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A Simple Line Drawing Definition and Transfer Model for Facial Animation Generation

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Abstract

The Line Drawing Animation is an active research area in Non-Photorealistic Rendering. Many researchs are focused on the skech abastract, like such as portrait drawing of human and animation generation. However most of the model are too complex to calculate or pay attention to the details which are not stable that are not suitable for realtime transfer for continuous sequence of video. This paper proposes a simple line drawing definition and transfer model with Bézier Curves and the core of the AAM fit parameters. The facial line drawings have seven basic emotions include neutral, happiness, anger, disgust, fear, sadness and surprised. Each of the drawing in a specific model is consisted of a same set of cubic Bézier curves. The proposed model is suitabl for shape conbination anmition. In the experiment, the AAM method is used to get the facial features of the face and then find the nearest combination of the emotion to transfer to the line drawing model. The result shows that the method is simple and fast. Only a few of the parameters are needed to transfer that is suitable to record and communication.

Keywords: *line drawing, bézier curves, AAM*

1. Introduction

Non-Photorealistic Rendering (NPR) is an area of computer graphics that has been widely used in digital art. Line drawing animation is one of the most active styles in NPR. Although considerable research has been done on line drawings, continuous line drawing animation which is suitable for facial expression animation automated generation and communication is still a challenging task.

Recent years, creating line drawings from images or 3D range data has been extensively studied [1-5]. [1] uses a set of hand-drawn images of facial features to perform morphs to generate animation that need some hand-drawn basic facial components pressions. In [2], They proposed a 3D pen and ink style drawings from a range image. [3] generate a line drawing from a shaded image. [4] proposes a method to produces plausible animated constructions of input line drawings. [5] propose an image creation model to produce line drawing from 3D models.

Previous research on facial line drawing cartoons has demonstrated the approach in portrait, e.g. [1] and [6], and then for facial sketch. [7] proposed a neighbour expression transfer model (NET) to transfer expressions and [8] presents a method to get expressive caricatures of basic main expressions but they need that there is a approximate face existed in the train set. [9], create multi-view hand-drawn sketches by using a hybrid sketch-based method. [10] use a facial expression graph to extract the facial actions and then transfer that to cartoon model based on ANN.

Although those researches are exciting, most of the model are too complex to calculate or pay attention to the details which are not stable that are not suitable for realtime transfer for continuous sequence of video.

This paper proposes a simple line drawing definition and transfer model with Bézier Curves and the core of the AAM [11] fit parameters. When an input video comming, the animation could be generated automaticly without manual intervention. And also the model is simple and easy to achieve which are suitable to transfer in the online communication.

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This paper is organized as follows. Section 2 we will propose the line drawing model definition with seven basic emotions based on bézier curves. Section 3 describe the research method, including how to train and track the facial feature points and how to decompose to basic emotions and transfer to the line drawing models. The last two sections are the results and conclusion.

2. Proposed Line Drawing Model

In this paper, we choose the shape combination method to make the facial animation. The shapes are divided into seven different emotions like the [12] proposed which are neutral, happiness, anger, disgust, fear, sadness and surprised. we choose bézier curve with width to describe the facial line drawing model and most of the curves are cubic curves with four control points. The control points are saved to file for reused. Some lines share one control point with the line previous or next to them.

3.1. Curves

In computer graphics and computer aided design, bézier curves are used widely. The curve is controlled by several control points and could be directly manipulated in the convex hull by control points intuitively. Adjustion of the positions of control points can make the curve deformed.

Linear Bézier curves A linear Bézier curve is a straight line and have two control points P_0 and P_1,

$$B(t) = (1-t)P_0 + tP_1, \quad t \in [0,1] \tag{1}$$

Quadratic Bézier curves A quadratic Bézier curve havs three control points P_0, P_1, and P_2,

$$B(t) = (1-t)^2P_0 + 2(1-t)tP_1 + t^2P_2, \quad t \in [0,1] \tag{2}$$

Cubic Bézier curves Four points P_0, P_1, P_2 and P_3 in the plane or in higher-dimensional space define a cubic Bézier curve. The curve starts at P_0 going toward P_1 and arrives at P_3 coming from the direction of P_2.

$$B(t) = (1-t)^3P_0 + 3(1-t)^2tP_1 + 3(1-t)^2t^2P_2 + t^3P_3, \quad t \in [0,1] \tag{3}$$

In this paper we choose Bézier curve with width to describe the facial line drawing model and most of the curves are cubic curves with four control points.

3.2. Line Drawing Model

The expressions of people could be classified into six facial expressions which are common to all. Those expressions are happy, anger, disgust, fear, sadness and surprised [12]. McCloud defined six basic emotions and considered these basic emotions can be blended to achieve complex emotions [13]. Grimace project gives the origin graph of the caricature based on [13] in their web site. In this paper, we defined this six emotions with line drawings of bézier curves to generate the animation.

Figure 1. Face Background and Curve Definition (eyebow and mouth), Red Circles are the Control Points

Table 1. Facial Line Drawing Model

No	Neutral			Happy			Anger			Disgust			Sadness			Fear			Surprised		
	x	y	w	x	y	w	x	y	w	x	y	w	x	y	w	x	y	w	x	y	w
0	365	270	1	365	285	1	366	290	1	365	298	1	367	302	1	367	272	1	365	268	1
1	340	243	4	339	261	4	339	263	4	340	274	4	346	273	4	346	249	4	341	222	4
2	304	244	4	304	262	4	296	286	4	304	297	4	312	306	4	312	285	4	304	223	4
3	274	264	3	275	279	3	274	307	3	275	300	3	275	277	3	275	252	3	274	253	3
4	132	269	1	133	285	1	132	290	1	133	298	1	131	302	1	131	272	1	133	268	1
5	154	248	4	159	261	4	159	263	4	158	274	4	152	273	4	152	249	4	157	222	4
6	190	242	4	194	262	4	202	286	4	194	297	4	186	306	4	186	285	4	194	223	4
7	221	263	3	223	279	3	224	307	3	223	300	3	223	277	3	223	252	3	224	253	3
8	345	303	1	345	303	1	345	303	1	345	303	1	345	303	1	345	303	1	345	303	1
9	331	278	3	330	289	3	330	283	3	328	300	3	329	312	3	330	269	3	330	269	3
10	302	276	3	302	295	3	305	278	3	302	302	3	298	303	3	301	264	3	301	264	3
11	282	309	2	282	309	2	282	309	2	282	309	2	283	299	2	282	309	2	282	309	2
12	152	304	1	153	303	1	153	303	1	153	303	1	153	303	1	153	303	1	153	303	1
13	169	278	3	168	289	3	168	283	3	170	300	3	169	312	3	168	269	3	168	269	3
14	200	278	3	196	295	3	193	278	3	196	302	3	200	303	3	197	264	3	197	264	3
15	215	307	2	216	309	2	216	309	2	216	309	2	215	299	2	216	309	2	216	309	2
16	282	309	1	282	309	1	282	309	1	282	309	1	283	299	1	282	309	1	282	309	1
17	298	307	3	299	295	3	301	308	3	301	295	3	300	307	3	299	310	3	299	310	3
18	326	333	3	325	292	3	327	324	3	327	304	3	328	312	3	327	331	3	327	331	3
19	345	303	1	345	303	1	345	303	1	345	303	1	345	303	1	345	303	1	345	303	1
20	215	307	1	216	309	1	216	309	1	216	309	1	215	299	1	216	309	1	216	309	1
21	200	309	3	199	295	3	197	308	3	197	295	3	198	307	3	199	310	3	199	310	3
22	178	331	3	173	292	3	171	324	3	171	304	3	170	312	3	171	331	3	171	331	3
23	152	304	1	153	303	1	153	303	1	153	303	1	153	303	1	153	303	1	153	303	1
24	241	454	3	241	430	3	239	432	1	241	429	1	239	446	1	239	431	1	247	428	1
25	249	454	3	249	430	3	249	434	1	249	434	1	249	444	1	249	429	1	249	431	1
26	261	454	3	261	430	3	260	430	1	271	426	1	267	450	1	267	432	1	267	425	1
27	273	454	3	273	428	3	275	429	1	282	426	1	285	442	1	285	431	1	273	432	1
28	258	454	3	258	430	3	259	432	1	257	429	1	259	446	1	259	431	1	251	428	1
29	249	454	3	249	430	3	249	434	1	249	434	1	249	444	1	249	429	1	249	431	1
30	237	454	3	237	430	3	238	430	1	227	426	1	231	450	1	231	432	1	231	425	1
31	225	454	3	225	428	3	223	429	1	216	426	1	213	442	1	213	431	1	225	432	1
32	261	454	3	261	430	3	261	432	1	261	429	1	267	446	1	267	432	1	261	429	1
33	273	454	3	273	428	3	278	425	1	291	422	1	294	436	1	291	426	1	273	428	1
34	285	455	3	297	428	3	292	433	1	306	428	1	310	443	1	299	438	1	284	438	1
35	304	454	1	313	434	1	303	455	1	305	452	1	307	453	1	303	453	1	283	465	1
36	237	454	3	237	430	3	237	432	1	237	429	1	231	446	1	231	432	1	237	429	1
37	225	454	3	225	428	3	220	425	1	207	422	1	204	436	1	207	426	1	225	428	1
38	214	455	3	211	428	3	206	433	1	192	428	1	188	443	1	199	438	1	214	438	1
39	194	454	1	184	434	1	195	455	1	193	452	1	191	453	1	196	453	1	215	465	1
40	304	454	1	313	434	1	303	455	1	305	452	1	307	453	1	303	453	1	283	465	1
41	288	455	3	297	464	3	289	462	1	304	464	1	309	462	1	306	483	1	282	475	1
42	280	455	3	277	480	3	272	464	1	282	460	1	294	463	1	286	473	1	270	482	1
43	268	455	3	261	479	3	260	466	1	266	456	1	266	461	1	266	473	1	257	483	1
44	194	454	1	185	434	1	195	455	1	193	452	1	191	453	1	195	453	1	215	465	1
45	210	455	3	201	464	3	209	462	1	194	464	1	189	462	1	192	483	1	216	475	1
46	218	455	3	221	480	3	226	464	1	216	460	1	204	463	1	212	473	1	228	482	1
47	230	455	3	237	479	3	238	466	1	232	456	1	232	461	1	232	473	1	241	483	1
48	280	454	3	272	476	3	275	462	1	280	460	1	286	462	1	286	473	1	270	480	1
49	268	454	3	259	481	3	261	467	1	266	456	1	266	459	1	266	473	1	258	484	1
50	249	455	0	249	479	0	249	466	0	249	455	0	249	459	0	249	472	0	249	485	0
51	241	456	3	242	480	3	238	465	1	239	457	1	240	461	1	240	474	1	242	483	1
52	218	454	3	226	476	3	223	462	1	218	460	1	212	462	1	212	473	1	228	480	1
53	230	454	3	239	481	3	237	467	1	232	456	1	232	459	1	232	473	1	240	484	1
54	249	455	0	249	479	0	249	466	0	249	455	0	249	459	0	249	472	0	249	485	0
55	258	456	3	256	480	3	260	465	1	259	457	1	258	461	1	258	474	1	256	483	1

The model includes seven images, a neutral expression and six basic emotions of happiness, anger, disgust, fear, sadness and surprised. Each image consists of a face

background (the nose and face contour. See Figure 1) and the facial features (the eyes, eyebrows, lip etc.) as shown in Table 1.

We use bézier curve with width to define the strokes and describe the stokes' width at every control point, as in (4).

$$\{(x_i, y_i, w_i) | \ 1 \ \leq i \ \leq n\} \quad (4)$$

Where (x_i,y_i) is the coordinate of the control point i and w_i is the width of the stroke.

On drawing, the width of every point is calculated by the segmentation and interpolation of the adjacent control points.

Those definition of the model are showed in Table 1. In this definition, the number of control points is 56 and curves number is 14. Each column show one emotion of the model. The unit is pixel and the rows are the control points.

Table 2 shows the lines of the model. There are 14 lines and each of those are cubic and include four lines for eyes, two for eyebrows and the eight lines for mouth. The numbers in Points No column shows the control points, with the order of curves control points.

Table 2. The Control Points of Lines

Line Name	Control Points Num	Points No
rbow	4	0,1,2,3
lbow	4	4,5,6,7
reyeulid	4	8,9,10,11
leyeulid	4	12,13,14,15
reyeblid	4	16,17,18,19
leyeblid	4	20,21,22,23
rmulink	4	24,25,26,27
lmulink	4	28,29,30,31
rmu	4	32,33,34,35
lmu	4	36,37,38,39
rmb	4	40,41,42,43
lmb	4	44,45,46,47
rmblink	4	48,49,50,51
lmblink	4	52,53,54,55

3. Research Method

With the seven basic emotions, we need get the ratios of the distribution of the emotions to blend the shape to achieve the animation. In this paper, a core of AAM is used to get the ratios. Before decomposing the expression, the person is required to perform some expression in front of the camera which is recorded and analysed with AAM to get the special emotion shape. When a frame is inputted, the AAM fit the shape of current face and locating the shape features points and then decompose that shape into ratios of personal emotion shapes. At last transfer this ratios to line drawing model to get the animation result. The process is showed in Figure 2.

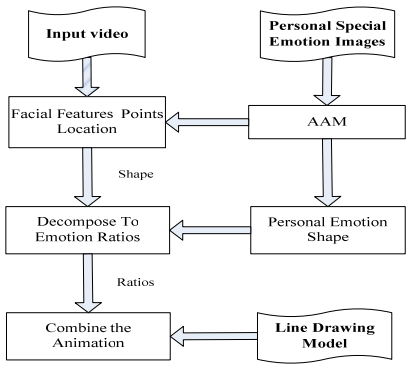


Figure 2. The Animation Generation Process

The AAM fit process is based on the work of [11]. See in (5).

$$\sum_{x\in S_0}\left[A_0(x)+\sum_{i=1}^{m} l_i A_i(x)-I\left(N(W(x;p);q)\right)\right]^2 \quad (5)$$

Where the coefficients p is the shape parameters and The base shape S_0 is the mean shape and the vectors Ai are the eigenvectors of the appearance, W(x;p) means warp the pixel in the current facial shape of the input image to S_0, q is the global parameter, include rotation, scale and translation.

In AAM, the global parameter q is used to adjust the fit result to match the inputted face and necessary in the fit process, however that is irrelevant to the expression. So in this paper, the parameter q of AAM fit result is abandoned after the fit process.

The personal special emotion images are performed and fit with AAM. The fit result shapes are recorded and used to decompose the fit result in above paragraph by singular value decomposition (SVD).

$$\begin{cases} S(x)=\sum_{i=1}^{7}\alpha_i E_i(x) \\ \sum_{i=1}^{7}\alpha_i = 1 \end{cases} \quad (6)$$

Where S is the shape and E_i is the shape of personal emotion shapes. α_i is the ratio of ith emotions.

After decomposition, the α_i is transfered to the corresponding line drawings.

4. Experiment Results and Discussion

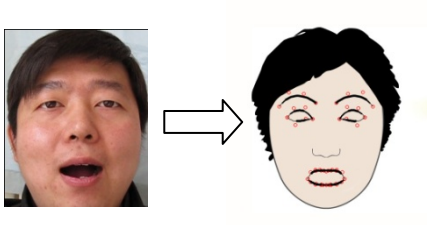
The line drawings are formed with bézier curve as showed in Table 1. In this paper, a simple facial line drawing model is used to finish the experiment. See it in section II.

We write a tool to design the line drawings which could draw the bézier curves and fit a video with AAM and output the ratios of the result. After animation generation, the ratios of each frame could be adjusted.

The AAM model is built with the IMM Face Database [14], some Asian facial images and a few of personal images. The tool is implemented with VC++2010 and OpenCV2.1.

The personal special images are showed in Figure 3. All of the special images are aligned to main shape of the AAM trained model. Seven emotions are recored and fit with AAM to get the shape of the special emotions which are corresponding to the emotions in line drawing model.

Figure 3. Personal Special Emotion Images (After align to AAM main shape)



Transfer ratios :

Neutral	0.22
Happy	0.11
Anger	0.50
disgust	-0.08
fear	0.11
sadness	0.06
surprised	0.06

Figure 4. A frame (No 316) of the Experiment, Transfer Ratios Shows the Ratio of Every Emotion

In the experiment, a video is inputted to test the model. From Each frame, the method get a ratios of the emotions and then transfer them to the line drawing model. Figure 4 shows a frame from the video. The sum of the ratios is 1, but a few of them may below zero which is caused by the decomposition and in the experiment and has not serious consequences on the results.

Some other line drawing results are showed in Figure 5. The number right to the images are the emotion ratios of the frame. From the result, we can draw a conclusion that although there are only seven ratios to express the facial expression, the model could effectively generate a rich animation.

Figure 5. Some Line Drawing Results

The test video has 1241 frames, the emotion ratios record file is only 26k Byte, the runtime of the transfer is about 100s which include the AAM fit process on a PC(CPU 2.3GHz, 2G Ram). That shows this method is suitable to record and communication.The distribution of the emotions are showed in Figure 6. Figure 6 illustrate that most of the emotion ratios are between -0.4 and 0.6. The neutral, anger and fear are easier to extract than happy and disgust with our method. The disgust complements to the other sometimes.

Figure 7 illustrate that surprised emotion is very stable between the frames and others fluctuates in a small range but change faster when the expression is changed quickly.

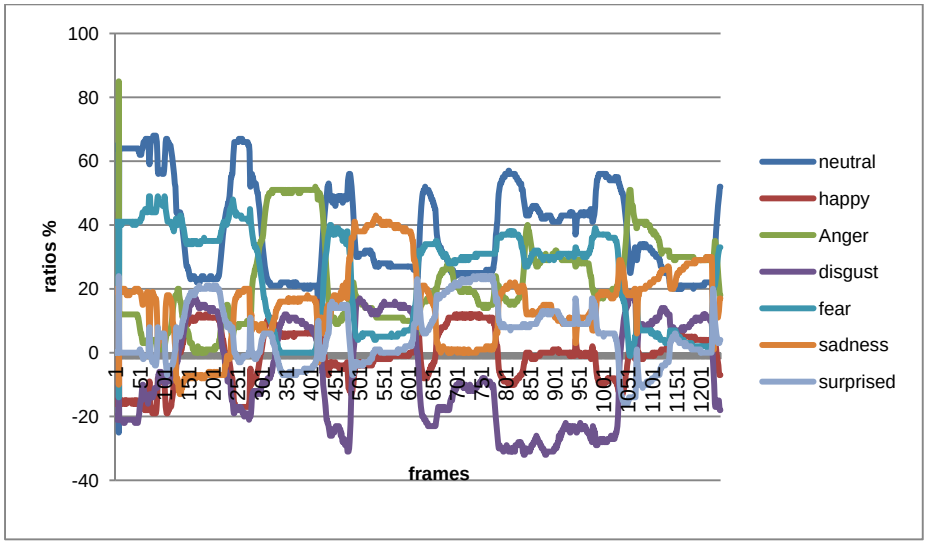


Figure 6. The Ratios of each Emotion in the Frames.

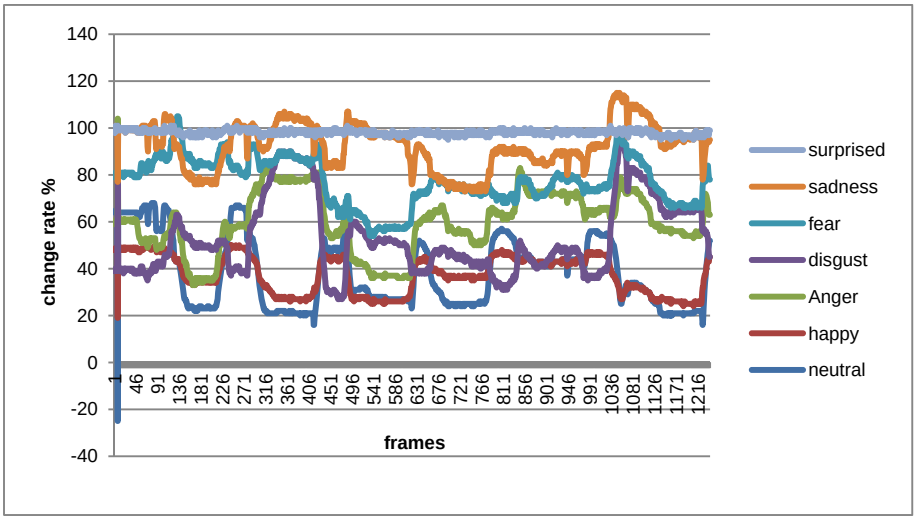


Figure 7. The Change Rate of the Ratios of each Emotion in the Frames

5. Conclusion

Through the proposed line drawing definition model and transfer method, a line drawing animation can be automaticly generated. The line drawings model are simple, easy to achieve, less memory space and run fast. So the proposed method is capable of transfering expression videos to line drawing animations for the purpose of communication. Because of the use of shape combination animation method, that conforms to the industrial standard and is easy to change the animation figure, even the animal figure. The person need play or input some special expressions for the decomposition of AAM that is lack of the method. Introduce a plenty of facial emotion image database to train the special AAM may solve that. More animation figure should be provided for output choise and the details of the face could be added. Those would be our work in the future.

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