A STUDY ON AGE PREDICTION FROM FACIAL IMAGES

Original Research Article

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ABSTRACT

Traditionally age progressed images are used by Medicos – physicians, forensic scientists and cybercrime Investigations. The key applications include the localization of missing children, the development of age-invariant face recognition systems, and automatic update of photographs appearing in smart documents. In most studies involving automatic age-prediction methodologies, authors demonstrate the effectiveness of a method by showing few examples of raw face images and the corresponding age-progressed images. This paper will provoke interest for this particular topic, so that researchers work in the area of age-prediction more cleverly. In general, the area of face image processing will benefit for most of the real-time applications.

I.   INTRODUCTION

People's age remains an important attribute of social interactions. Estimates of age are important because they can be compared with antemortem records or other information to contribute to the identification process or help resolve other medico-legal issues, such as evaluation of age of living individuals in immigration cases. The way we act, the vocabulary we choose, our body attitude in front of someone else depends on his age. These attributes can be related to dress code or body gesture, but they are primarily linked to facial appearance. The research focuses on changes that occur with age on human faces. The human body grows and matures with age, especially in children and adolescents. Therefore, the main idea behind the medical methods is to compare measurements of physical maturity of the body with age. However, due to individual variation in the timing of skeletal and dental development, the results of any method are subject to uncertainty when applied to a single individual. There are also issues related to the relevance and representativeness of the available reference populations. There exist several methods and a fairly substantial literature on the field. This age perception problem taken by a researcher normally involve the following three major objectives:

i.   To describe the facial changes with age,
ii. To explore the incidence of these changes on the perceived age, and
iii. To propose an automatic algorithm for age prediction based on facial images.

The study of age perception / estimation will promote the following factors,
a.   By understanding the contribution of each facial attribute to the overall aging appearance, one can design better procedures for facial rejuvenation.
b.   Understanding how people code and interpret faces is still an open problem in psychology. This work can contribute to better understanding of how signs of aging are read and interpreted.

The study on with facial aging can be categorized in three popular kinds of aging viz.,
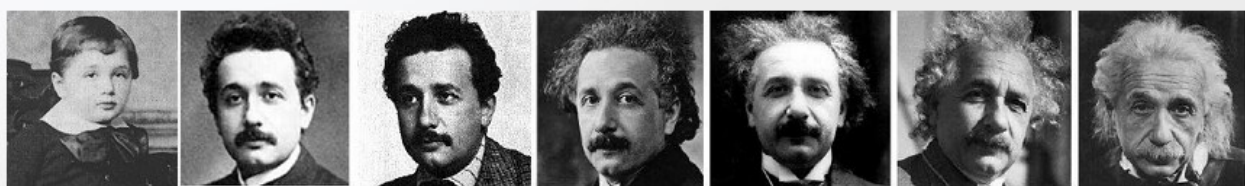a.   Chronological aging, b. Photo aging   and c. Apparent aging.

Fig. 1. Human Aging Process

II.   FACIAL AGING

Facial aging happens due to various reasons. Reason might be genetic, living conditions, life style, food intake gender and many other factors. But, if we consider facial changes, 3 major variables are considered, Shape, Texture and Color.

A. Facial anatomy

a.   Bones :

Bones give the body a framework, maintain its shape, and protect vital organs. They also provide a place for muscles, supporting structures to attach. Bones are also sites for mineral storage and blood cells formation.

b.   Muscles and fat :

Facial muscles and fat are known in the literature as soft tissues. Their distribution smoothes the bones shape and gives the face its identity. The front face is made of more than sixteen major bones muscles that give life to facial expressions and mouth movements (speech and chewing). The results of muscles movements arise on the skin and can lead to permanent wrinkles known as expression wrinkles.

c.   Skin :

The skin is the most voluminous body organ. Its main function is to be a protective barrier that interfaces against hostile environment including microbes and bacteria Facial skin in particular is exposed to many external aggressive factors   such

as sun and atmospheric pollution. Consequently, the facial skin aging will results from both chronological and extrinsic aging. Skin comprises of 3 layers, the outer layer epidermis, middle layer dermis which supports epidermis and inner most subcutaneous tissue made of fat and connective tissues.

i. Skin wrinkles : Wrinkles are folds of the skin frequent on the face of aged people. They are caused by the changes in the thickness of the epidermis and structural transformation in the dermis related to aging. There are three types of wrinkles:

a.   Crinkling-type wrinkles are fine wrinkles that formed from folded skin. They usually   appear in old skin (person more than 75 years old) and may be caused by sun damage on individuals with elastosis.

b.   The glyphic wrinkles have a crisscross pattern and are frequently seen on the cheek and the neck.

c.   The deep wrinkles form long and straight major lines or deep grooves. They Usually appear on the forehead and the crow's feet area.

ii. Skin color : Color is an essential component of physical properties of the skin. Skin color arises from the interactions of light with the epidermis and the dermis. The perceived color also depends on the detector.

B.   *Changes with age*

Several authors have described the overall changes on face with age and the following section describes various effects of aging on face.

a.   Changes on shape

Changes on facial shape with age are related to bones, muscles, fat and skin transformations and are tightly linked to body weight and gravity.

b.   Bone transformation

Many have explored age-related changes of the craniofacial skeleton of a Caucasian population. They performed anthropometric measurements on 160 skulls selected randomly from 1500 specimens. Observed changes in craniofacial morphology included: i. Appreciable reduction of facial height,   ii. Most marked in the maxilla and mandible, strongly correlated with loss of teeth,   iii. Modest increase in facial width, and iv. Modest increase in facial depth, except in those regions associated with tooth loss.

c.   Muscles and fat transformation

With increasing age, a degenerative myopathy of all the body muscles takes place due to the reduction of the number and the size of the muscular fibrous and vascular vessels. This leads to a reduction of about 30% of the muscle mass between 30 and 80 years of age Fat also redistributes making the face looking more concave, with a hill and valley topography.

d.   Skin transformation

Many skin shape transformations are the results of the changes in the deepest skin layers. The resorption of mandibular and maxillary bones and the fat absorption in the cheek and the chin area combined with the lost of the skin elasticity lead to chin ptosis. The nasolabial fold also becomes deeper with age as the combination result of facial movement and fat redistribution.

e.   Changes on texture

Wrinkling is the principal change in skin texture with age. Facial wrinkles are related to two concomitants facts: skin aging and facial expression. Both extrinsic and intrinsic aging lead to transformation in the thickness of the epidermis and the structure of the dermis. Expression wrinkles arise from the repetitive movements of the skin caused by facial expressions.

f.   Changes on color

The age related changes on skin color is caused by the modifications in the distribution of chromophores and by the transformation in the dermis structure. These changes are caused on sun exposed sites by both chronological aging and photo aging.

III.   FACTORS INFLUENCING FACIAL AGING

The major factors influencing facial aging are given in the following section.

a.   Ethnicity

Some studies have been done to understand the similarities and differences in facial attributes as a function of age and ethnicity. It is a difficult task to evaluate the influence of ethnicity comparatively to climatic condition, pollution and lifestyle.

b.   Gender

The main differences between men and women aging is related with the specificity of their hormonal balances.

c.   Environment and lifestyle

Together with the hands, the face is the main exposed body part to environmental factors. Facial appearance is affected by sun exposure and atmospheric pollution but also by long term moods and habits.

IV.   FACIAL CHANGES

The changes on face happen on shape, eyes area and lower face areas (Nasolabial fold, lips and jaw line).

a. Changes on shape

The average change on faces were happen on day-to-day and exposed clearly on each decade, to capture the overall changes in shape. Although small variations such as wrinkles or brown spots have disappeared with the averaging, shape changes are obvious. Therefore, the following can be noticed: i) An increase of the nasolabial fold, ii) A reduction of lips volume, iii) A square shape of the jaw line, iv) A reduction of the size of the eyes, and v) An increase of bags under the eyes.

b.   The eyes area

If the areas around the eyes are notified, then ages reveal the following facts:

    i.   The volume of the bags under the eyes linearly increases with age at least until 74 years old, but the slope of the raise is slow.

    ii.   The opening of the eyes significantly decreases until 40-50 years of age then reach a plateau.

    iii.   The sloping upper the eyelids linearly increase until 60 years of age

c. The Lower face (Nasolabial fold, lips and jaw line)

The changes in lower face are clearly captured. The nasolabial fold becomes deeper with age. The increase particularly accelerates after 50 years of age. There is no significant difference between the groups 30-39 and 40-49 years. The lip thickness slowly decreases with age, and the changes even become smaller after 50 years of age. In average, the changes are statistically visible after 20 years. The changes recorded by clinical grading are confirmed by imaging.

V.   TEXTURE CHANGES

The textural parameters that change the perception of age are wrinkles, skin texture related to pores size and glyphics. Average faces do not capture these changes since they occur at a millimetric scale and cannot be aligned from one subject to another within a group of age.

A.   *Wrinkles*

Changes in the outer skin layer, combined with facial expressions leads to wrinkles which become more numerous and deeper with age. VAS allows quantifying the following changes on facial wrinkles:

    i.   The number and the depth of crow's feet wrinkles linearly increase with age.

    ii.   The crow's feet fine lines increase slower than the crow's feet wrinkle and reach a plateau at 60 years of age. Fine lines tend to increase fast in the early stage (30-40 years) and then after the menopause (50-60 years).

iii. The forehead wrinkles linearly increase with age.

iv. The depth of the frown lines linearly increases with age, each group being significantly different from the previous one.

v. The under eye wrinkles slowly increases with two-plateau regions; the first one around 40 years and the second one above 60 years.

vi. Upper lip wrinkles appear above 40 years and linearly increase with age.

The correlation between facial skin texture (related to pores and glyphics) and age is not significant. The two measured attributes (skin texture and grain of the skin) are not related with age.

VI.   CHANGES IN COLOR

Aged people's skin is described as uneven, yellowish and dull. These perceived changes are mainly related to photo-damage and pollution. The skin color attributes that were clinically measured for this study are:

a. Skin Color:
A youthful skin is pinky while an older one looks yellowish.

b. Color uniformity:
The non-uniformity of skin in younger skin is mainly caused by acne. Older skins are affected by pigmentation disorders leading to spots.

c. Brown spots:
The number and the size of the brown spots should increase with age, as sun damage accumulates with time.

d.   Radiance:
The radiance describes the skin ability to reflect light and is affected by pollution.

e.   Diffuse redness:
The redness around the area diffuses the surrounding region.

f.   Dark circles under the eyes:
The skin under the eyes can be very thin, allowing the blood underneath the skin to become more visible.

VII.   AGE PERCEPTION BIASES

The facial appearance of a person does not always reflect the chronological age. Humans are more accurate at recognizing, remembering and classifying individuals belonging to their own group. Some people look younger or older than they really are. people are having more interactions with others within their own racial, age and gender group and are more trained (and efficient) with these categories of faces.

a. Own-race bias
The own-race bias is known as the capacity for people to better recognize faces from their own race.

b. Own-gender bias
The women have greater accuracy in face recognition than men, and that women could more easily recognize female faces. On the contrary, men did not show any difference in recognizing women's or men's faces. Looking at gender bias in age prediction, it has also been demonstrated that women and men do not estimate age the same way.

C. Own-age bias
Researchers found an own-age bias in the oldest group, meaning that they better recognize oldest people. Others have found that young people better recognize young faces.

Fig. 2. Human Facial Aging Data Samples

VIII.   FACIAL CHANGES DURING GROWTH AND AGING

Geng et al. [14] recognized two stages of facial aging viz., the first phase is the early years, defined as the years from birth to adulthood; At this stage, most of the changes are caused by changes in craniofacial growth and : a. Chin becomes more prominent, b. Cheeks are spread over a larger area, c. Characteristics of the face increase and cover the interstices, d. Forehead falls back, reduces the free space on the surface of the skull. In addition to changes caused by craniofacial growth, minor changes in the skin occur: a. Facial hair become denser and change color, b. Skin color changes. In the second phase of the aging face, is during adulthood.

Adulthood is defined as the time from the end of growth to old age. The main changes in this stage are changes in skin texture. Skin becomes thinner, darker, less elastic and more leathery. Also, wrinkles, under chin, sagging cheeks and lowered bags under the eyes appear. But there is also some small craniofacial growth at this stage, mainly changes in the shape of the face, but most of the craniofacial growth occurs at an early age of the individual.

IX.   FACIAL REPRESENTATION MODELS

The important models for facial representation recognized by most researchers are:

i. Anthropometric Model [AM]

Facial Anthropometry is the science of measuring the size and proportions of the human face [15]. The main idea of this model is to consult research related to craniofacial growth and development. From the craniofacial research theory AM uses a mathematical model for description of a person's head from birth to adulthood. It defines facial anthropometric, as measures taken from the characteristic points of the face taken over years [16]. For age estimation, distances and ratios between characteristic points are commonly used, instead of using a mathematical model, because it is difficult to measure face profile on the two-dimensional face images.

ii. Active Appearance Model [AAM]

The AAM has been expanded to facial aging using an aging function. The function defines the relationship between person's age and facial description parameters. There are different forms of an aging function. Some examples of such functions are: quadratic aging function, linear aging function, cubic aging function and others. It works in a way that takes into consideration not only the geometry of human face, but its texture also.

iii. Aging Pattern Subspace [AGES]

Aging pattern is defined as a sequence of facial image of a person, sorted by time. AGES works in two steps. The first step is a learning step, the second step is the age estimation step. The emphasis of this model is the use of facial images of a person at different ages to define the aging pattern.

iv. Age Manifold [AMF]

This model uses a manifold embedding technique for learning a low-dimensional aging trend for many facial images of the same age. The only requirement of this model is that the sample size for learning is large enough so that embedded manifold can be taught with statistical sufficiency.

v. Hybrid

This model combines one more of the above mentioned models along with state-of-the art techniques used for pattern recognition.

X.   AGE ESTIMATION

In age estimation the person's age can be determined in many ways, based on two-dimensional digital images of human subjects. According to Geng et al., there are four common types of age:

- *Chronological age* is defined as the number of years a person has lived .

- *Appearance age* is the information about age, defined by person's appearance .

- *Perceived age* is defined by other people who define it on the basis of a person's appearance .

- *Estimated age* is the age defined by computer based on persons appearance .

Appearance age is usually very close to the actual or chronological age. The objective of age estimation is that estimated age is as close to appearance age as possible [14].

XI.   CONCLUSION

These guidelines recommend approaches for estimating age depending on the age category. Practitioners of forensic anthropology should implement these guidelines to the fullest extent as applicable, practical, and appropriate. Age estimation involves first assessing physiological age and then attempting to correlate it with chronological age. The developmental or degenerative traits used as age standards undergo sequential chronological change. The final age estimate is a matter of expert judgment by synthesizing all available information. Factors to be considered are: appropriateness of the reference data, skill in using one method over another, condition of the remains, applicability of statistical models, etc. Factors of the environment and life history of the individual can introduce non-age related variation in the expression of degenerative traits and thus represent a potential source of error. Most research suggests that for adults, consulting multiple age indicators provides more accurate results than using single indicators. Age perception variation, of younger individuals can in general be aged more accurately than older individuals. Thus, age increase also prone to the variation produced by environmental factors and life history increases. The final age estimate is a matter of expert judgment with all available information and factors considered for prediction. The researcher who is interested in this domain can utilize the publicly available datasets such as FG-NET, MORPH and for large size MORPH, YGA, LHI, NI's Web Collection and Gallagher's Web Collection Databases for their analysis.

REFERENCES

[1]   Y. Fu, G. Guo, and T. Huang. Age synthesis and estimation via faces: A survey. IEEE Trans. PAMI , 32(11):1955 –1976, Nov. 2010.

[2]   G. Guo and X. Wang. A study on human age estimation under facial expression changes. In Proc. IEEE CVPR, pages 2547–2553, 2012.

[3]   M. C. Voelkle, U. L. N. C. Ebner, and M. Riediger. Let me guess how old you are: Effects of age, gender, and facial expression on perceptions of age. Psychology and Aging, 27(2):265–277, 2012.

[4]   Arumugam P, Selvakumar S and Muthukumar S, Facial Forehead Wrinkles Detection using Colour based Skin Segmentation, Advances in Natural and Applied Sciences, 9(12), Pages: 71-80, August 2015.

[5]   T. Wu, P. Turaga, and R. Chellappa. Age estimation and face verification across aging using landmarks. IEEE Trans. IFS , 7(6):1780 –1788, Dec. 2012.

[6]   C. Otto, H. Han, and A. Jain. How does aging affect facial components? In Proc. ECCV , pages 189–198, 2012.

[7]   M. Rhodes. Age estimation of faces: A review. Applied Cognitive Psychology , 23(1):38 – 59, 1995.

[8]   Black S, Aggrawal A, Payne James J. Age Estimation in the Living: The Practitioner's Guide. Wiley Blackwell, ISBN: 978-0-470-51967-7, 2010.

[9]   Schmeling A, Garamendi PM, Prieto JL, Landa MI. Forensic Age Estimation in Unaccompanied Minors and Young Living Adults. In Forensic Medicine – From Old Problems to New Challenges. Ed: D.N. Vieira, InTech, ISBN: 978-953-307-262-3, 2011.

[10]   P. Thukral, K. Mitra, and R. Chellappa. A hierarchical approach for human age estimation. In Proc. IEEE ICASSP, pages 1529 –1532, 2012.

[11]   V. N. Vapnik. Statistical Learning Theory . John Wiley, NewYork, 1998.

[12]   M. C. Voelkle, U. L. N. C. Ebner, and M. Riediger. Let me guess how old you are: Effects of age, gender, and facial expression on perceptions of age. Psychology and Aging, 27(2):265–277, 2012.

[13]   Arumugam P, Muthukumar S, Selvakumar S and L.Sindhu, Detecting Wrinkles and Sagginess of Skin from Human Face Photographs   Advances in Natural and Applied Sciences, 9(12) August 2015, Pp: 59-64.

[14]   Geng Xin, Fu Yun, Smith-Miles Kate. Automatic Facial Age Estimation, Tutorial at PRICAI, 2010.

[15]   A. Montagu, A Handbook of Anthropometry, 1960.

[16]   L.Farkas. Anthropometry of head and face. Raven Press, 1994.

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