Facial Expression Parameter Extraction with Cohn-Kanade Based Database

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***Abstract*—The facial expression simulation is a new application field. The Cohn-Kanade facial expression database is adapted in this paper, which based on the Face Action Coding System (FACS), to extract facial expression parameters. A more perfect parameterized model is built for the facial expression simulation. Experiment results show the method in the paper works well.**

***Index Terms*—facial expression simulation, feature extraction, FACS, Cohn-Kanade database**

I. Introduction

Nowadays, facial expression simulation is one of the research hotspots in face simulation, which involves a very wide range of application, and it is closely related to our lives. It is widely applied in different fields, including entertainments, video games, virtual meetings, assisted teaching, medical research, etc [1] and [2].

Experts all over the world have made a lot of researches on facial expression simulation [3]-[6], and the parameterized facial expression modeling is one of the major methods [7]. In this paper, the parameterized facial expression model based on the Face Action Coding System (FACS) is simulated, and the Cohn-Kanade facial expression database is used to extract facial expression parameters.

II. Introduction of Facial Action Coding System and Cohn-Kanade Database

A. Facial Action Coding System (FACS)

Facial Action Coding System, hereinafter referred to as FACS, is an integrated system which tries the best possibility to make a distinction between face movements on the basis of further research in the movement of facial muscles and the control action of expression, which is made by Ekman, etc [8]. The system based on the face anatomical basis analysis, stimulate each muscle tissue in the face, causing reaction activity, taking picture and video to record the movement of each muscle, and matching with each expression, so as to determine the muscle motion combination standards of each expression.

In the FACS, Face Action Unit (Action Unit, hereinafter referred to as AU) is used to measure the independence movement of face muscle, while various kinds of expression change are the combinations of multi muscles motion. Such as: AU1 (the internal tip of the brow ascension), AU4 (the Eyebrows ascension), AU15 (the corners of the mouth pull-down) and AU23 (the Lips tightened) can form a sad expression.

FACS does synthesis, analysis expressions through the movement of feature point. This method is to use expression parameters to implement the shape deformation of frame model, and so synthesize facial expressions. The main problem about this method is how to define expression parameters. The expression of peoples is formed through stretching of the facial muscles.

B. Cohn-Kanade Expression Database

Cohn-Kanade AU-Coded Facial Expression Database provides a test platform for individuals and research institutes who conduct dynamic expression analysis research. Fig. 1 shows several pleased expression sequence fragments of a tester.

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Figure 1. A sequence of pleased expression.

Cohn-Kanader facial expression database implements expression coding with FACS, as shown in Table I.

TABLE I. ALL THE TEN PERSON EXPRESSION SEQUENCE OF FACS CODING IN COHN-KANADE.

Basal Expression	AU Assemble
Surprise	AU1, 2, 5, 15, 20
Scare	AU1, 2, 4, 5, 15, 20
Aversion	AU2, 4, 9, 15, 17
Angry	AU2, 4, 9, 20, 26
Happy	AU1, 6, 12
Grief	AU1, 4, 15, 23

III. PARAMETRIC MODELING OF FACIAL EXPRESSION

A. Properties of the Sequence Selection

We use the FACS to define the standard face mesh, and the parameterized modeling is based on this mesh. We divide the model into six areas, including eyebrows, eyes, nose, cheeks, lips and chin, and define feature points of each parts (see Fig. 2). All muscle motion units (AU) defined in the FACS are included in these six areas.

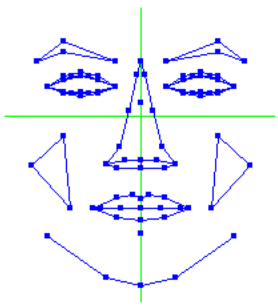

Figure 2. Standard facial mesh model.

The motion of each AU is measured by the motion vector of its corresponding feature points. In order to make the motion of AU with global usability, we have introduced in the face animation parameter unit (FAPU) of the MPEG-4 facial standard to describe the motion vector of the AU. The MPEG-4 face standards use six distances as the basic parameters, namely: diameter of iris, distance between two eyes, distances between eyes and nose, nose and mouth, distance between two lips and the deflection magnitude.

B. Cohn-Kanade Expression Database Analysis

After grouping all facial expression sequences in Cohn-Kanade facial expression database, we find out that amounts of the six expressions above are 93, 36, 33, 55, 105 and 75, respectively. In addition, there are 67 natural expressions. Then count the number of AU in these six basic facial expressions, respectively. As shown in Table II.

TABLE II. BASAL EXPRESSION CONSTITUTE IN COHN-KANADE DATABASE.

Subject #	Session #	FACS Code
10	001	1+2+20+21+25
10	002	1+2+5+25+27
10	003	4+17
10	004	4+7e+17d+23d+24d
10	005	4+6+7+9e+16+25

Moreover, we present the AU Frequency Statistics in the database which involve all the facial expression sequence. As shown in Table III (omit the AU of which frequency lower than 40).

TABLE III. AU FREQUENCY TABLE IN COHN-KANADE EXPRESSION DATABASE.

AU Number	Quoted Time	Description
25	294	Lips part
4	168	Brow Lowerer
17	157	Chin Raiser
1	144	Inner Brow Raiser
6	117	Cheek Raiser
12	113	Lip Corner Puller
2	100	Outer Brow Raiser
5	97	Upper Lid Raiser
27	76	Jaw Drop
15	74	Lip Corner Depressor
20	69	Lip stretcher
9	50	Nose Wrinkler
23	43	Lip Tightener
24	43	Lip Pressor

We can see from Table II and Table III that the high Frequency of AU can be combined to a variety of basic Expressions. Therefore, we can build an initial parameterized model of facial expression simulation, after extracting the motion vectors of all high-frequency AU.

C. Facial Expression Movement Parameters Extraction

We practice and adjust a lot with the expression sequences related to the above-mentioned high frequency AU. The basic idea of the experiment is:

1) Determine the animation parameters of AU motion vector according to the region and the corresponding feature points of facial standard mesh, and then extract the feature points of the same image sequence. As shown in Fig. 3;

2) According to the feature point trajectory fitting the motion vectors of feature points in an image sequence;

3) Repeat (1) (2) step on the same AU with different expression sequence, then filter the motion vector group of each feature point, take the averaging as the motion vector of the feature point, and then combine all the motion vectors as the definition of the AU Expression Parameters.

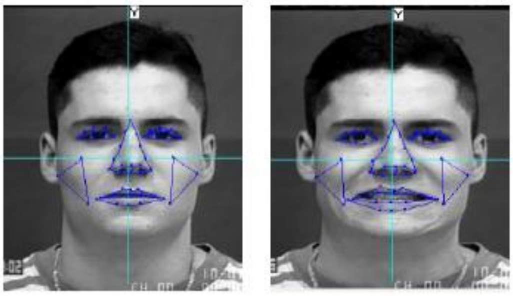

Figure 3. The feature points extracted in the same expression sequence.

The specific expression of AU expression motion unit can be extracted follow the above 3 steps. The specific process is:

1) steps of matching to extract the corresponding feature points:

a) Standardized the size of each image as 640*480;

b) Confirm the facial region of AU expression motion unit and the used animation parameter units;

c) Divide the facial image into various areas with Adaboost Face Detection Algorithm [9], and target the region which the AU belongs to;

d) Extract the corresponding feature points in the region with Edge and Corner Detection Algorithm, and calculate the value of the animation parameter units. Adopting the manual calibration in the cheek area as a supplement, for it is not obvious;

e) Save the value of animation parameter units and the corresponding coordinates of the AU feature points;

2) steps of fitting the motion vectors of feature points in a graphical sequence:

a) Set the initial coordinates of feature point S0 as the first image coordinates in the image sequence. The space of initialized picture is n0 = 1;

b) In the image sequence, calibrate the coordinates S1, S2, S3 ….. Sn (n is the image number of the image sequence) of feature points in each image. Then, generate motion vector V10, V20, V30 ….. Vn-10 according to the coordinate differences between the image feature points of adjacent n0;

c) Calculate the mean of motion vector V0', and treat V10, V20, V30 ….. Vn-10 as n-1 sample values of motion vector V, V0' as initial expectation of V, then the variance r0'of motion vector V can be calculated;

d) Set n1 = n0 + 1, generate the motion vector V11, V21, V31….. Vn-11 according to the coordinate differences between the image feature points of adjacent n1, and calculate the mean of motion vector V1' and the new variance r1';

e) Set ni = ni-1 + 1, repeat step (4) till ni = n;

f) Choose the minimal Vi' of Variance ri' (0<i<n-1) as motion vector of the feature point in the image sequence.

IV. Experimental Results

There are 15 groups of AU motion vectors extracted in the above experiment, and the deferent facial expressions can be constituted by the AU motion vectors. The specific facial expression can be simulated by applying the AU motion vector to the specialized human face mesh. The 2 groups of facial expression simulation results are shown in Fig. 4 and Fig. 5.

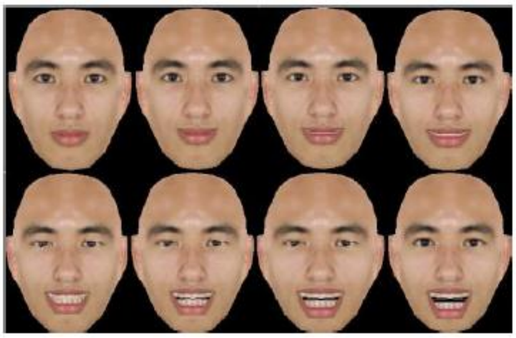

Figure 4. A group of laughing facial expression simulation sequence.

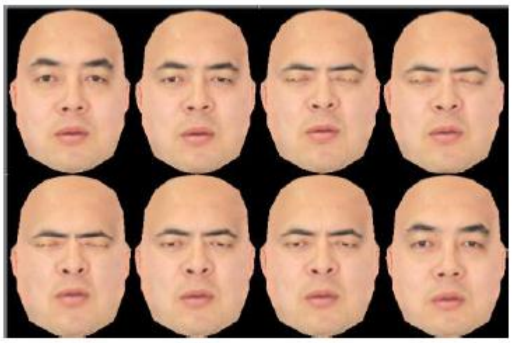

Figure 5. A painful facial expression simulation sequence.

V. Summary and Prospect

The paper extracts facial expression motion vector with Cohn-Kanade Facial Expression Database, and constructs an expression animation parametric model with expression motion vector, which obtains good simulation results. The next step is the optimization and improvements of Facial Expression Parametric Model.

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