An Aging Face Synthesis Method Based on Feature Regions Morphing and Wavelet Image Enhancement

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Keywords: Aging face synthesis, feature region morphing, wavelet image enhancement, Delaunay triangulation.

Abstract: Image morphing method based on trigonometric feature region was used to change contours of face images, and method of wavelet decomposition and synthesis was used to transfer aging textures, so as to synthesize aged face image. Experimental results show that better aged face images can be synthesized through our method and that it has certain practical value.

1 INTRODUCTION

Face recognition has made great progress till now, and it has been applied in some occasions such as railway station and supermarket. However face changes with age, which has a great influence on the correct rate of face recognition. It is helpful to improve the recognition effect of face recognition system if face aging problem was solved. There are few researches on face aging at present. Face aging methods can be classified into methods based on empirical knowledge and methods based on statistical learning. Skulls and skins that varies with age are considered to simulate aged face images in methods based on empirical knowledge. Wu developed a 3-layer facial structure to simulate the aging process dynamically(Wu Y,1999). Wu Xuefeng used active shape model algorithm to extract children's face features, and obtained aged images by changing geometric and texture features(Wu X F,2015).Large scale face databases are studied to find the law of how face contours and textures varied with age in methods based on statistical learning. Liu et al proposed a method to estimate aging pattern by aging increment distribution for re-rendering of facial age effects, so as to realize face aging(Liu J, 2007). Hu Weiping combined face morphing algorithm based on the feature line pairs and wavelet decomposition and synthesis algorithm to obtain aged face images(Hu W P,2016). Huang Fenglan used extending face database and IBSDT algorithm to improve the face prototype synthesis effect and adopted nonlinear operator method to enhance face textures(Huang F L, 2017). Liu Zhenyu established a face aging model through the gated recurrent unit to obtain aging face smoothly(Liu Z Y,2018).However in general, research on aging is still in the basic stage.

Considering that there are two distinct stages in the process of face aging, that is mainly contours change from children to young people, and skins and textures mainly change from young to old age, this study adopts a combination of two different strategies.Firstly, face contours are morphed by method of feature region deformation. Then wavelet transform method is used to enhance facial aging features. Finally, the aging characteristics are synthesized.

2 THE COMPOSITION OF FACE AGING SYNTHESIS SYSTEM

The system consists of four parts: image pre-processing, contours morphing, extraction and strengthening of aging characteristics and face aging features synthesis, as shown in Figure 1.

The image pre-processing part is responsible for pupils alignment, geometry normalization and illumination normalization. The deflected face can

be turned into a positive face by the pupil alignment, the resolution of face images becomes uniform by geometric normalization, and the illumination becomes relatively uniform by the histogram equalization and the gray transformation.

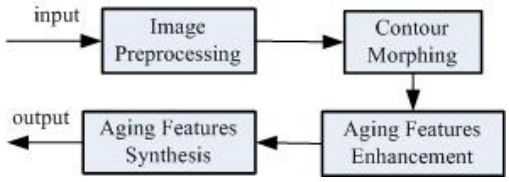

Figure 1: System structure.

In the face morphing part, the feature region deformation method is adopted. Firstly, the average face of different age segments is obtained according to the face database. Secondly the face images are divided into several triangles using the Delaunay triangulation method, and then each characteristic triangle is deformed between the source image and the target image, so as to obtain face images with changed contours.

The aging feature extraction and strengthening part are divided into two parts. The wavelet image decomposition method is used in extraction part to extractthe aging features such as wrinkles, eye bags and decree lines. The following strengthening module enhances the aging characteristics.

Wavelet image synthesis method is used in the synthesis part to add the enhanced aging features to the morphed images, so as to get the final synthetic images.

The face pre-processing method is described in Face illumination compensation algorithm based on symmetrical blocks(Hu W P,2014), here we will not go into details of them.

3 FACE FEATURE REGIONS MORPHING METHOD

Face feature points can be manually punctuated and also can be obtained by ASM algorithm. The FG-NET aging face database of Cyprus University is used which provided 68 face features with each image. Considering the importance of hairstyle in the aging process,22 extra feature points are added to characterize hairstyle. In order to get the change rule of feature points in face aging process, average faces of each age group are calculated, and aged face image can be obtained according to difference of average faces, as shown in equation (1).

$$U_{aging} = U_{origin} + (M_{aging} - M_{origin}) \quad (1)$$

U_{aging}, U_{origin}, M_{aging}, M_{origin} are respectively the contours of aged test image, origin test image, aged average face and origin average face.

After obtaining the target face coutours, Delaunay triangulation is used to get triangulated face images, as shown in Figure 2.

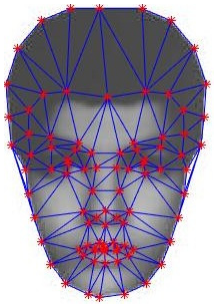

Figure 2: Delaunay triangulation.

Then we use the deformation method shown in Figure 3 to deform each feature triangle into each corresponding feature triangle.For any point F in the target triangle, we can get xy coordinates of D and E, and calculate the proportion of AD to AB ,AE to AC and DF to DE. We can calculate xy coordinates of point d, e and f with the same proportions.To avoid holes, we start from the target triangle area to find its corresponding pixels in the source triangle area, and use the bilinear interpolation method to determine the gray value of each point. All triangles transformed and merged, the morphed face image can be obtained.

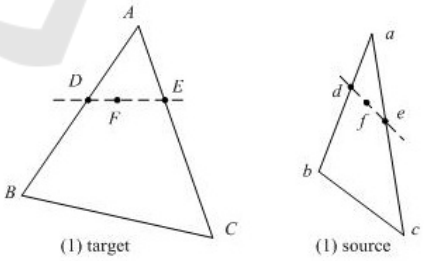

Figure 3: Feature region morphing.

4 EXTRACTION AND ENHANCEMENT OF AGING FEATURES

Considering the aging features such as wrinkles and eyes bags are sudden changes while contours of face

are smooth changes, we use wavelet image decomposition method to extract high-frequency parts of face images to characterize aging features.

$$(LL(I), HL(I), LH(I), HH(I)) = \mathrm{DWT}(I) \quad (2)$$

LL(*I*),*HL*(*I*),*LH*(*I*) and *HH*(*I*) are respectively the low-frequency component, the horizontal, vertical and diagonal high-frequency components of image *I*.

In order to enhance the aging features, we change wavelet coefficients to highlight high-frequency information and suppress low frequency information. That is, for each data g_{xy} in *HL*(*I*),*LH*(*I*) and *HH*(*I*), we can transfer with formula (3).

$$g_{xy} = \begin{cases} g_{xy} \times 2 & if\ g_{xy} > 240 \\ g_{xy} \div 2 & if\ g_{xy} \le 240 \end{cases} \quad (3)$$

5 FACE AGING FEATURES SYNTHESIS

In order to get the image after aging, we use the method mentioned in part 2 to change the contours of face image, and then increase the aging features.

We choose a typical aging face photo as aging model. The model face and test face are decomposed by two-level wavelet decomposition method. The high-frequency part of model face is enhanced by method mentioned in part 3.

The weighted average of the high frequency part of typical aging image and target image is calculated and considered as the high frequency part of target image. Then we can obtain the final synthesis image by two-layer wavelet synthesis method, as shown in formula (4) to (9).

$$(LL(T), HL(T), LH(T), HH(T)) = \mathrm{DWT}(T) \quad (4)$$

$$(LL(M), HL(M), LH(M), HH(M)) = \mathrm{DWT}(M) \quad (5)$$

$$\mathrm{T}' = \mathrm{IDWT}(LL(T), HL'(T), LH'(T), HH'(T)) \quad (6)$$

$$HL'(T) = (HL(T) + HL'(M))/2 \quad (7)$$

$$LH'(T) = (HL(T) + HL'(M))/2 \quad (8)$$

$$HH'(T) = (HH(T) + HH'(M))/2 \quad (9)$$

LL(T), HL(T), LH(T), HH(T) and LL(M), HL(M), LH(M), HH(M) are respectively the low-frequency component, the horizontal, vertical and diagonal high-frequency components of image I and model M. HL'(M), LH'(M), HH'(M) are high frequency partsenhanced by formula (3).

6 EXPERIMENT RESULTS AND ANALYSIS

In order to verify the algorithm, we randomly selected some face photos to test. The sample image is pre-processed first, then the triangle feature region method is used to change the contour, and the wavelet decomposition and synthesis method is used to increase the aging features. We compare it with the method in the article Face illumination compensation algorithm based on symmetrical blocks(Hu W P,2014). The results show that algorithm proposed in this paper has obvious aging effect, and gain faster speed.

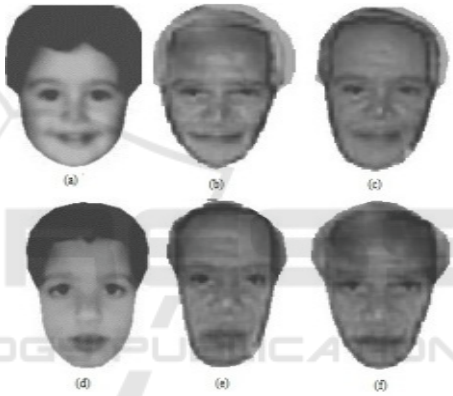

Figure 3: Experiment Results.

In Figure 3, (a) and (d) are two test images, (b) and (e) are results of reference while (e) and (f) are results of our algorithm. We can find in the figure that our aging effect is better.

7 CONCLUSIONS

The face aging synthesis method proposed in this paper combined the method of facial feature region morphing and face texture transplantation to deal with the changes of contours and textures in the aging process. The aging effect is obvious, and the execution speed is faster. It can be used to improve the face recognition system easily.

In this system, the manual punctuation of face feature points is adopted. In practical application, ASM algorithm can be used to automatically

punctuate the point, which can greatly improve the operation efficiency.

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