Dynamic Texture for Facial Expression

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Abstract

In this paper, we present a method to generate dynamic textures for facial expression. We first build a facial texture library for a head model. This series of facial textures correspond to each facial expression. For each facial expression we calculate the expression parameters and store it in the library. We use the expression parameter to transfer an expressive texture from one character to another. For each expressive texture, we can control the strength of the emotions. The method increases realism and amplifies extreme emotions. Test cases show convincing results in animated facial expressions.

Keywords: facial expression, facial color, facial animation, texture

1. Introduction

Realistic facial modeling and animation demand not only facial deformation, but also skin color changes that depend on the emotional status of the person, such as the six universal facial emotions: anger, disgust, fear, happiness, sadness and surprise [1]. Not much research has been reported on this subject. The first notable computational model of vascular expression was reported by Kalra et al. [2], although simplistic approaches were conceived earlier [3]. Dynamic textures can dramatically improve the facial expression. For example, when a person is angry, the face becomes red or white, or the blue veins show up clearly. Different skin colors will have different results: black skin becomes darker; white skin becomes red. Skin color of old people may become cyan in the cheeks.

The creation of dynamic skin shading in film and game workflows depends mostly on artists, who carefully create all necessary skin textures. The textures for each character must be created individually by hand, a slow and costly process that requires experienced digital artists. Alternative facial animation techniques circumvent this difficulty by relying on performance capture [4, 5] to simultaneously obtain dynamic geometry and appearance, but they are not designed to derive a generic, transferable model. We propose a system that dynamically changes facial textures according to the facial expression. There are four stages for the algorithm.

2. Related work

Dynamic textures are sequences of images of moving scenes that exhibit certain stationary properties over time [6]. The dynamic is represented as a time-dependent state process and the appearance of the image frames over time.

The multi-image texture representation of skin presented by Cula et al. [7] focuses on surface microgeometry, and takes into account appearance variations caused by changes in illumination and viewing direction. Kalra et al. [2] describe a computational model of emotion that includes visual characteristics as vascular effects and their pattern of change during the term of the emotions. In [8], a system is proposed where the facial coloration is realized by changing the vertex color according to its position in the local coordinate system of the head. The amount of colorization is controlled by the emotional state of the virtual character. Skin appearance can be classified according to spatial scales [9]. Donner et al. [10] simulate skin reflectance by accounting for lateral inter-scattering of light between skin layers. Using known chromophore spectra, they derive spatial chromophore distributions from multi-spectral photographs of skin through inverse rendering.

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3. Our approach

3.1 Building a facial texture library

Dynamic textures are combined with animations of expressions to create convincing emotions. Emotion caused skin changes must be customizable and consistent with existing animations. To realize these conditions, we need to know whether the face should blush or pale, in which area the color should be changed, and the duration. We build a facial texture library for each of the facial expressions. We have neutral textures (see Figure 1(a)). To obtain textures for different expressions, such as anger (see Figure 1(b)), we paint specific colors on specific expressive 3D facial models. For example, Figure 1 (d) is the result of this process for Figure 1 (c). We set these neutral and expressive textures as template textures.

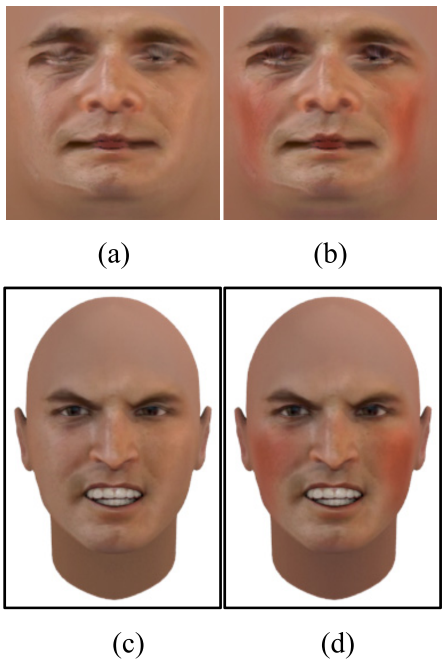

Figure 1: (a) Neutral texture. (b) Expressive texture. (c) Model with neutral texture. (d) Cheeks are painted red.

3.2 Obtaining expression parameters

We obtain expression parameter k for each expression from the neutral texture and expressive texture. We assume that the neutral texture and the expressive texture are Lambertian models and the image intensity I_c at a point P in each of the RGB color channels is

$$I_c = \rho \sum_{i=1}^{m} I_i N L_i,\ c \in \{R, G, B\}.$$

Where N is the surface normal, m is the number of point light sources, L_i, $1 \le i \le m$, is the light direction from P to the ith light source with intensity I_i. We assume the surface is diffusive, and ρ is the reflectance coefficient at P.

The intensity of the neutral texture is

$$I_{c-neutral} = \rho \sum_{i=1}^{m} I_i N_{neutral} L_{i-neutral} \qquad (1)$$

After a color is painted on the neutral texture, the intensity of the expressive texture is:

$$I_{c-expression} = \rho \sum_{i=1}^{m} I_i N_{expression} L_{i-expression} \qquad (2)$$

From equations (1) and (2), we have

$$\frac{I_{c-expression}}{I_{c-neutral}} = \frac{\sum_{i=1}^{m} N_{expression} L_{i-expression}}{\sum_{i=1}^{m} N_{neutral} L_{i-neutral}} = k$$

k is stored in the database as an expression parameter.

3.3 Transferring an expressive texture from one character to another

Once the template of expressive textures is generated, it can be used by any individual character for animating facial color changes. We can transfer an expressive texture from one character to another. Figure 2 (a) is a neutral texture. This texture is generated in the same system as the template texture (see Figure 1(a)). These two textures have corresponding points, such as eye corners, mouth corners, nose tip, etc. We would like this model to have an expressive texture as Figure 1 (b). For instance, in the angry expression, the cheeks are red. We denote $J_{c-neutral}$ as the intensity of the neutral texture and $J_{c-expression}$ as the intensity of the expressive texture. Human faces have approximately the same geometrical shape. If they are in the same expression, their surface normals at the corresponding positions are almost the same and the lighting directions are also almost the same.

So, we have

$$\frac{J_{c-expression}}{J_{c-neutral}} = \frac{I_{c-expression}}{I_{c-neutral}}, \quad J_{c-expression} = kJ_{c-neutral}$$

The expressive texture is generated by multiplying the intensity of the neutral texture

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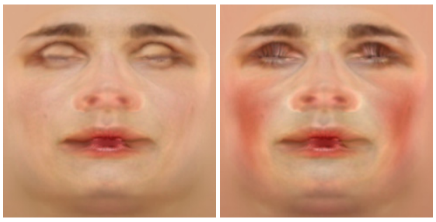
by k. Figure 2 (c) is k in RGB color mode. The result is shown in Figure 2 (b).



(a) (b)

(c)

Figure 2: (a) Neutral texture. (b) Transferred expressive texture. (c) k in RGB color mode.

3.4 Setting the strength of emotions

We set the strength of emotions or the intensity of textures for the animated facial expression along with animated facial textures. The texture can reflect the emotion strength. The expressive texture in the library sometimes may be too strong for another animated emotion model; a formula is defined to reduce the strength. Let $J_0 = J_{c-expression}$ express full emotion or full intensity of the texture. The ratio of each reduced intensity level and the preceding intensity level is a constant r; e is the execution time. Therefore, we have:

$$J_0 = J_0,\ J_1 = rJ_0,\ J_2 = rJ_1 = r^2 J_0, \ldots,\ J_e = r^e J_0.$$

We have a series of strength of textures for each expression.

The model animated expression sequence matches the sequence of its texture. If the facial animation from a neutral to an expression has f frames, we morph the neutral texture to an expressive texture J_e to generate the same number of frames f.

Figures 3, 4 and 5 are examples generated using our method. Figure 3 shows selected frames of a running cycle of anger as her facial skin color gradually turns red. Figure 4 shows selected frames of a running cycle of sadness as the skin color around the eyes become red. Figure 5 shows 3D animated tear shedding that is integrated with the head model [11]. It shows four selected frames of a running cycle as facial textures turn from normal color to pale color.

4. Conclusion

A method to generate dynamic textures for facial expression is presented**.** The facial skin color changes are associated with the perception of certain emotions. For example, the skin color pales during anger and reddens during shame. Both add to the emotional effect. When included, it increases realism and amplifies extreme emotions. The new approach is general enough to complement most existing animation techniques. The new method can also be applied to CG human body skins. The method is not only for animation by a trained artist, but also for industry.

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Figure 3: Selected frames of a running cycle of anger.

Figure 4: Selected frames of a running cycle of sadness.

Figure 5: Selected frames of a running cycle of facial color turning pale as tears shed.

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