Facial Expression Data Recording and Labeling Protocol for FEAFA+ Dataset

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1. Introduction

Facial expression analysis based on machine learning requires large number of well-annotated data to reflect different changes in facial motion. Publicly available datasets truly help to accelerate research in this area by providing a benchmark resource, but all of these datasets, to the best of our knowledge, are limited to rough annotations for action units, including only their absence, presence, or a five-level intensity according to the Facial Action Coding System [1]. To meet the need for videos labeled in great detail, we present FEAFA+ [2] (https://www.iiplab.net/feafa+/). One hundred and twenty-two participants, including children, young adults and elderly people, were recorded in real-world conditions. In addition, 99,356 frames were manually labeled using Expression Quantitative Tool developed by us to quantify 9 symmetrical FACS action units, 10 asymmetrical (unilateral) FACS action units, 2 symmetrical FACS action descriptors and 2 asymmetrical FACS action descriptors, and each action unit or action descriptor is well-annotated with a floating point number between 0 and 1. To provide a baseline for use in future research, a benchmark for the regression of action unit values based on Convolutional Neural Networks are presented. We also demonstrate the potential of our FEAFA dataset for 3D facial animation. Almost all state-of-the-art algorithms for facial animation are achieved based on 3D face reconstruction. We hence propose a novel method that drives virtual characters only based on action unit value regression of the 2D video frames of source actors.[4][5]

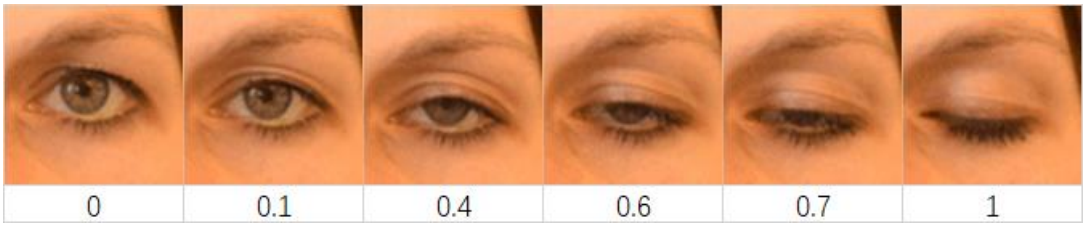
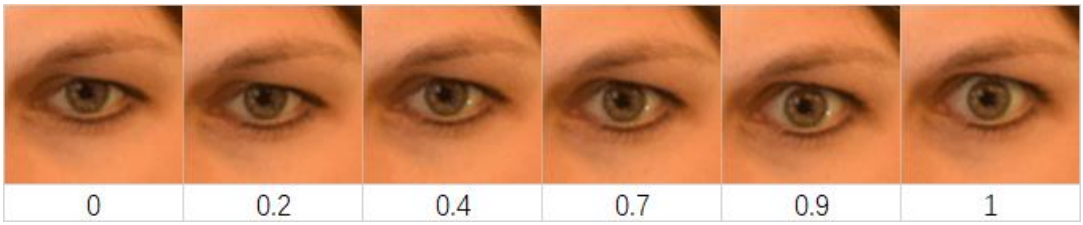
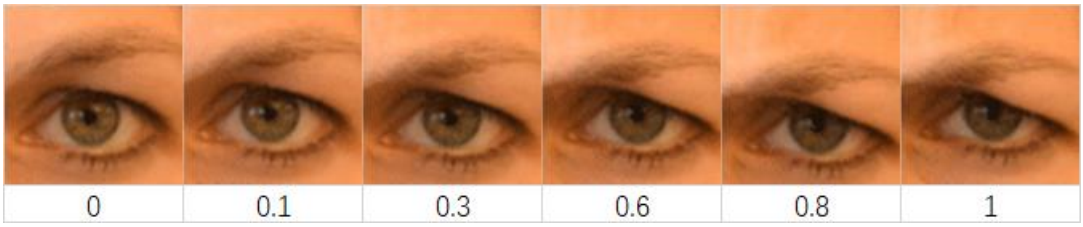
2. AU Annotation

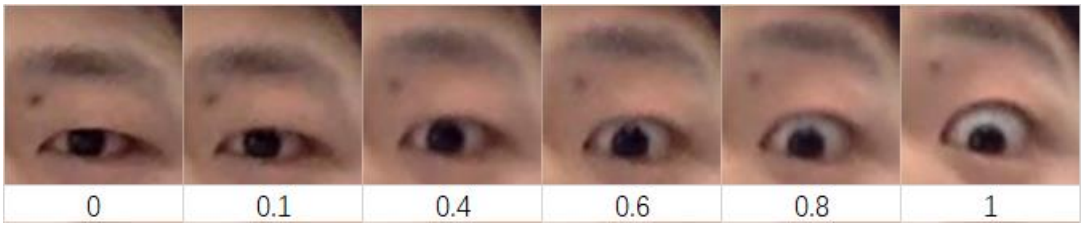
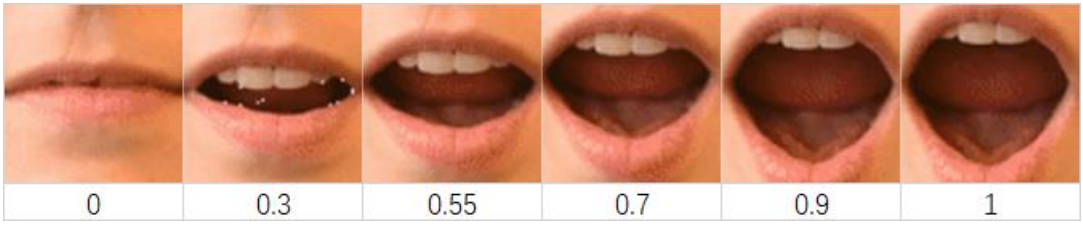
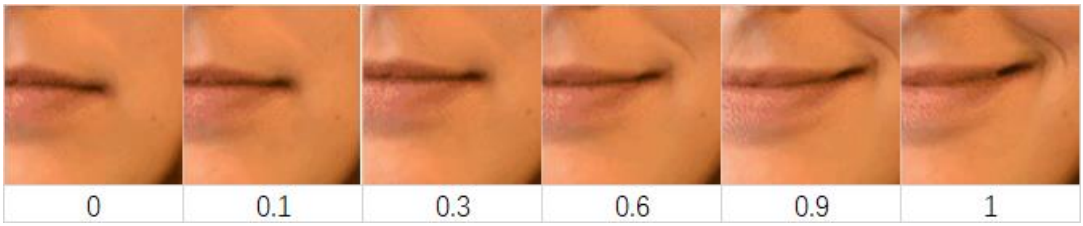
We provide a parameter system with 25 re-defined AUs for facial expression quantization in order to describe facial expression in great detail. We selected nine symmetrical FACS AUs, 10 asymmetrical (unilateral) FACS AUs, two symmetrical FACS ADs, and 2 asymmetrical FACS ADs to describe most expressions of the human face. To facilitate facial expression analysis based on our database, especially the blendshape process for 3D facial animation, we reorganized and renumbered the FACS AUs and ADs. Moreover, we refer to all of these facial actions as AUs for convenience. We also renamed the asymmetrical AUs, and, in particular, we also subdivided some AUs into upper and lower ones. Specifically, for AU43 (Eye Closure) in the FACS, we regard Left Eye Close and Right Eye Close as two different AUs. In addition, AU2, AU4, AU5, AU20, AU30 in the FACS are also subdivided in this way. For AU28 (Lip Suck) in the FACS, we subdivided it into Upper Lip Suck and Lower Lip Suck. We hence obtained neutral expression and the 24 AUs to cover common facial expressions that vary among different individuals.

For AU annotation, we require labels that are more precise than those of FACS which only has five levels for each action units. Hence, we use floating point numbers from 0 to 1 and accurate to two decimal places to quantify each AU. A facial action state that is close to a neutral state is given a corresponding AU value close to 0; larger deviations of the facial action state from the neutral state are given a corresponding AU value that is closer to 1. This special annotation method is instrumental in identifying AU values with expression coefficients. Table 1 shows the definition and description for each AU.

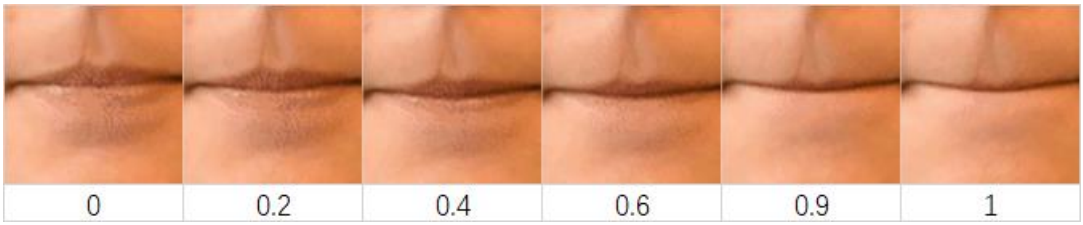
Table 1 AU Definition and Description

AU	Definition	FACS No.	Description
0	Neutral Expression	AU 0	Describe the neutral face with no other special expression. All AUs are 0.
1	Left Eye Close	AU 43	Describe the closure of the left eye. Should be set to 1 when the left eye is completely closed.

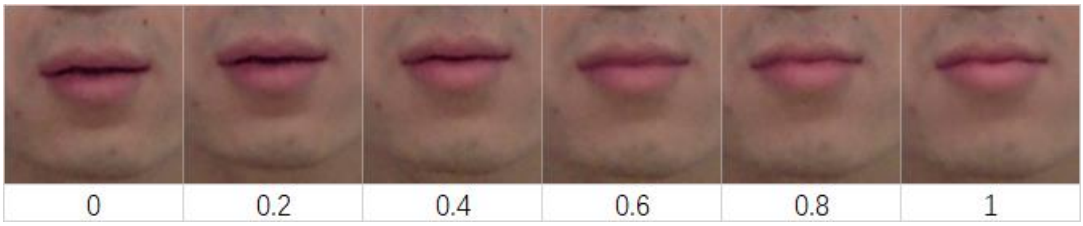
2	Right Eye Close	AU 43	Describe the closure of the right eye. Should be set to 1 when the right eye is completely closed.
 			
3	Left Lid Raise	AU 5	Describe how much the left eye is widened when left lid raises. Should be set to 1 when the left lid raises to the limit.
4	Right Lid Raise	AU 5	Describe how much the right eye is widened when right lid raises. Should be set to 1 when the right lid raises to the limit.
 			
5	Left Brow Lower	AU 4	Describe how much the left brow is pressed downward to show the frown expression.
6	Right Brow Lower	AU 4	Describe how much the right brow is pressed downward to show the frown expression.
 			
7	Left Brow Raise	AU 2	Describe how much the left brow raises，with left lid raising, to illustrate surprise.
8	Right Brow Raise	AU 2	Describe how much the right brow raises， with right lid raising, to illustrate the surprise expression.

			
9	Jaw Drop	AU 26	Describe how much the mouth opens driven by the jaw. Should be set to 1 when the mouth is open to the limit.
			
10	Lip Slide Left	AD 30	Describe how much the lower lip slides left driven by the lower jaw.
			
11	Lip Slide Right	AD 30	Describe how much the lower lip slides right driven by the lower jaw.
12	Left Lip Corner Pull	AU 12	Describe how much the left lip corner raises, which causes the left cheek to raise as well, and AU1 may be involved.
13	Right Lip Corner Pull	AU 12	Describe how much the right lip corner raises, which causes the right cheek to raise as well, and AU2 may be involved.
			
14	Left Lip Corner Stretch	AU 20	Describe how much the left lip corner stretches to the left, to illustrate the action of lip corner and smile face in daily chat. Should be set to 1 when stretching to the limit.

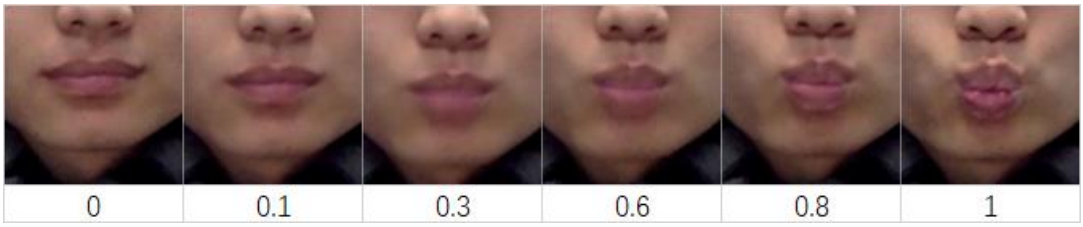
15	Right Lip Corner Stretch	AU 20	Describe how much the left lip corner stretches to the right, to illustrate the action of lip corner and smile face in daily chat. Should be set to 1 when stretching to the limit.
16	Upper Lip Suck	AU 28	Describe how much the upper lip purses to illustrate the pursing expression.
17	Lower Lip Suck	AU 28	Describe how much the lower lip purses to illustrate the pursing expression.

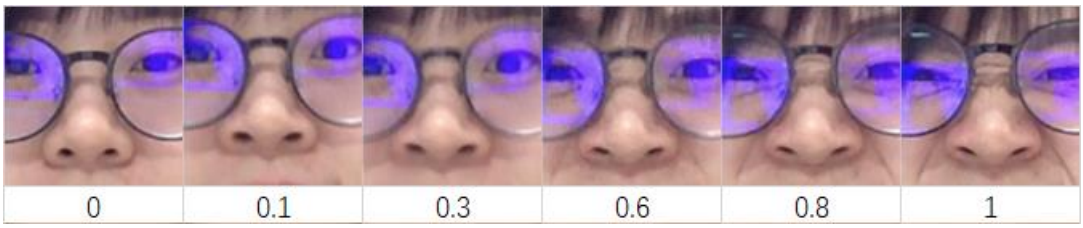


18	Jaw Thrust	AD 29	Describe how much the lower lip moves outward. The variation of this expression is tiny.



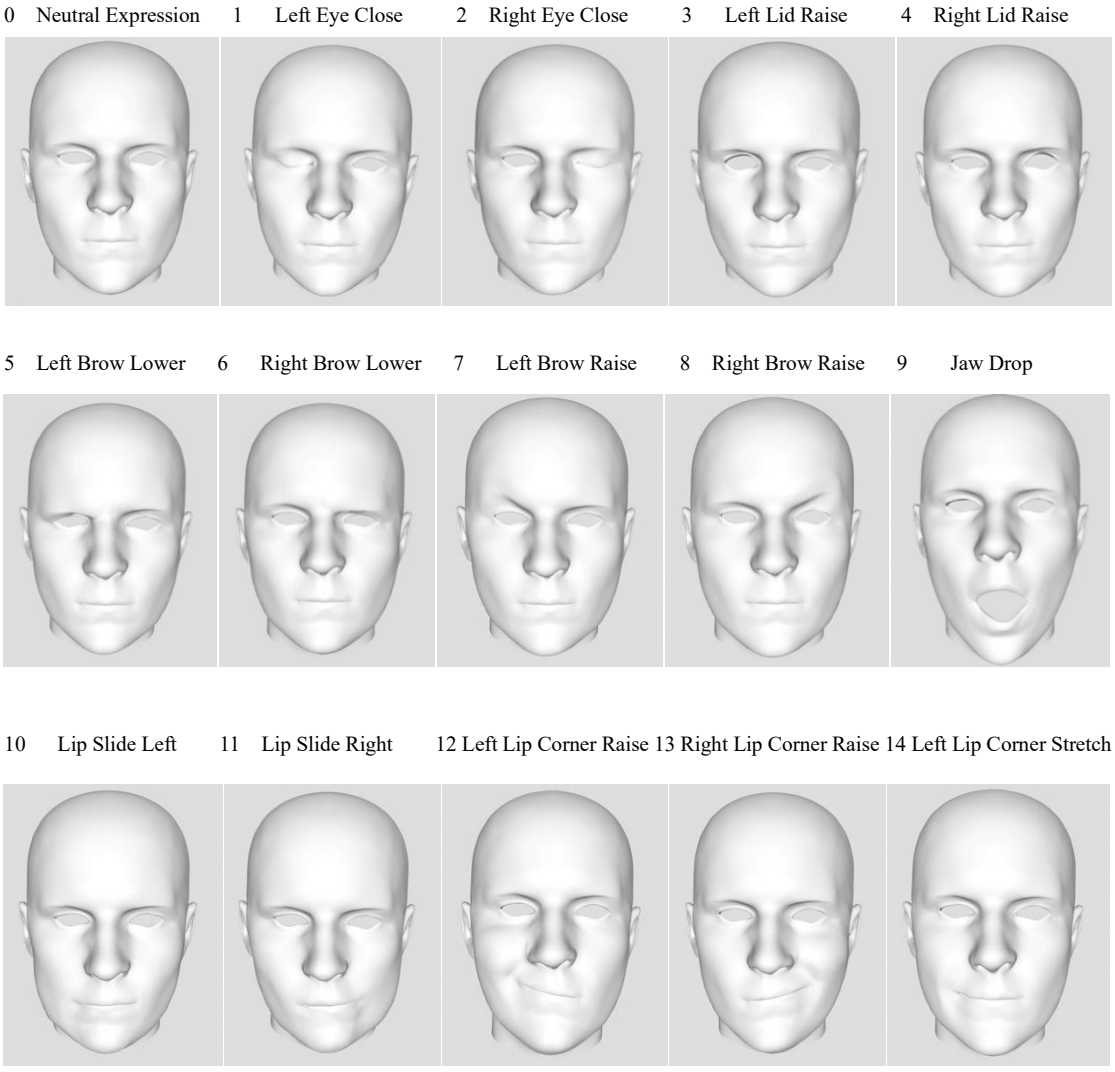
19	Upper Lip Raise	AU 10	Describe how much the upper lip raises, which causes the wing of nose to raise. This expression is not driven by palate.

20	Upper Lip Raise	AU 16	Describe how much the lower lip moves down，with the jaw moving down as well. This expression is not driven by the palate. Notice that the combined effect of AU19 and AU20 is not equal to the effect of AU9.
 0 0.2 0.4 0.6 0.8 0.9			
21	Lower Lip Raise	AU 17	Describe how much the left and right lip corners move down driven by the lower lip raising.
 0 0.3 0.5 0.7 0.85 1			
22	Lip Pucker	AU 18	Describe how much the left and right lip corners move toward each other，with lip wrinkling and pouting.
 0 0.1 0.3 0.6 0.8 1			
23	Cheeks Puff	AD 34	Describe how much the cheeks puff by filling them with the air.
 0 0.1 0.3 0.6 0.8 1			
24	Nose Wrinkle	AD 9	Describe how much the nose raises with wrinkling, which usually illustrates disgust.



3. Relationship between AUs and expression blendshapes

Similar to many facial animation techniques, we represent facial expressions in terms of expression blendshapes. To generate any possible expression of the source actors, we need a neutral face blendshape and 24 expression blendshapes. Figure 1 shows an example of the expression blendshapes selected from FaceWarehouse[3]. And the participants can make expression according to these facial expression model.



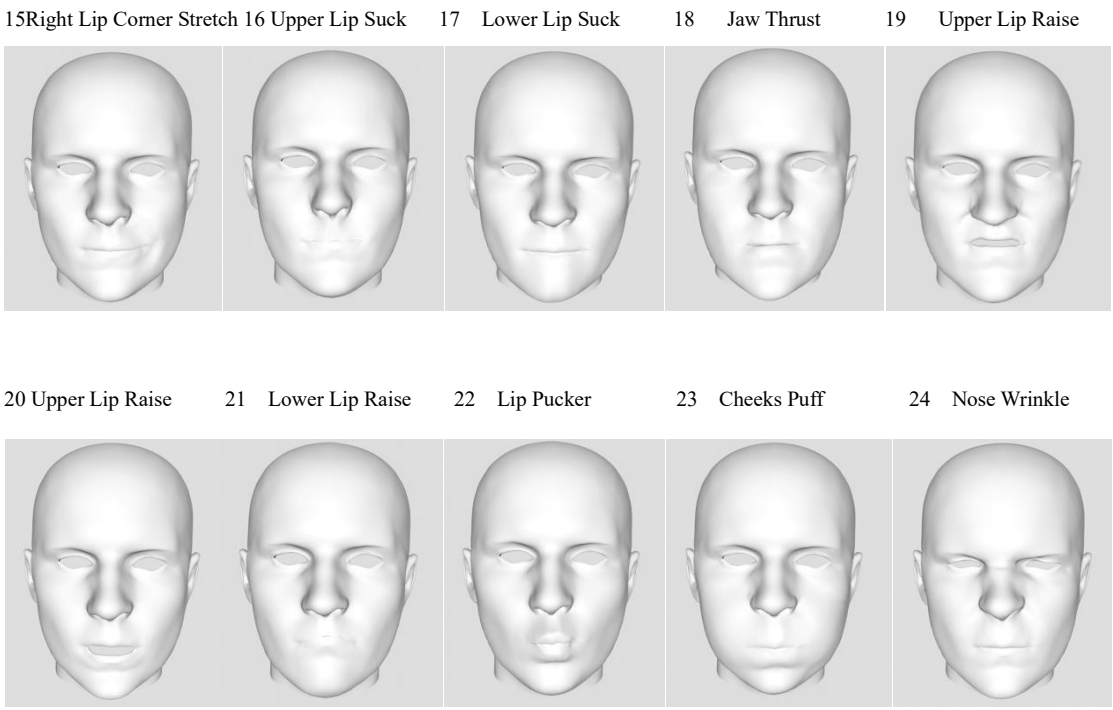


Figure 1 Relationships between AUs and Expression Blendshapes

4. Required Expression

When the videos are recorded, the required expressions are as follows:

1) Eye closure, concerning AU1 and AU2;
2) Surprise. Upper lid raise and outer brow raise，concerning AU3、AU4、AU7、and AU8;
3) Frown. Brow lower and eye maybe little close, concerning AU5 and AU6 and maybe concerning AU1 and AU2;
4) Mouth open, concerning AU9;
5) Mouth stretcher. Firstly, the left lip corner stretches and then back to neutral expression. Secondly, the right lip corner stretches and then back to neutral expression. Finally, both the left lip corner and the right lip corner stretch simultaneously, concerning AU14 and AU15. This expression variation is relatively subtle;
6) Suck. Upper lip sucks, and then lower lip sucks and then both of them suck simultaneously, concerning AU16 and AU17;
7) Smile. Smile without teeth, concerning AU12 and AU13, and then toothy smile,

concerning AU12, AU13 and AU9;

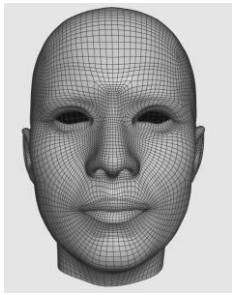
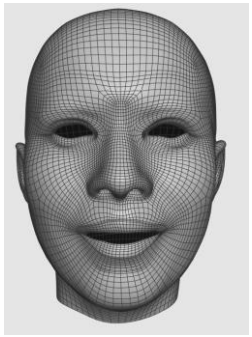
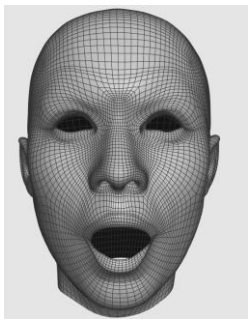
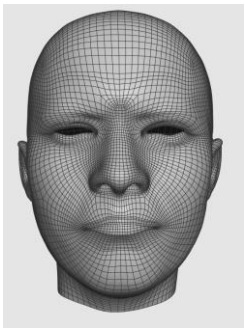
8) Jaw sideways. Jaw slides left and then slides right, concerning AU10 and AU11;
9) Lip corner puller. Left lip corner pull (AU12)， maybe concerning AU1; then right lip corner pull (AU13), maybe concerning AU2;
10) Others. Lip pucker (AU18). Upper lip raiser (AU19). Lower lip depressor (AU20). Chin Raiser (AU21). Lip Pucker (AU22). Cheeks Puff (AU23). Nose Wrinkler (AU24)
11) Mixture expressions.
    a. Lids raise (AU3, AU4) and outer brows raise (AU7, AU8) and jaw drop (AU9);
    b. Jaw Drop (AU9) and slides left and right (AU10, AU11);
    c. Frown (AU5, AU6, AU1, AU2)and Lip depresses (AU21);
    d. Eyes close (AU1、AU2) and cheeks puff (AU23);
    e. Jaw drop (AU9) and upper lip raises (AU19) and lower lip depresses (AU20);
    f. Left lip corner raises (AU12) and left eye closes (AU1) and left brow depresses (AU5), maybe concerning AU2, AU6.
    g. Right lip corner raises (AU13) and right eye closes (AU2) and right brow depresses (AU6), maybe concerning AU1, AU5.

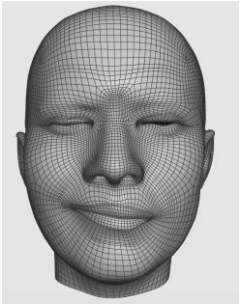
Participants should choose at least 3 expressions and make them trained by our members. Every expression should repeat two or three times

5. Illustration for Labelling AUs

In fact, since the elicited expression changes gradually frame by frame, AU Annotations also should change smoothly. Meanwhile， due to individual differences， the elicited expression would be different even though participants make the same expression. Therefore, during labelling, we need to set right AU values to make the expression on source video frames and the expression on generated 3D facial model as similar as possible. Additionally, we need to measure the deviations of the specific expression from neutral expression for the current subject to set right AU values. Table 2 shows some examples about how to labelling AUs.

Table 2　Examples for labelling AUs.

Video Frames	Generated 3D Model	Labelling Advice
		All AUs should be set to 0.
		AU1: 0.10 AU2: 0.10 AU12: 0.65 AU13: 0.65 AU9: 0.28
		AU3：0.88 AU4: 0.88 AU7：0.85 AU8：0.85 AU9：0.90
		AU: 0.45 AU2: 0.35 AU5：0.8 AU6：0.8 AU21：1 AU24：0.2

		AU1：0.90 AU2：0.73 AU5：0.55 AU6：0.30 AU12：0.95

6. References

[1] Ekman P. Facial Action Coding System: manual. Agriculture, 1978.

[2] Wei Gan, Jian Xue, Ke Lu, Yanfu Yan, Pengcheng Gao and Jiayi Lyu. FEAFA+: An Extended Well-Annotated Dataset for Facial Expression Analysis and 3D Facial Animation[J]. arXiv:2111.02751 (https://arxiv.org/abs/2111.02751), 2021.

[3] Cao C, Weng Y, Zhou K, et al. FaceWarehouse: A 3D Facial Expression Database for Visual Computing. IEEE Transactions on Visualization and Computer Graphics, Vol. 20, No. 3, pp. 413-425, 2014. DOI: 10.1109/TVCG.2013.249

[4] Yanfu Yan, Ke Lu, Jian Xue, Pengcheng Gao and Jiayi Lyu. FEAFA: A well-annotated dataset for facial expression analysis and 3d facial animation. 2019 IEEE International Conference on Multimedia & Expo Workshops (ICMEW 2019), pp. 96-101, Shanghai, China, Jul. 8-12, 2019. DOI: 10.1109/ICMEW.2019.0-104

[5] Yan Yanfu, Lyu Ke, Xue Jian*, Wang Cong, and Gan Wei. Facial Animation Method Based on Deep Learning and Expression AU Parameters. Journal of Computer-Aided Design & Computer Graphics, Vol. 31, No. 11, pp. 1973-1980, 2019. DOI: 10.3724/SP.J.1089.2019.17682