An Interactive Facial Animation System

Fatih Erol

Uğur Güdükbay

Department of Computer Engineering
Bilkent University
06533 Bilkent, Ankara, Turkey
{ferol, gudukbay}@cs.bilkent.edu.tr

ABSTRACT

In this paper, an interactive facial animation system is described. The system is built on top of the facial animation system developed by Keith Waters, which uses a muscle-based face model. We built an interactive facial animation system on top of it to produce keyframe animations of a synthetic face model. The user creates keyframes interactively by either giving predefined universal expressions to the face (or a meaningful combination of these expressions blended naturally on the face model), or giving expressions to the face by moving the muscle vectors defined on the face model. The user might also change the orientation of the face for a keyframe by rotating it in x- and y-directions. To create intermediate frames, we use cosine interpolation.

Keywords: interpolation, keyframing, facial animation, expression blending

1 INTRODUCTION

One of the most important issues in facial animation is giving universal expressions to the face, such as fear, anger, surprise, disgust, happiness and sadness, through time and blending these expressions realistically with each other as in the real face. It is very difficult to define a model capable of performing realistic face motions. It is even more complicated to construct a model which is both realistic and efficient enough to run at interactive rates.

In this paper, we present an interactive system for creating realistic animation of a synthetic face using keyframing. We built our system on top of the facial animation software developed by Waters [2]. He modeled the face muscles as the forces deforming a group of vertices of the face model.

We built a graphical user interface to control the rendering parameters and the facial animation parameters, like face orientation and facial expressions for each keyframe of an animation. By using this interface, the user may create keyframes of an animation interactively. He can do this by either giving predefined universal expressions to the synthetic face (or a meaningful combination of these expressions blended naturally on the face model), or giving expressions to the face by moving the muscle vectors defined on the face model. The user may also change the orientation of the face for a keyframe by rotating it in x- and y-directions. To create intermediate frames, we use cosine interpolation, which is an interpolation technique for facial animation.

2 PREVIOUS WORK

Previous studies for facial modeling and animation started with the work of Parke [3]. He used keyframing techniques and cosine interpolation to animate the face. Since each key frame must be completely specified to animate the face, simple keyframing cannot be easily used for three-dimensional (3D) facial animation. Parametric systems have emerged as a result of this [4]. A parametric facial animation system defines a set of parameters for the face. These are mainly the expression parameters for different parts of the face, such as mouth and eyes and the conformation parameters that apply globally to the whole face. The major parameters for the mouth are jaw rotation, width of the mouth, etc. The major parameters for the eyes are pupil dilation, eyelid opening, eyebrow position and shape. The conformation parameters are skin color, aspect ratio of the face, etc. Each expression parameter effects a set of vertices of the face model. In this way, key frames can be defined easily.

The disadvantage of the parametric systems is that they cannot easily blend facial expressions since each parameter effects a disjoint set of vertices in the face model. This limitation led to the development of structure based facial models which are based on the anatomy of the face [5]. However, all these models do not take into account the fact that the face is not only a geometric model but a complex biomechanical system. Physically-based face models have emerged to overcome these limitations. Terzopoulos and Waters model the face in a layered fashion and incorporate an anatomically based muscle model with a physically based layered tissue model. They used a trilayer facial tissue concept modeled as a trilayer mesh of vertices connected by springs [6]. The trilayer mesh propagates the tissue deformations from the innermost layer (muscle actuators inserted into the innermost later) to the face skin with the help of springs connecting the vertices. Anatomically based muscle models are first used by Waters [7] to animate major facial expressions.

3 FACIAL MODELING

The skin can be modeled as a mesh of springs that is deformed under a tension of a muscle. Muscles can be interpreted as forces deforming the polygonal mesh of the face. The factors affecting the deformation are tension of the muscle, elasticity of the skin (skin is not a perfect elastic material; it is visco elastic), and zone of influence (a muscle can affect only a portion of the skin) [7]:

Our synthetic face is based on the model developed by Keith Waters, which is using linear muscles [2]. A linear muscle deforms the mesh like a force and can be modeled with the parameters *influence zone*, *influence start*, *influence end* and *contraction value*. Since a linear muscle is a force, its direction is also important and it is defined by the direction of muscle vector. Starting point of the vector is never repositioned and it is the originating point of the muscle. A muscle pulls or pushes the mesh vertices along this muscle vector [7]. The face model contains nine pairs of muscles that are placed symmetrically through the face. These are *zygomatic major*, *angular depressors*, *labi nasi*, *inner labi nasi*, *frontalis outer*, *frontalis major*, *frontalis inner*, *lateral corigator*, and *secondary frontalis*.

The parameters of the face are the contraction values of the muscles, the rotation in x- and y-axis, and the jaw openness. When the jaw is opened, the vertices in the lower chin are rotated to give the effect of mouth opening, which is very important for convincing animations.

4 FACIAL ANIMATION

One of the most widely used techniques in facial animation is key framing based on facial parameters. We also use key framing as follows. The user sets the expression parameters, which determine the appearance of the face, in important frames. The user also sets the orientation of the face and rendering parameters. The system generates the inbetweens using cosine interpolation, which is suitable for approximating the viscoelastic behavior of the skin. It is the most suitable technique when the model is complex and small differences between two frames can be seen better with the model having enough detail. This is because the muscles' acceleration and deceleration can be represented as a cosine function of time.

Six universal expressions are predefined in our software and we have also added other expressions that can be formed by blending a meaningful subset of these six expressions. The expressions are defined by the set of parameters for the face model that give the look of that expression. We represent facial state for each keyframe by specifying the muscle values necessary to generate facial expressions for the frame.

5 GRAPHICAL USER INTERFACE

The animation system has a graphical user interface (see Figure 1) developed using XForms library [8]. The user interface is event-driven and contain buttons to draw the face according to the specified rendering mode (wireframe, flat-shaded, smooth shaded, textured), to set up the expression and face orientation parameters, to generate inbetweens of an animation using interpolation, saving, loading and playing an animation, etc.

The user can easily generate the keyframes by using the buttons and interpolate them to generate a facial animation. The animations are saved to a file in the form of expression parameters and orientation parameters for each keyframe and they are interpolated to generate inbetweens.

The part of the user interface for expression blending as follows. There are six buttons that correspond to the six universal facial expressions.

The parameters for these expressions are predefined and can be given to the face by using appropriate buttons in the graphical user interface. The user might also give any expression to the face by contracting or expanding the muscle vectors individually by using slider controls. The user may click any expression buttons in combination as long as the combination is meaningful. The meaningful expression combinations are predefined in the system, which are

happiness: `happiness-anger, happiness-surprise, happiness-anger-surprise`

anger: `anger-surprise, anger-sadness, anger-fear, anger-disgust, anger-sadness-disgust, anger-fear-disgust, anger-surprise-sadness, anger-surprise-disgust, anger-sadness-fear, anger-surprise-fear, anger-surprise-sadness-fear anger-surprise-sadness-disgust, anger-surprise-fear-disgust, anger-sadness-fear-disgust, anger-surprise-sadness-fear-disgust`

surprise: `surprise-sadness, surprise-fear, surprise-disgust, surprise-sadness-fear, surprise-sadness-disgust, surprise-sadness-fear-disgust`

sadness: `sadness-fear, sadness-disgust`

fear: `fear-disgust`

6 RESULTS

We display the face with different expressions in Figure 2. In the first picture, the face is in neutral state. In the next six pictures the face has only one universal expression, namely happiness, surprise, fear, anger, sadness, disgust respectively. In the following pictures, the face has the double expression combinations happiness-surprise, anger-surprise, fear-surprise, disgust-surprise, sadness-surprise respectively. Then, the face has triple expression combination anger-fear-surprise, and quadruple expression combination anger-fear-surprise-disgust. These facial states could be saved as a keyframe together with a possible face orientation.

7 CONCLUSION AND FUTURE WORK

An interactive facial animation system is described in this paper. The system is built on top of an existing muscle-based facial animation system developed by Keith Waters. We have built an interactive facial animation system on top of it to develop keyframe animations of a synthetic face model. The user creates keyframes of the animations interactively by either giving predefined universal expressions (or plausible expression combinations blended naturally) to the synthetic face or giving expressions to the face by moving the muscle vectors defined on the face model. The user might also change the orientation of the face for a keyframe by rotating it in x- and y-directions. Intermediate frames are generated using cosine interpolation technique.

Possible future extensions are as follows:

- We are planning to generate and animate the face models of individuals by using the approach defined in [1]. This technique uses orthogonal photos to locate the Face Definition Parameters defined for MPEG-4 and uses these parameters to deform a generic face model using Free-Form Deformations to obtain the individual's face model. After generating individual face models facial muscle vectors in the generic model could be modified to fit the new model.
- The user interface could be improved by grouping the items in a logical way using menus. However, this would increase the time the user will interact with the program to create keyframes.
- The face model could be improved both in terms of face geometry and adding ears, hair, eyebrows, etc. A detailed face model would be useful for getting realistic looking expressions. A tool for editing the face geometry would also be useful.

REFERENCES

[1] Lee, W.-S., Escher, M., and Sannier, G., Magnenat-Thalmann, N., "MPEG-4 Compatible Faces from Orthogonal Photos," in Proc. *IEEE Computer Animation'99*, 1999.

[2] Parke, F.I. and Waters, K., Computer Facial Animation, A.K. Peters, Wellesley, MA, 1996.

[3] Parke, F.I., "Computer Generated Animation of Faces", *Proc. of ACM National Conference*, Vol. 1, pp. 451-457, 1972.

[4] Parke, F.I., "Parameterized Models for Facial Animation", *IEEE Computer Graphics and Applications*, Vol. 2, No. 9, pp. 61-70, 1982.

[5] Platt, S.M., "A Structural Model of the Human Face," Ph.D. Thesis, University of Pennsylvania, Dept. of CIS, 1985.

[6] Terzopoulos, D. and Waters, K., "Physically-based Facial Modeling, Analysis, and Animation", *The Journal of Visualization and Computer Animation*, Vol. 1, pp. 73-80, 1990.

[7] Waters, K., "A Muscle Model for Animating 3D Facial Expression", *ACM Computer Graphics*, Vol. 21, No. 4, pp. 17-24, 1987.

[8] Zhao, T.C. and Overmars, M., "Forms Library: A Graphical User Interface Toolkit for X", `http://bragg.phys.uwm.edu/xforms`.

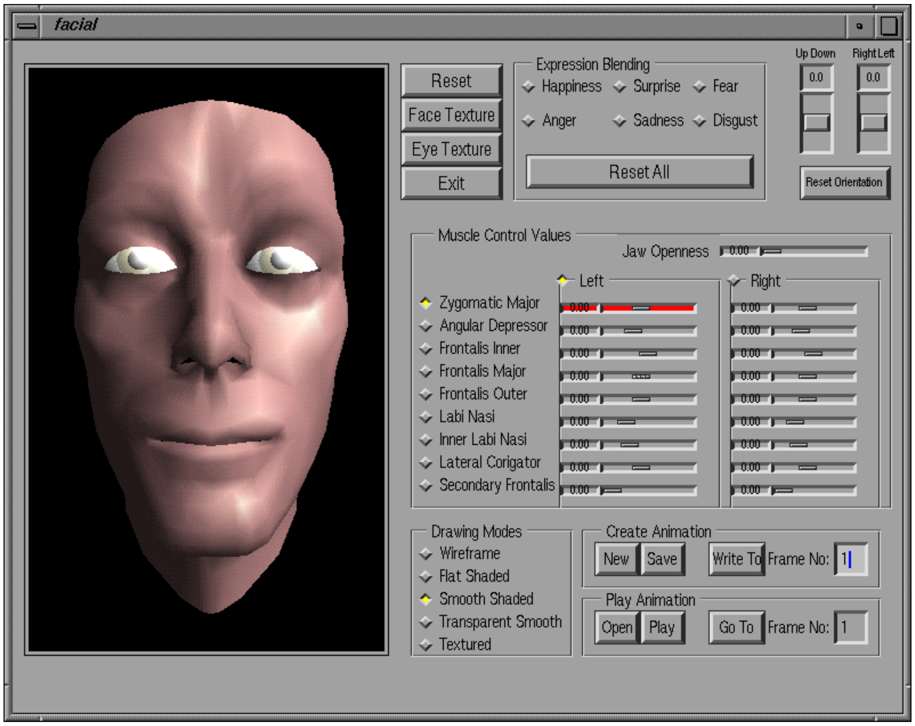

Figure 1: Graphical user interface of the system.

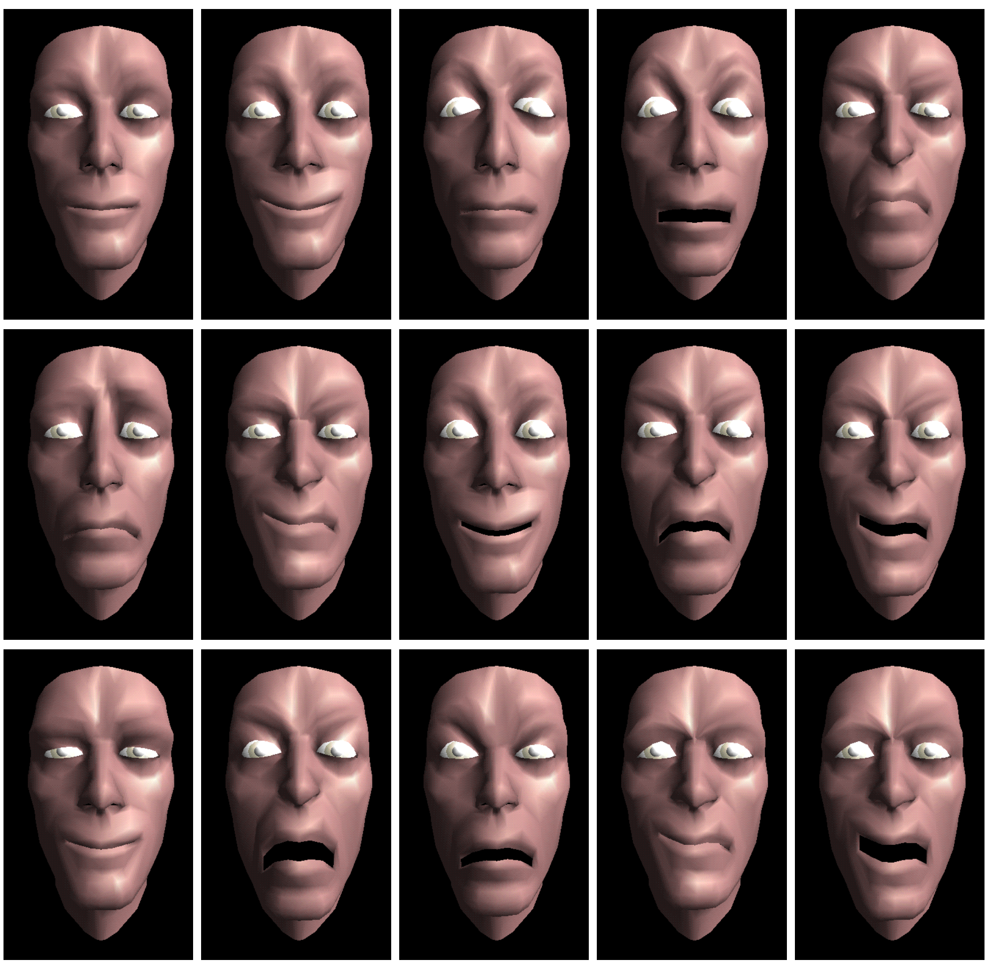

Figure 2: Different facial expressions and expression combinations; from left-to-right and top-to-bottom (rowwise order): neutral, happiness, surprise, fear, anger, sadness, disgust, happy_surprise, anger_surprise, disgust_surprise, happy_anger, anger_fear, anger_sadness_surprise, anger_sadness_disgust, anger_sadness_surprise_disgust