

Age Synthesis and Estimation From Face Image

Ms. Deepali R. gadbail¹, Prof. S.S. Dhande², Prof.Kanchan M. Pimple³

¹Ms. Deepali R Gadbail,
Computer Science and Engineering Department,
Sipna COET,Amravati.
deepaligadbail@email.com

² Prof. S. S. Dhande,
Computer Science and Engineering Department,
Sipna COET,Amravati.

³Prof.Kanchan M. Pimple,
IBSS College of engg. & tech.,Amravati

Abstract: *Human age, as an important personal trait, can be directly inferred by distinct patterns emerging from the facial appearance. Computer-based age synthesis and estimation via faces have become particularly prevalent topics because of their explosively emerging real-world applications, such as forensic art, electronic customer relationship management, security control and surveillance monitoring, biometrics, entertainment, and cosmetology. Age synthesis is defined to rerender a face image aesthetically with natural aging and rejuvenating effects on the individual face. Automatic age-progression is the process of modifying an image showing the face of a person in order to predict his/her future facial appearance. Age estimation is defined to label a face image automatically with the exact age (year) or the age group (year range) of the individual face. During growth, aging is affected in two main forms, one is the size and shape variation and the other is the textural variation. In this paper, we use the textural variation of the face during the growth, which appear more in the adulthood in the form of wrinkles.*

Keywords: Face aging, age estimation, age synthesis, age progression, geometry features.

I. INTRODUCTION

As a “window to the soul” [1], the human face conveys important perceptible information related to individual traits. The human traits displayed by facial attributes, such as personal identity, facial expression, gender, age, ethnic origin, and pose, have attracted much attention in the last several decades from both industry and academia since face image processing techniques yield extensive applications in graphics and computer vision fields [2], [3], [4].

There are two fundamental problems inspiring the development of these techniques.

. Face image synthesis: Render face images with customized single or mixed facial attributes (identity, expression, gender, age, ethnicity, pose, etc.).

. Face image analysis: Interpret face images in terms of facial attributes (identity, expression, gender, age, ethnicity, pose, etc.).

Especially, the forensic artist [7] can imagine and make realistic age progression pictures in terms of photos or semantic description of given faces. Well-trained Swedish alcohol salespeople have professional skills for accurate age estimation with low bias. Age of face has also been considered as an important semantic or contextual cue in social networks [2], [7]. Can a machine perform the same as a human? Technology advances in computer science and engineering have given a positive answer to this question. There are two basic tasks in

this field, computer-based age synthesis and estimation, that are described as follows:

- Age synthesis: Rerender a face image aesthetically with natural aging and rejuvenating effects on the individual face.
- Age estimation: Label a face image automatically with the exact age (year) or the age group (year range) of the individual face.

As our aim is to determine the age of a person, we can concentrate on the features that can be extracted for age estimation. As we all know, age of a person affect his face in two main forms. One is the Geometrical Feature Variation where the size and shape of the face changes as he grows. If we use this information of the face, we can see that this change is gradual and most of the size variation stops at certain age. Even worse condition occurs in some case where the facial size gradually decreases when he reaches the old age. So using this method of Geometrical Feature Variation is challenging. But of course, this method can be used to classify the age broadly into three main classifications like baby, youth and adult. Age-progression is the process of deforming the facial appearance of a subject shown in an image, in order to predict how the face of the person will look like in the future. The ability to produce

accurate age-progressed images is important in a number of key applications including the localization of missing children, the development of age-invariant face recognition systems, and automatic update of photographs appearing in smart documents (i.e., smart id cards).

II. EXISTING METHOD

In [6], authors proposed a new framework for face-image-based automatic age estimation. A manifold learning method was introduced for learning the low-dimensional age manifold. The Support Vector Machine and Support Vector Regression methods were investigated for age prediction based on the learned manifolds. To improve the age estimation performance and robustness, a Locally Adjusted Robust Regressor (LARR) was also designed. Anil Kumar Sao and B. Yegnannarayna [8] proposed analytic phase based representation for face recognition to address the issue of illumination variation using trigonometric functions. To decide the weights to the projected coefficients in template matching, eigen values were used. Authors in [7] combined the local and holistic facial features for determining the age. They used combined features that roughly classify a face as young (0-20) or adult (21-69). In most of the previous studies the age groups are not arranged properly. Another related work in the age estimation selects discriminative features to estimate face age. Primary studies on age estimation coarsely divided human faces into groups based on facial landmarks and wrinkles. Most recent approaches considered the continuous and temporal property of face age and formulated age estimation as a regression problem. Researchers explored different features, including AAM coefficients, image intensities features designed heuristically, and adopted various regression methods, such as quadratic function, piecewise linear regression, multiperceptron projection, etc. differently from the above mentioned methods. Geng [9] defined an aging sequence as an aging pattern and estimated age by projecting a face instance onto appropriate position of a proper pattern.

Boissieux et al. [10] generate typical wrinkle prototypes for different groups of faces. For example, they generate wrinkle prototypes for males and females with different expressions. Based on biochemical data, they define the relationship between age and wrinkle strength so that it is possible to define the strength of wrinkles to be added on faces according to the target age. Given a face to be age-progressed, the most appropriate wrinkle prototype is chosen so that a given face is age-progressed by adding wrinkles of appropriate strength from the optimum wrinkle prototype. Leta et al. [11, 12] establish the correlation of 26 facial distance measurements with age so that it is possible to predict how the 26 distance measurements are modified, as a person grows older. Image warping techniques are used for modifying the shape of a face in order to inflict age-related shape deformations specified by the modification of the 26 distance measurements. Lanitis et al. [17] propose a model-based age-progression methodology. In this context, parametric functions that relate the model-based representation of faces and ages are established and used as the basis for implementing age estimation and age-progression. Because the parametric representation of faces discards high-frequency information, this approach is not ideal for generating high-resolution age-progressed images. This approach is more appropriate for modeling distinct age-related facial transformations like shape variations and major texture variation. A number of researchers also describe methods based

on aging functions defined either in relation with 2D faces [13, 14] or 3D faces [15, 16].

III. AGE SYNTHESIS

Age synthesis, also called age progression, is often implemented by first building a generic face model. Face modeling has been prevalent for a long time in both the computer graphics and computer vision fields.

Age Synthesis using aging functions:

In propose a model-based age-progression algorithm that uses aging functions for modeling aging variation within a training set. During the training phase, they generate a statistical appearance face model that describes the major sources of variability within the training set. During the process, each face shape in the training set is represented by the coordinates of 68 landmarks. All training shapes are aligned and the mean shape among the training set is established. Image warping is used for warping training faces to the mean shape so that the shape-normalized texture from each face is extracted.

A statistical appearance face model is generated by applying principal component analysis on training shapes and shape-normalized face intensities. Since all training faces are warped to the same shape, information related to the absolute scale of training faces is discarded. Although scaling is an important aspect in age-progression, the use of scale information requires prior knowledge regarding the scale of faces in the training and test images—such information is usually not available in images encountered in most face image processing applications. One of the most important features of PCA-based face models is the ability to represent faces using a small number of model parameters. The coding achieved based on this methodology is reversible enabling the reconstruction of new faces once the values of model parameters are fixed. More details related to the training and use of statistical models of this type are presented elsewhere. It convert all training samples into the low dimensional model-based representation and define a polynomial function (the so-called aging function) that relates the model-based representation of each subject to the actual age;

$$\text{age} = f(\mathbf{X}),$$

Where \mathbf{X} is a vector of model parameters and f is the aging function. Once an aging function is established, it can be used for estimating the age of faces in images and also for generating typical images showing a face at desired age. Fig. 1 shows synthetic faces at different ages produced by using an aging function trained using images from the FGNET Aging database.



Fig. 1: Images showing synthetic faces at ages between 0–50 years

IV. AGE ESTIMATION

Age estimation is the determination of person's age based on biometric features. Although age estimation can be accomplished using different biometric traits, this thesis is focused on facial age classification that relies on biometric features extracted from a person's face. Age estimation will be more accurate when shape and skin features are taken into consideration. The basis of this thesis is a statistical analysis of

facial features in order to classify the facial images according to corresponding age intervals.

Ratio Analysis:

The primary facial features are located to compute the ratios for age classification. Four ratios are calculated for facial face database comprising young aged, middle aged and old aged adults. Age estimation classified ages from facial images into 3 age groups as babies, young adults and senior adults. We cranio-facial development theory and skin wrinkle analysis. Using the primary features of the human face such as eyes, nose, mouth, chin and virtual top of the head; mainly 6 different ratios are calculated to distinguish babies from young adults and senior adults. The secondary feature analysis with a wrinkle geography map to detect and measure wrinkles to distinguish seniors from babies and young adults. Finally, combined ratios and wrinkle information obtained from facial images to classify faces into 3 age groups. In babyhood, the head is near a circle. The distance from eyes to mouth is close to that between two eyes. With the growth of the head bone, the head becomes oval, and the distance from the eyes to the mouth becomes longer. Besides, the ratio of the distance between babies' eyes and noses and that between noses and mouths is close to one, while that of adults' is larger than one *Algorithm Using Ratio Analysis*

The algorithm is as follows:

Step 1: Locating the primary features is very important step in extraction of features, and it can be automatically or manually. Automatically located the primary features. First of all central horizontal line of the image is found, then they found the eyes location, and finally nose and mouth location is found.

Step 2: Find the distance between the primary features.

Step 3: Find the ratios as follows

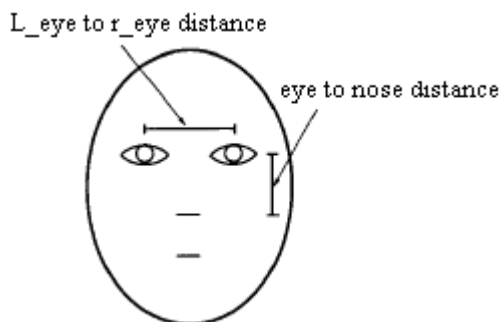


Fig. 2: Ratio 1

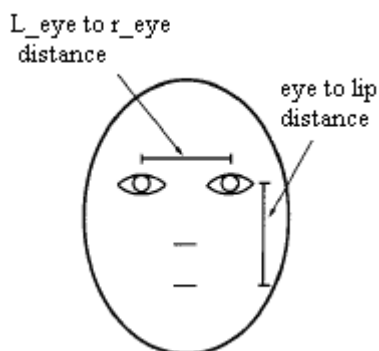


Fig. 3: Ratio2

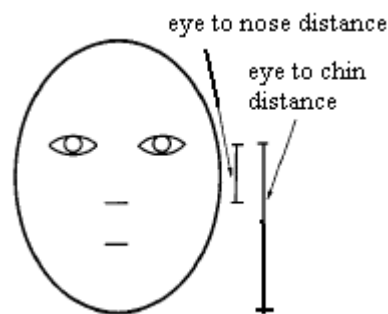


Fig. 4: Ratio 3

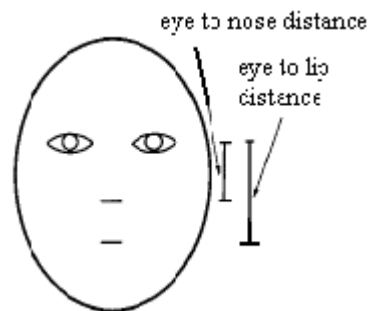


Fig. 5: Ratio 4

The first geometric feature is defined as The first geometric feature is defined as

$$R_{em} = \frac{D_{em}}{D_{ee}}$$

where D_{em} is the distance between the eyes and the mouth, and D_{ee} is the distance between two eyes' iris. R_{em} in babies smaller than R_{em} in adults, because the baby's faces is near a circle so R_{em} in adults becomes larger.

Second geometric feature is

$$R_{enm} = \frac{D_{en}}{D_{nm}}$$

where D_{en} is the distance between the eyes and the nose, and D_{nm} is the distance between the nose and the mouth. The distance between the eyes and the nose of a baby is smaller than the distance between the eyes and the nose of an adult, so the value of R_{enm} becomes larger in adult faces. The values of these two ratios are used to recognize babies.

V. AGE ESTIMAION

There are many popular real-world applications related to age synthesis and estimation. Computer-aided age synthesis significantly relieves the burden of tedious manual work while at the same time providing more photorealistic effects and high-quality pictures. Age estimation by machine is useful in applications where we don't need to specifically identify the individual, such as a government employee, but want to know his or her age.

A. Forensic Art

The forensic art involves interdisciplinary knowledge of anthropometry, psychology, postmortem reconstruction, human aging, perception, and computer graphics. As a principal artistic technique in forensic art, age progression is used to modify and enhance photographs by computer or manually (with professional hand drawing skills) for the purpose of suspect/victim and lost person identification with law enforcement. This technique has evolved when police

investigative work and art united throughout history. When the photos of missing family members (especially children) or wanted fugitives are outdated, forensic artists can predict the natural aging of the subject faces and produce updated face images, utilizing all available individual information, such as facial attributes, lifestyle, occupation, and genetics. Age synthesis by machine can significantly enhance the efficiency of the forensic artist while at the same time providing more photorealistic aging/rejuvenating effects that can satisfy the needs of aesthetics.

B. Electronic Customer Relationship Management(ECRM)

The ECRM is a management strategy to use information technology and multimedia interaction tools for effectively managing differentiated relationships with all customers and communicating with them individually. Since different groups of customers have very different consuming habits, preferences, responsiveness, and expectation to marketing, companies can gain more profits by acknowledging this fact, responding directly to all customers' specific needs, and providing customized products or services. The most challenging part hereby is to obtain and analyze enough personal information from all customer groups, which needs companies to establish long-term customer relationships and sustain a large amount of cost input. For example, a fast food shop owner might want to know what percentage of each age group prefers and purchases what kind of sandwiches; the advertisers want to target specific audiences (potential customers) for specific advertisements in terms of age groups; a mobile phone company wants to know which age group is more interested in their new product models showing in a public kiosk; a store display might show a business suit as an adult walks by or jeans as a teenager walks by. Obviously, it is almost impossible to realize those due to privacy issues. However, with the help of a computer-based automatic age estimation system, a camera snapping photos of customers could collect demographic data by capturing customers' face images and automatically labeling age groups. All of these can be done without violating anyone's privacy.

C. Security Control and Surveillance Monitoring

Security control and surveillance monitoring issues are more and more crucial in our everyday life, especially when advanced technologies and explosive information become common to access and possess. With the input of a monitoring camera, an age estimation system can warn or stop underage drinkers from entering bars or wine shops; prevent minors from purchasing tobacco products from vending machines; refuse the aged when he/she wants to try a roller coaster in an amusement park; and deny children access to adult Web sites or restricted movies. In Japan, police found that a particular age group is more apt to money transfer fraud on ATMs, in which age estimation from surveillance monitoring can play an important role. Age estimation software can also be used in health care systems, such as robotic nurse and intelligent intensive care unit, for customized services. For example, a personalized Avatar will be selected automatically from the custom-built Avatar database to interact with patients from different age groups with particular preferences.

D. Entertainment

Aging and rejuvenating are popular special visual effects in film making, especially for science fiction films such as "The Curious Case of Benjamin Button". Without any noticeable artifacts in many such movies, the actor's appearance can be

transformed from young to old or reverse instantly or gradually with extremely realistic aging effects. Some of these mysterious visual effects are generated by age synthesis techniques to provide fantastic experiences to audiences. Image morphing is often used to generate a seamless transition for animation purpose, such as Michael Jackson's music video "Black or White". Automatic album management of consumer photographs is a possible application for age estimation. Users can select photo groups from the automatically organized album according to the facial attributes labeling.

VI. CONCLUSION

In general, different age synthesis and estimation techniques and algorithms can be effectively applied to particular scenarios or applications. For face modeling, the appearance-based face model can be considered as a marriage of geometry-based model and image-based model, which shows more photorealistic effects aesthetically for age synthesis *purposes*. Shape synthesis is more effective for the age progression of young faces whose craniofacial growth and development are more dominant over skin aging. Texture synthesis is more effective for the face aging after adulthood when skin aging dominates and craniofacial growth slows down. Appearance synthesis is applicable to both cases since, usually, a statistical model will be available built on a large face aging database. Aging cues can be learned statistically for all aging stages and implemented to realistic age synthesis. But the most difficult part of appearance synthesis is the database collection and automatic face correspondence.

E. Biometrics

Age estimation is a type of soft biometrics that provides ancillary information of the users' identity information. It can be used to complement the primary biometric features, such as face, fingerprint, iris, and hand geometry, to improve the performance of a primary (hard) biometrics system. In real face recognition or identification applications, it is often the case that the system needs to recognize or identify faces after a gap of several years, such as passport renewal and border security, which reveals the importance of age synthesis. Integrated with a dynamic aging model, the face recognition or identification system can dynamically tune the model parameters by considering the shape or texture variations during the aging process. System robustness to time gap can be significantly improved.

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