Personal style & NMF-based Exaggerative Expressions of Face

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Introduction

- **Personal Style Mapping**
  - The human face plays a significant role in non-verbal communication with a plethora of expressions varied by personality.

FACIAL EXPRESSION REPRESENTS THE INTERNAL BEHAVIOR OF THE INDIVIDUAL

Introduction

- **Exaggeration Mapping**
  - The magnitude of an expression's intensity causes different interpretations.
  - Diverse levels of intensity exist for even a single expression.

METHODOLOGY FOR EXAGGERATING FACIAL EXPRESSION IS NECESSARY TO HELP PEOPLE COMMUNICATE EFFICIENTLY IN DIGITAL SPACE.

Introduction

- **Motivation**
  - Observers are curious about exaggerated expressions suitable for the personality of characters depicted in applicable areas.
  - Most researches in the area of facial expression synthesis seem to focus on realistic expressions or retargeting rather than exaggerating expressions.
  - In this research, we focus on a methodology for automatic exaggeration of facial expression based on personal style

Related Works

- **Muscle-based facial expression**
  - The influence of a particular muscle is determined by certain parameter. (Parke & Waters, 1987)
  - Implementing the face surface in which the muscles are elastically interconnected with modeled springs. (Platt & Badler, 1981)
  - Method of automatically determining muscle activations that track a sparse set of surface landmarks obtained from motion capture marker data. (Sifakis et al, 2005)

Related Works

- **Performance-driven animation and retargeting**
  - Geometry-driven facial expression synthesis system which automatically synthesizes the corresponding expressions image. (Q. Zhang et al, 2006)

  - A method to solve the motion-cloning problem for retargeting the motion of a source character to a target character with a different structure. (Park & Shin, 2004)
  - Track the motion of traditionally-animated cartoons and retarget it onto 3D models, 2D drawings and photographs. (Bregler et al, 2002)

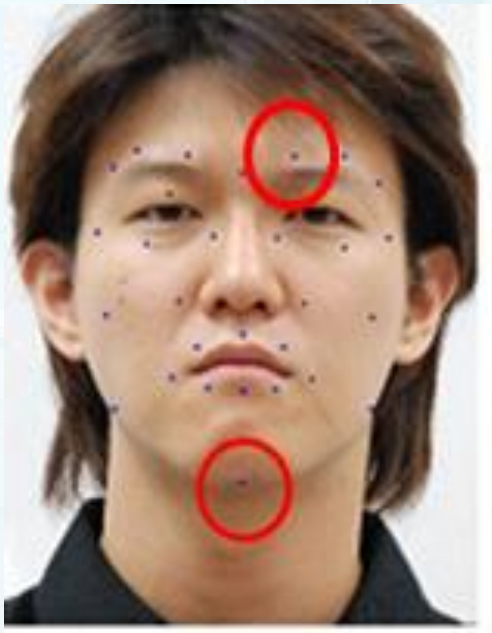
Methodology

- **Personal Style Mapping**
  - Classifying individuals into meaningful and coherent homogeneous groups is required to find common features.
  - Using MBTI G-form and the facial motion samples, 30 participants are classified into four groups of personal styles.
    - EF(extroversion and feeling), ET(extroversion and thinking)
    - IF(introversion and feeling), IT(introversion and thinking)
  - Emotional perception affects mostly Extroversion or Introversion and Thinking or Feeling dimensions.

    (Morand, 2001 / Martin et al., 1996)

Methodology

- **Personal Style Mapping**
  - Take pictures of neutral expression and six universal expressions (i.e. surprise, happiness, anger, disgust, sadness, fear) to get facial motion samples.
  - The 30 markers called Facial Feature Points were defined while referencing MPEG-4



A sample of pictures taken with denoted markers.

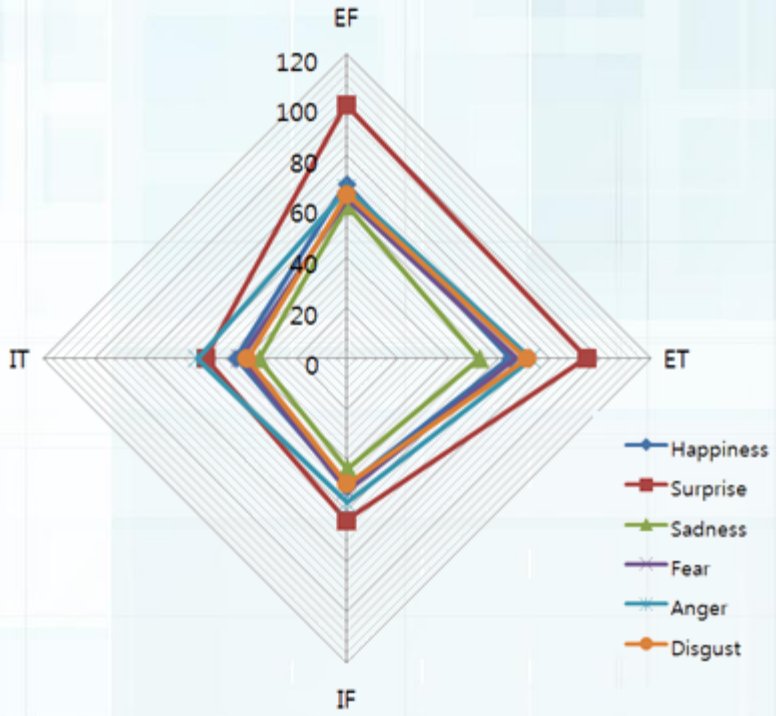
Methodology

- **Personal Style Mapping**
  - Compute a distance δ between markers of six expressions and markers of neutral expressions.

$$\delta = \left(\sum_{s=1}^{k} \| m_s - m_{Ns} \|^p \right)^{\frac{1}{p}}$$

Expression\Style	*EF*	*ET*	*IF*	*IT*
Happiness	**68.82**	64.45	50.90	43.65
Surprise	**100.14**	94.73	64.05	55.82
Sadness	**60.19**	52.17	43.39	34.69
Fear	62.78	**66.91**	52.20	41.86
Anger	67.10	**72.80**	56.94	58.99
Disgust	64.81	**70.88**	49.65	39.42

The average distances of expressions from neutral



Methodology

- **Personal Style Mapping**
  - The initial style rates are calculated the distances of each expressions with style constant g.

$$\varphi_i = \frac{\Delta_{max} - \Delta_i}{\Delta_{max}} + \frac{\Delta_i}{\Delta_{max} \cdot g}$$

$$\Delta_{max} = \delta_{max} - \delta_{min}$$

$$\Delta_i = \delta_{max} - \delta_i$$

Expression\Style	*EF*	*ET*	*IF*	*IT*
Happiness	1.00	0.97	0.88	0.83
Surprise	1.00	0.98	0.86	0.83
Sadness	1.00	0.95	0.89	0.83
Fear	0.97	1.00	0.90	0.83
Anger	0.94	1.00	0.83	0.85
Disgust	0.97	1.00	0.89	0.83

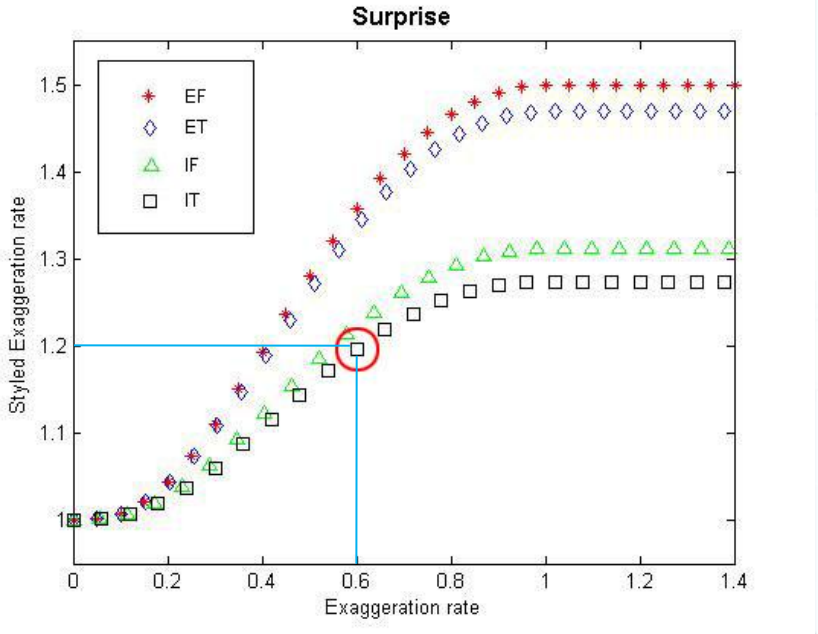
Methodology

- **Personal Style Mapping**
  - Styled Exaggeration Rate (SER)

$$\Theta_s(\omega) = \begin{cases} C & \text{for } \omega \geq 1 \\ k\left(\omega \cdot \frac{1}{\varphi}\right)^n \cdot e^{-\frac{1}{\varphi}(\omega+1)\cdot n} + 1 & \text{for } 0 \leq \omega < 1 \end{cases}$$

- *style index s,*
- *exponent parameter n,*
- *scale parameter k,*
- *convergent value C,*
- *exaggeration rate ω (0~1)*

ω=0 means no exaggeration is applied.
ω =1 indicates the highest rate is demanded.

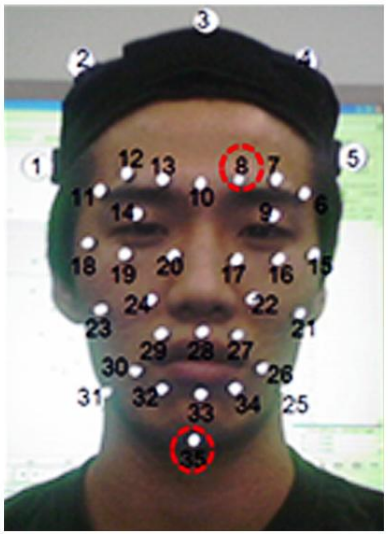


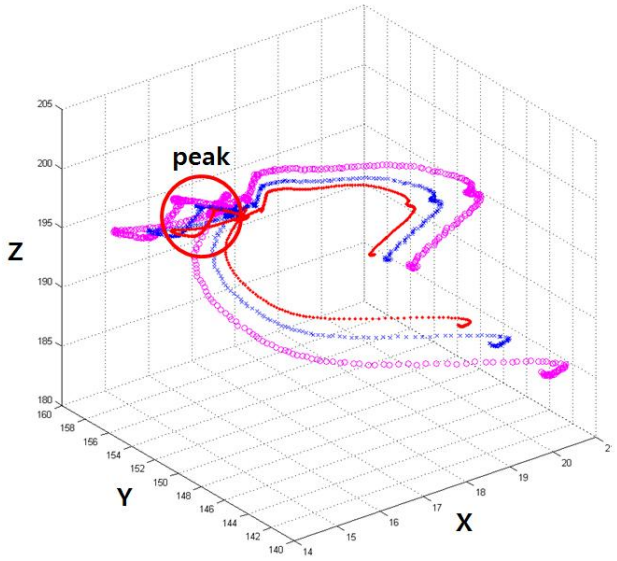
Methodology

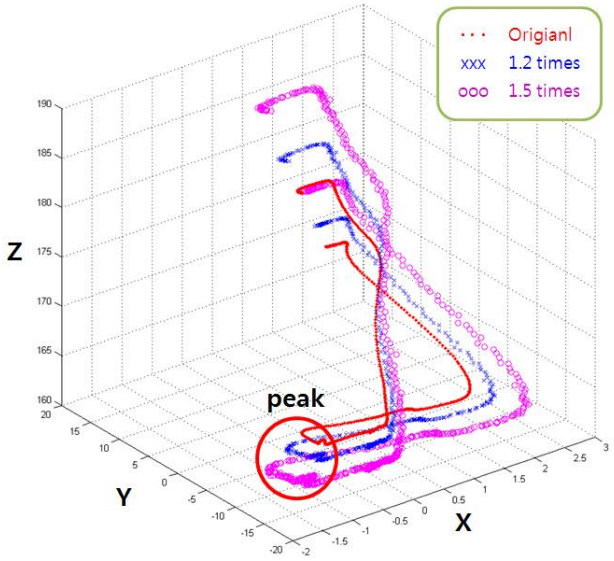
- **Exaggeration Mapping**
  - Emphasize the feature points in which their movements are relatively greater than others.
  - Proper data factorization is required to make this work.
  - NMF is successfully applied to a variety of data set to find part-based linear representations of non-negative data.

Methodology

- **Exaggeration Mapping**
  - Our approach is to employ NMF to represent the feature points of expressions obtained by using optical motion capture system.







Methodology

- **Exaggeration Mapping**
  - NMF decomposes M into two matrices B and E.

$$M_{i\mu} \approx (BE)_{i\mu} = \sum_{a=1}^{r} B_{ia} E_{a\mu}$$

    - Each column of matrix B contains a basis vector.
    - Each column of matrix E includes the weights corresponding to the measurement column in M using the bases from B.

Methodology

- **Exaggeration Mapping**
  - Continuing the iteration of the update,

$$B_{ia} \leftarrow B_{ia} \sum_{\mu} \frac{M_{i\mu}}{(BE)_{i\mu}} E_{a\mu} \qquad E_{a\mu} \leftarrow E_{a\mu} \sum_{i} B_{ia} \frac{M_{i\mu}}{(BE)_{i\mu}}$$

  - M finds an approximate factorization B and E by converging to a local maximum of the objective function.

$$H = \sum_{i=1}^{n} \sum_{\mu=1}^{m} [M_{i\mu} \log(BE)_{i\mu} - (BE)_{i\mu}]$$

Methodology

- **Exaggeration Mapping**
  - Divide E into the mean and the deviation of each column.
  - Each dimension is composed of a basis vector and it's weight, including the mean and the deviation.
  - The facial motion being composed of the feature points for an expression f is in the form of a non-negative linear combination of the basis and a residual.

$$\vec{f} = \sum_i e_i \cdot \vec{b_i} + \vec{r} = \sum_i (m_i + d_i) \cdot \vec{b_i} + \vec{r}$$

Methodology

- **Exaggeration Mapping**
  - The exaggeration mapping is calculated by scaling the deviation and residual with an exaggeration factor.

$$\vec{f}\,' = \sum_i (m_i + t \cdot d_i) \cdot \vec{b_i} + 0.5 \cdot \Theta(\omega) \cdot \vec{r}$$

- $t = 1$ if $|d_i| < 2 \cdot s_i$ and
  $t = \Theta(\omega)$ if $|d_i| \geq 2 \cdot s_i$ with $|d_i| = |e_i - m_i|$ and s_i
- If a style is defined, $\Theta(\omega) = \Theta_s(\omega)$,
  and if not, $\Theta(\omega) = \Theta_e(\omega),\ 1 \leq \Theta_e(\omega) \leq 1.5$

Experimental Results

- **Validation of Exaggeration of Facial Motion**
  - Taking six universal expressions of 30 participants
    - Sadness, Happiness, Anger, Surprise, Fear, Disgust

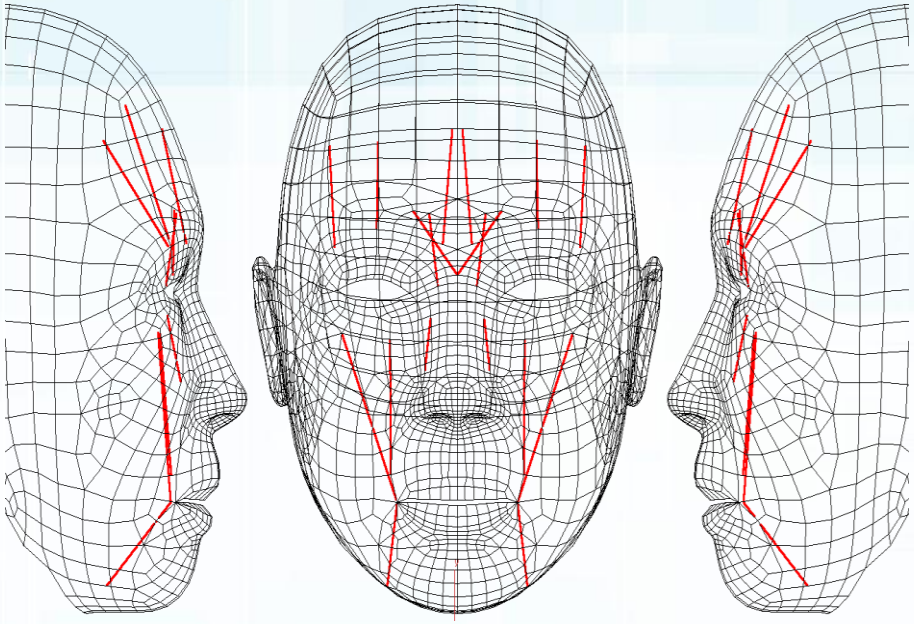
A sample of pictures taken with denoted markers.

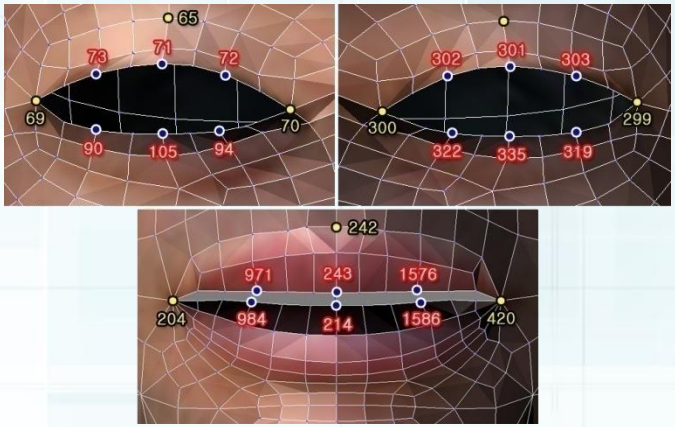
Experimental Results

- **Exaggerating Facial Expressions**
  - A muscle-based method employed to simulate exaggerated facial expressions.
    - 18 linear muscles and 3 circular muscles are embedded into the 3D face model.
    - Facial motions composed of markers are given and making expressions by adjusting muscle contraction.
  - Manipulating muscles by selecting proper contraction values based on exaggerating facial motions.

Experimental Results

- **3D model planted muscles**



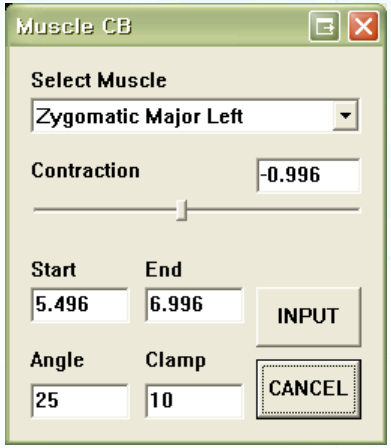


Experimental Results

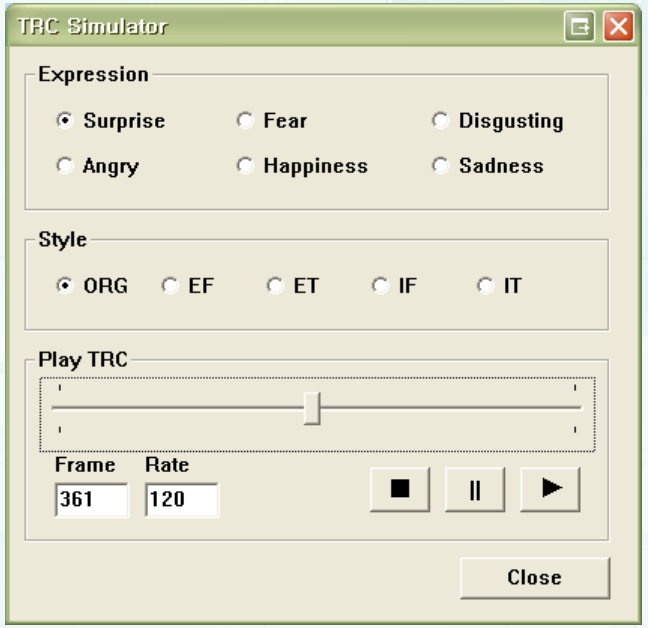
- **Exaggerating Facial Expressions**
  - System interface

3D Model Viewer

Muscle Control Box



TRC Simulator



Experimental Results

Happiness (IF)

ω=0, SER=1.0

ω=0.55, SER=1.2

Sadness (EF)

ω=0, SER=1.0

ω=0.41, SER=1.2

Surprise (IT)

ω=0, SER=1.0

ω=0.73, SER=1.2

Anger (IT)

ω=0, SER=1.0

ω=0.57, SER=1.2

Experimental Results

- **Exaggerating Facial Expressions**
  - Neutral Expression

Frontal View

Lateral View

Perspective View

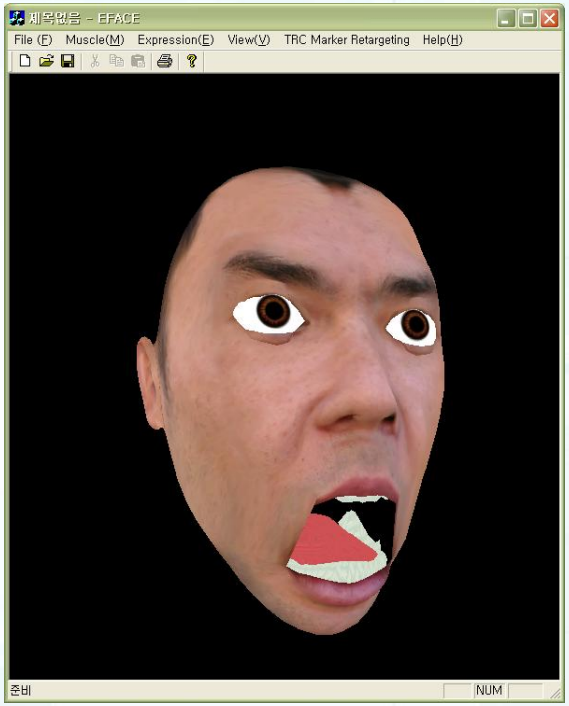
Experimental Results

- **Exaggerated Facial Expressions**
  - Surprise

Normal

$\Theta(\omega) = 1.0$

Exaggerated (IT)



$\Theta(\omega) = 1.274$

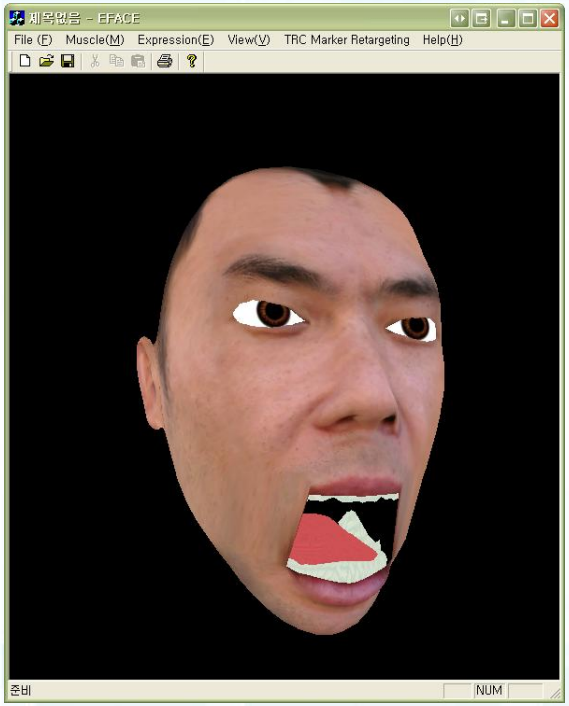
Exaggerated (EF)

$\Theta(\omega) = 1.5$

Experimental Results

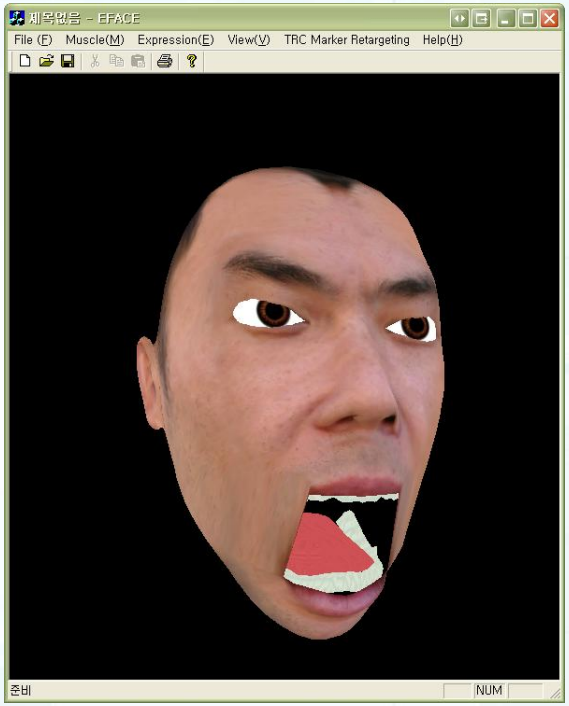
- **Exaggerated Facial Expressions**
  - Anger

Normal



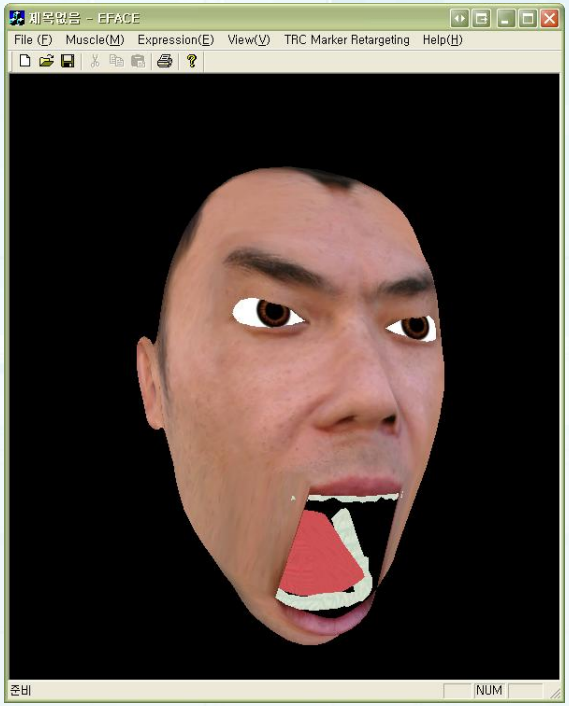
$\Theta(\omega) = 1.0$

Exaggerated (IT)



$\Theta(\omega) = 1.3$

Exaggerated (EF)



$\Theta(\omega) = 1.413$

Conclusion

- Facial expression represents the internal behavior of the individual
- Current studies on facial expression synthesis tend to concentrate on realistic expression or retargeting.
- In this research, we focus on a methodology for automatic exaggeration of the facial expression
- By conducting experiments, we show the validity of the proposed method by implementing facial expressions based on muscles.

Acknowledgement

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Demonstration

Q & A

Thank-you