ABBREVIATIONS

Landmark No.	Description	Abbreviation
1	Midpoint of the nasofrontal suture	MNS
6	Highest point of the eyelid (left)	HEL
7	Highest point of the eyelid (right)	HER
8	Medial hinge of the eyelid (left)	MEL
9	Medial hinge of the eyelid (right)	MER
10	Lateral hinge of the eyelid (left)	LEL
11	Lateral hinge of the eyelid (right)	LER
12	Lowest point in the middle of the margin of the lower eyelid (left)	LMLEL
13	Lowest point in the middle of the margin of the lower eyelid (right)	LMLER
18	Most inner point between the nose tip and the upper lip	INTUL
19	The midpoint of the vermilion border of	MVUL

	the upper lip	
22	Most lateral point where the upper and lower lip meet (left)	LULML
23	Most lateral point where the upper and lower lip meet (right)	LULMR
24	Midline point where the upper and lower lip meet	MULLM
25	Midpoint of the lower margin of the lower lip	MLLL
26	Midpoint of the pogonion and lower lip	MPLL
28	Lowest point in the midline on the lower border of the chin	LMLC
29	Protrusion of the mental tubercle (left)	PMTL
30	Protrusion of the mental tubercle (right)	PMTR
31	Most lateral point at the angle of the mandible (left)	LAML
32	Most lateral point at the angle of the mandible (right)	LAMR
36	Most lateral point on the nasal ala (left)	LNAL
37	Most lateral point on the nasal ala (right)	LNAR
44	Most portruded point of the head (left)	PHL
45	Most portruded point of the head (right)	PHR
46	Middle point of the forhead (left)	MFL
47	Middle point of the forhead (right)	MFR
48	Highest point of the head	HH

After defining landmark points, image analysis (FGnet face database [12]) of 20 randomly selected people at different ages of their lives is made. For this purpose, a script that takes images as input, and gives the position of manually selected landmark points as output, is made. After that, all possible distances between these points are calculated. Distance is calculated using the formula for the Euclidean distance (1).

If A and B are points in two-dimensional space with coordinates (x_1,y_1) and (x_2,y_2) respectively, Euclidean distance between those two points is defined by

$$d(A,B) = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}. \quad (1)$$

IV. Ratios of Human face

Essential ratios were defined by anthropometric model and are presented in section II of this paper. Besides the six ratios defined by anthropometric model, six additional ratios are introduced. These six additional ratios are defined based on previous research on craniofacial growth [1],[2],[4],[8],[9].

Anthropometric model ratios:

Ratio 1: d(HEL,HER)/(d(LER,INTUL)

Ratio 2: d(HEL,HER)/(d(LER,MVUL)

Ratio 3: d(LER,INTUL)/(d(LER,LMLC)

Ratio 4: d(LER,INTUL)/(d(LER,MVUL)

Ratio 5: d(HEL,HER)/(d(LER,LMLC)

Ratio 6: d(LER,LMLC)/(d(HH,LMLC)

Additional ratios:

Added 1: d(PHL,PHR)/d(HH,LMLC)

Added 2: d(LAML,LAMR)/d(HH,LMLC)

Added 3: d(INTUL,MVUL)/d(MNS,MVUL)

Added 4: d(HH,MNS)/d(HH,LMLC)

Added 5: d(MEL,MER)/d(MNS,INTUL)

Added 6: d(LULML,LULMR)/d(LAML,LAMR)

V. Results

Results of this research show that there indeed are similarities in human face ratios in people of the same age which were measured. Values of Ratio 6 for example are in range from 0,594572886 to 0,623155133. To show these similarities, Fig. 4 and Fig. 5 are given. It is visible that ratio d(LER,LMLC)/(d(HH,LMLC) is almost the same for measured people of the same age. Also, values of ratios Added 4 (d(MEL,MER)/d(MNS,INTUL)) and Added 6 (d(LULML,LULMR)/d(LAML,LAMR)) are close together. Based on this research, ratios which best represent age of these six people are Ratio 6, Added 4 and Added 6. Results cannot be applied to the whole human population because of the small sample used.

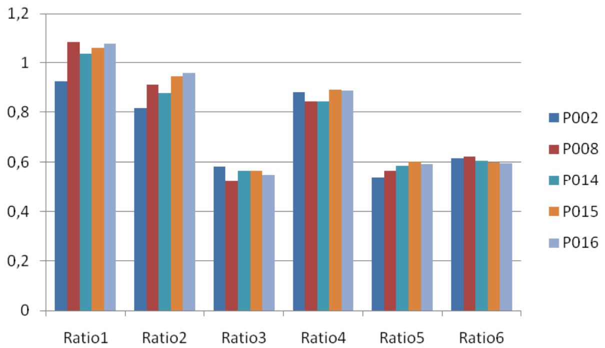

Figure 4. Corresponding anthropometric ratios of five different people (P002, P008, P014, P015, P016) at the same age

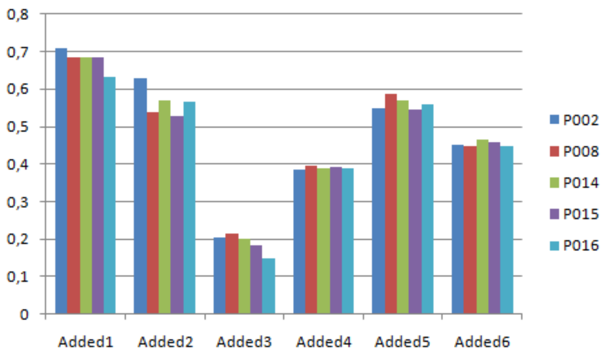

Figure 5. Corresponding aditional ratios of five different people (P002, P008, P014, P015, P016) at the same age

VI. Conclusion

According to the results of this preliminary research, there are similarities in CM of individuals of the same age. But there are some problems which are identified in this study. One problem is the lack of quality images, and since the research involves minors, there is a problem of collecting photographs of minors. Also, since the landmark points of the face are manually determined, there is the possibility of error.

Future research shall investigate options of defining the age groups to which a person belongs to based on the middle part of the person's face (the upper point of the eyebrows to the bottom of the lip) and will focus on age estimation based on facial images of children and young adults to better investigate differences in the structure of the face of babies, children, teenagers and young adults. Also, further research will include a larger sample, and will automatically determine landmark points. In addition, by using pattern recognition and clustering, based on data obtained in this study, groups for classification will be determined.

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REFERENCES

[1] Sydney R. Coleman, Rajiv Grover, “The anatomy of the aging face: volume loss and changes in 3-Dimensional topography”, Aesthetic surgery journal, January/February 2006

[2] Karl Ricanek Jr et al., “Craniofacial aging”, Wiley Handbook of Science and Technology for Homeland Security, 2008

[3] Feng Gao, Haizhou Ai, “Face age classification on consumer images with gabor feature and fuzzy LDA method”

[4] Andreas Lanitis, “Facial biometric templates and aging:problems and challenges for artificial intelligence”, AIAI-2009

[5] Ramesha K et al., “Feature extraction based face recognition, gender and age classification”, International Journal on Computer Science and Engineering, Vol. 02, No.01S, 2010, 14-23

[6] Patterson et al., “Automatic representation of adult aging in facial images”, 2006

[7] Pettersson Olle, “Implementing LVQ for age classification”, Master of Science Thesis, 2007

[8] Young H. Kwon, Niels da Vitoria Lobo, “Age classification from facial images”,Computer Vision and Image Understanding, Vol. 74, No. 1, April, pp. 1–21, 1999

[9] Geng Xin, Fu Yun, Smith-Miles Kate, “Automatic facial age estimation”, Tutorial at PRICAI 2010

[10] C. Demayo, M. Torres, P. Olvis & N. Manlegro, “Face shape differences in selected indigenous peoples’ groups in Mindanao, Philippine”

[11] L. Farkas, "Anthropometry of the head and face", Raven Press, 1994.

[12] http://www.fgnet.rsunit.com/, loaded 01st October, 2010.