A NEW FACE FEATURE POINT MATRIX BASED ON GEOMETRIC FEATURES AND ILLUMINATION MODELS FOR FACIAL ATTRACTION ANALYSIS

JIAN ZHAO *, FANG DENG, JIAN JIA
CHUNMENG WU, HAIHO LI, YUAN SHI AND SHUNLI ZHANG
School of Information Science and Technology
Northwest University, Xi’an, China

ABSTRACT. In this paper, we propose a 81-point face feature points template that used for face attraction analysis. This template is proposed that based on the AAM model according to the geometric characteristics and the illumination model. The experimental results demonstrate that, the attraction of human face can be analyzed by the feature vector analysis of human face image quantification and the influence of light intensity on the attraction of human face. By taking the appropriate algorithm, the concept of facial beauty attractiveness can be learned by machine with numeric expressions.

1. Introduction. Beauty is a universal part of human experience, and the perception of facial beauty or attractiveness is one of the most common human activities in our daily life. Facial beauty delights our sight and provokes pleasure in our mind, but, what is beauty? Is there any “beauty code” existing objectively? Mounir Bashour (2006) argues that human attraction is a visual enjoyment of face-to-face encounters, and its operation is defined as a static two-dimensional face visual feature that gives viewers a visual enjoyment[11]. Rubenstein, Langlois and Roggman created averaged faces by morphing multiple images together and proposed that averageness is the answer for facial attractiveness [6, 12].

At present, to study face attractive is mainly from the field of psychology and medical at domestic and foreign. To study the beautiful face attractive has just risen in recent years by using computer information processing technology. The ultimate goal of machine intelligence is to let the computer have the same intelligence as people, including perception, reasoning, judgment, identification and other aspects of the ability[9]. Since people have a cognitive ability for beautiful appeal to the face, is it also possible to let the computer through the machine to learn the means to get the same intelligence? We think this is a basic question of whether the concept of “beautiful attraction about human face” can be learned.

In [14], based on the AAM model, an algorithm for fast and accurate fitting of AAMs under field conditions is proposed. In [1], the new method of distinguishing
response mapping (DRMF) is proposed to improve the shortcoming of CLM framework. In [3], proposing several geometric features that characterize the attraction of Chinese women’s faces; On the basis of this, the paper analyzes the attractiveness of oriental people from the geometric features, and then analyzes the influence of the illumination model on the attraction of the human face, and provides a reference for the judgment of the human attraction. In the past, the data were mostly used by Westerners, and there were few reports on the beauty of the face of the Orient. In this paper, the Orient people face image data, focusing on the Oriental face to analyze the attraction.

2. AAM. The current research results show that the model-based location method has better positioning effect and robustness. Model-based feature point positioning method The two most typical models currently used in the most widely used are the active shape model (AAM) and the active visual model (ASM)[10].

AAM are generative, parametric models of a certain visual phenomenon that show both shape and appearance variations[4]. First, Learning the shape model requires consistently annotating a set of landmarks [x₁, y₁, x₂, y₂, ..., xₜ, yₜ] across training images, These points are said to define the shape of each object. Next, Procrustes Analysis is applied to normalize and remove similar transformations from the original image[5]. Finally, PCA is applied on these shapes to obtain a shape model defined by the mean shape and shape eigenvectors.

Assume that we are given a new similarity-free shape s = (x₁, y₁, x₂, y₂, ..., xₜ, yₜ)^T and shape variation is expressed by a linear combination of a mean shape s₀ and n shape basis vectors sᵢ. Then, the model can be used to represent s as

\[ s = s₀ + \sum_{i=1}^{n} p_i s_i \]  

where s₀ is the mean shape, pᵢ denotes the iᵗʰ shape parameter, and p = {p₁, p₂, ..., pₘ} is the shape parameter vector for the input face image. The principal component analysis of all the textures is obtained

\[ g = \bar{g} + p_gb \]  

where \( \bar{p} \) is the average texture, \( p_g \) is the transformation matrix formed by the texture components of the texture components calculated by PCA, and \( p_b \) is the statistical texture parameter that controls the texture change. The appearance variation is expressed by a linear combination of a mean appearance \( A₀(x) \) and n appearance basis vectors \( A_i(x) \) as \n
\[ A(x) = A₀(x) + \sum_{i=1}^{n} \lambda_i A_i(x) \forall x \in s₀ \]  

Where \( \lambda \) denotes the iᵗʰ appearance parameter, and \( \lambda = \{\lambda₁, \lambda₂, ..., \lambdaₙ\} \) is the appearance parameter vector for the input face image. The pixel value of the input image at pixel \( W(x;p) \) is \( I(W(x;p)) \). The sum of squares of the difference between \( A(x) \) and \( I(W(x;p)) \) is minimized, that is, the error function:

\[ E = \sum_{x \in s₀} [A₀(x) + \sum_{i=1}^{n} \lambda_i A_i(x) - I(W(x;p))]^2 \]  

where q is the global pose parameter vector including the scale, rotation, and horizontal/vertical translation.
The following figure shows using the AAM algorithm detected the characteristic points by the Westerners and the Orientians.

3. The algorithm proposed in this paper.

3.1. Geometric model. Geometric features are a significant problem in quantitative description of human attraction. It has the same impact on the West and the East for the distance of facial features and the proportion of the beautiful face. The geometric methods used by predecessors are less likely to take into account the direct use of facial features as a feature to predict the face of beauty, we believe that facial features also indirectly reflect the face of rich geometric information, such as eye size, facial features, forehead width and so on.

On the basis of 68 feature points, this paper increases the number of features of ear and forehead. On the basis of contemporary Chinese theory of the aesthetic theory of mankind[7, 8, 15], this paper puts forward the description of oriental people face the beauty of the distance feature vector, the feature vector is mainly composed of the seven-dimensional component of the vector attraction which is not involved in the previous study. The schematic and description of the features are shown in the figure 2.
### Table 1. 7-dimensional distance feature vector description.

| Feature quantity number | Feature quantity symbol | Feature quantity description                        |
|-------------------------|-------------------------|----------------------------------------------------|
| 1                       | F1                      | Nose and ears width (nose up to the top of the ear) |
| 4                       | F4                      | Nose to the height of the forehead center          |
| 5                       | F5                      | Nose to the eyes of the angle                      |
| 6                       | F6                      | Forehead center to the side of the distance        |
| 7                       | F7                      | The distance on both sides of the forehead         |

3.2. **Light illumination model.** When the light emitted from the light source is irradiated onto the surface of the object, the reflected light and the transmitted light can stimulate the human eye to produce a visual effect. The intensity of reflected light and transmitted light determines the degree of shading on the surface of the object [13]. From the visual effect, in the illumination model, assuming that the light emitted by the light source is white and the object is opaque, the color of the surface of the object is reflected only by the light Decision.

In many cases, the content of the image does not change, but the change of light has changed the effect of the image. The illumination image of different regions in the face image is different. The size of the light intensity affects the judgment of the attraction of the face.

According to Lambert’s law, the intensity of diffuse reflected light reflected on the surface of an ideal diffuse object is proportional to the cosine of the angle between the incident light and the surface normal of the object [2].

$$I = k_d I_l \cos \theta$$  \hspace{1cm} (5)

Where $I$ is the brightness of the diffuse reflected light at the illuminated point $P$, $I_l$ is the incident light intensity emitted by the point light is the incident light intensity emitted by the point light source, $k_d(0 \leq k_d \leq 1)$ is the diffuse reflectance of the surface of the scene, and $\theta$ is the incident angle between the light and the surface normal vector. (5) can be expressed as the following vector form if the unit vector of the surface of the scene is $N$ at the point of irradiation $P$ and the unit vector of $P$ to the point source is $L$,

$$I = k_d I_l \cdot (N \cdot L)$$ \hspace{1cm} (6)

In the local light illumination model, we often assume that the ambient reflected light is a uniformly diffuse light and uses a constant to represent its intensity. In this way, the Lambert diffuse light illumination model can be written as:

$$I = k_a I_a + k_d I_l \cdot (N \cdot L)$$ \hspace{1cm} (7)

Where $I_a$ is the incident flood light intensity and $k_a$ is the diffuse reflectance of the surface of the object to flood light. It is worth noting that equation (7) does not reflect the distance attenuation effect of light. It is well known that the propagation of light is attenuated from the square of the square, that is, the intensity of the incident light somewhere is inversely proportional to the square of the distance between the point and the light source. We can use the following Lambert diffuse reflection model to simulate the various attenuation effects of light:

$$I = k_a I_a + f k_d I_l (N \cdot L), f = \max\left(\frac{1}{c_1 + c_2 d + c_3 d^2}, 1\right)$$ \hspace{1cm} (8)
Where $f$ is the light source intensity attenuation factor, $c_1$, $c_2$ and $c_3$ are the user-defined constants.

4. **Experiments and results.** In this paper, it is quantifiable the abstract concept of human attraction. Through the geometric features and the illumination model, the human face can be quantitatively predicted by machine learning. A total of 89 samples of the experiment, this article only selected 6 as a description.

   According to the statistical evaluation of human attraction, it is more attractive when the height of the nose is approximately the same as that of the ear. The closer the face triangle is to the nearest 60 degrees, it is more attractive.

   Figure 3, the new forehead feature points 3, the tip of the nose, the amount of heart, and both sides of the forehead to take the characteristics of a triangular area, the triangular area closer to the triangle, especially the tip of the nose and the angle of the eye closer to 60 degrees, the face is more attractive.

   Table 2 can be seen in the nose and ears in the face of the attraction, when the slope of $\frac{-1}{1} < k < 0.1$, more attractive, $k > 0.1$, slightly less attractive. In the experimental sample, Figure 2 and Figure 4 are more attractive.

   Figure 4 lighting model, the new feature points 6, 81 feature points selected in this paper is completed. According to the brightness level of the incident light is divided into $[-100,-60]$, $[-60,-30]$, $[-30,0]$, $[0,30]$, $[30,60]$, $[60,100]$. In the artificial evaluation, light intensity in $[30,60]$, the face is more attractive. On this basis, in order to find the best light intensity, the second experiment, in the $[30,60]$ light level to continue to refine the light level $[30,40]$, $[40,50]$ and $[50,60]$. As shown in the experiment, the experiment shows that $[40,50]$ is the most attractive, with
Figure 4. The feature point diagram of the illumination model
| Experimental sample | Slope 1 | Slope 2 | Difference |
|---------------------|---------|---------|------------|
| 1                   | 0.0280  | 0.0399  | -0.0119    |
| 3                   | 0.0196  | -0.0402 | 0.0598     |
| 4                   | -0.0047 | -0.0562 | 0.0086     |
| 5                   | 0.0840  | 0.0224  | 0.0616     |
| 6                   | 0.1369  | 0.1168  | 0.0201     |

Table 2. The slope of the nose of the ears.

Figure 5. Improved light intensity map

artificial evaluation as the standard, the accuracy model used in this paper reached 93.6%.

Acknowledgments. This work was supported by National Natural Science Foundation of China No. 61379010, 61772421.

REFERENCES

[1] A. Asthana, S. Zafeiriou, S. Cheng and M. Pantic, Robust discriminative response map fitting with constrained local models, *IEEE Conference on Computer Vision and Pattern Recognition*, (2013), 3444–3451.

[2] R. Basri and D. W. Jacobs, Lambertian reflectance and linear subspaces, *IEEE Transactions on Pattern Analysis & Machine Intelligence*, 25(2) (2003), 218–233.

[3] F. Chen and D. Zhang, A benchmark for geometric facial beauty study, *Lecture Notes in Computer Science*, 6165 (2010), 21–32.

[4] Y. Cheon and D. Kim, Natural facial expression recognition using differential-AAM and manifold learning, *Pattern Recognition*, 42 (2009), 1340–1350.
[5] T. F. Cootes, G. J. Edwards and C. J. Taylor, Active appearance models, *European Conference on Computer Vision*, (2001), 484–498.

[6] J. H. Langlois and L. A. Roggman, Attractive Faces Are Only Average, *Psychological Science*, 1 (1990), 115–121.

[7] X.-F. Lu, Chinese research facial pattern types and techniques, China Academy of Fine Arts doctoral dissertation, 2010.

[8] X.-F. Lu, Yuan Dynasty painter Wang Yi’s “writing like a secret” and portrait program, *Fine Arts.*, 18 (2005), 72–73.

[9] H.-Y. Mao, Facial beauty attractive characteristics of the analysis and machine learning, South China University of Technology, 2011.

[10] I. Matthews and S. Baker, Active appearance models revisited, *International Journal of Computer Vision*, 6165 (2004), 135–164.

[11] S. C. Rhee and S. H. Koo, An objective system for measuring facial attractiveness, *Plastic & Reconstructive Surgery*, 119 (2006), 1953–1954.

[12] A. J. Rubenstein, J. H. Langlois and L. A. Roggman, What makes a face attractive and why: The role of averageness in defining facial beauty, G Rhodes & L. 62 Zebrowitz, Facial Attractiveness: Evolutionary, Cognitive, & Social Perspectives, 2002.

[13] Y. Sato, M. D. Wheeler and K. Ikeuchi, Object Shape and Reflectance Modeling from Observation, *Modeling from Reality. Springer US*, (2001), 95–116.

[14] G. Tzimiropoulos and M. Pantic, Optimization Problems for Fast AAM Fitting in-the-Wild, *IEEE International Conference on Computer Vision*, (2014), 593–600.

[15] X.-M. Zhang, *China United States*, Beijing: Xinhua Publishing House, 2005.

Received July 2017; revised December 2017.

E-mail address: zjctec@nwu.edu.cn
E-mail address: dengfang@stumail.nwu.edu.cn
E-mail address: jiajian@nwu.edu.cn
E-mail address: wuchunmeng0208@foxmail.com
E-mail address: 8420018828@qq.com
E-mail address: nwu_sy@stumail.nwu.edu.cn
E-mail address: slzhang@nwu.edu.cn