Computer Graphics

Character Animation II

Mark Pauly

Geometric Computing Laboratory

Face Animation

Expression Model

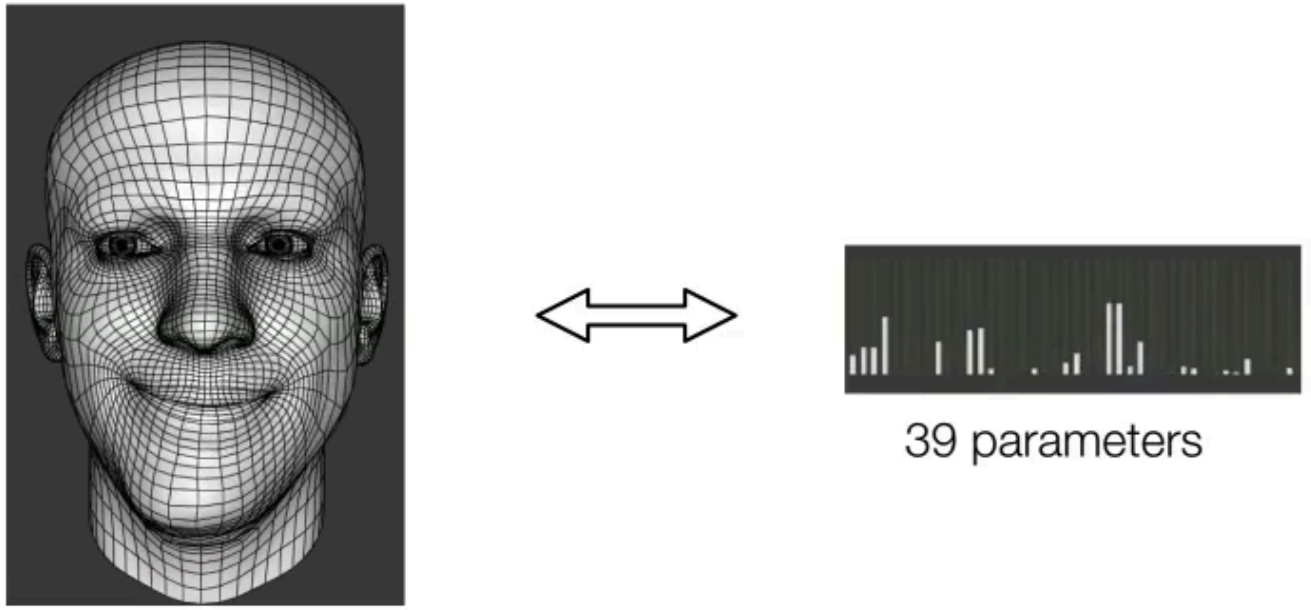
- Darwin argued in 1872 that certain emotional expressions are the same for all people
- Hager & Ekman showed that there are constants across cultures in the emotional meanings of certain facial expressions

Aim for a generic facial expression model!

Hager, Ekman: *The Inner and Outer Meanings of Facial Expressions*, 1983

Parametric Expression Model

- Low-dimensional representation of facial expression space

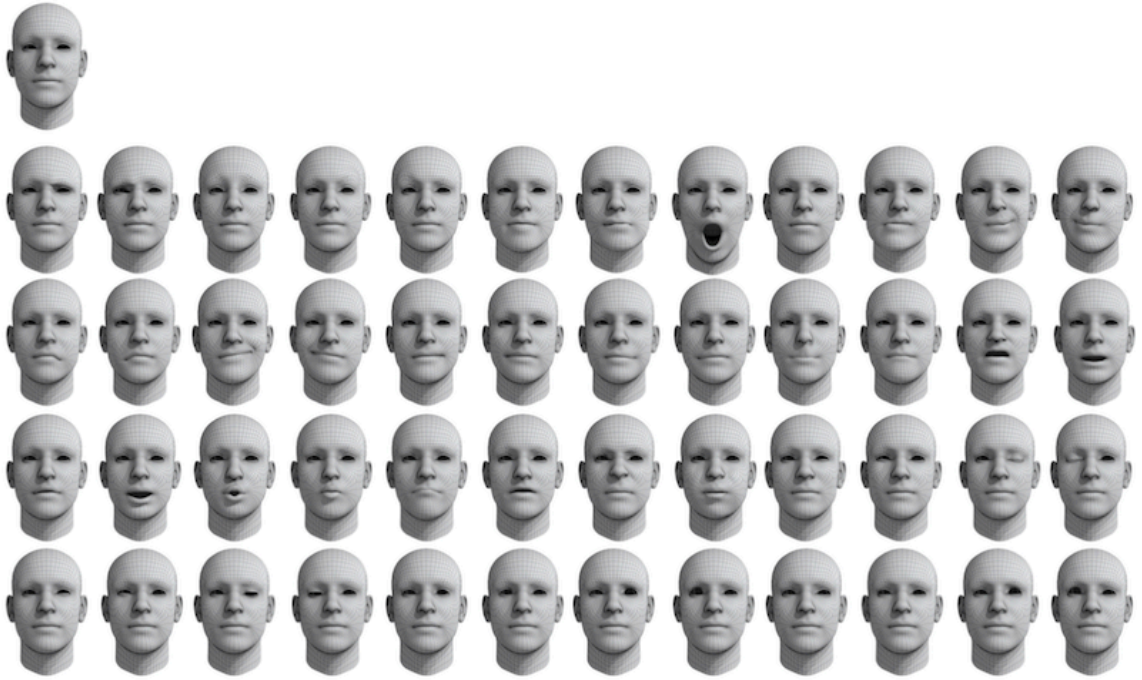


Blendshapes / Morph Targets

- Use neutral face $\mathbf{b}_0$ and expressions $\mathbf{b}_1, \ldots, \mathbf{b}_n$
- Each blendshape $\mathbf{b}_i$ is a vector of m stacked vertex positions

$$\mathbf{b}_i = \begin{pmatrix} \mathbf{x}_1^{(i)} \\ \vdots \\ \mathbf{x}_m^{(i)} \end{pmatrix} \in \mathbb{R}^{3m}$$

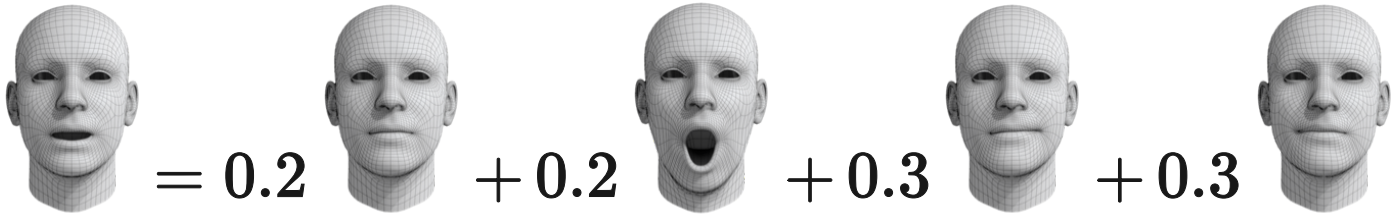
- All meshes must have the same number m of vertices and the same triangulation



Linear Blendshapes

- Produce new facial expression $\mathbf{F}(\alpha)$ by *affine combination* of example shapes $\mathbf{b}_0, \ldots, \mathbf{b}_n$ (with $\sum_k \alpha_k = 1$)

$$\mathbf{F}(\alpha) = \sum_{k=0}^{n} \alpha_k \mathbf{b}_k$$

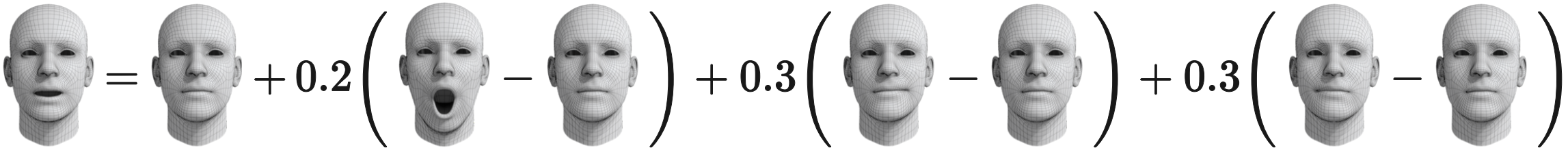


Weights α_k hard to control

Linear Delta-Blendshapes

- Produce new facial expression $\mathbf{F}(\mathbf{w})$ by adding to the neutral face $\mathbf{b}_0$ a weighted sum of expression-displacements:

$$\mathbf{F}(\mathbf{w}) = \mathbf{b}_0 + \sum_{k=1}^{n} w_k \left(\mathbf{b}_k - \mathbf{b}_0\right)$$



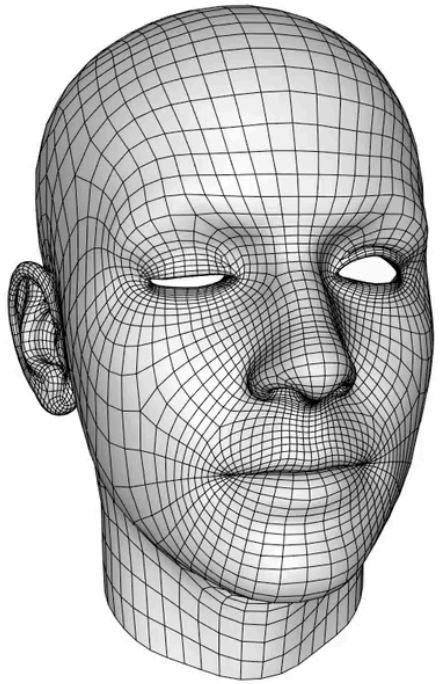
Weights w_k are easier to control than α_k

Linear Delta-Blendshapes

- Facial expressions by blending example poses

$$\mathbf{x}_i = \mathbf{x}_i^{(0)} + \sum_{k=1}^{n} w_k \left(\mathbf{x}_i^{(k)} - \mathbf{x}_i^{(0)} \right)$$

  - Examples (blendshapes) **must** have identical triangulation
  - Linear interpolation per vertex $\mathbf{x}_i$
  - Weights w_k typically are in $[0, 1]$.
    (see what happens at 200% on youtube)

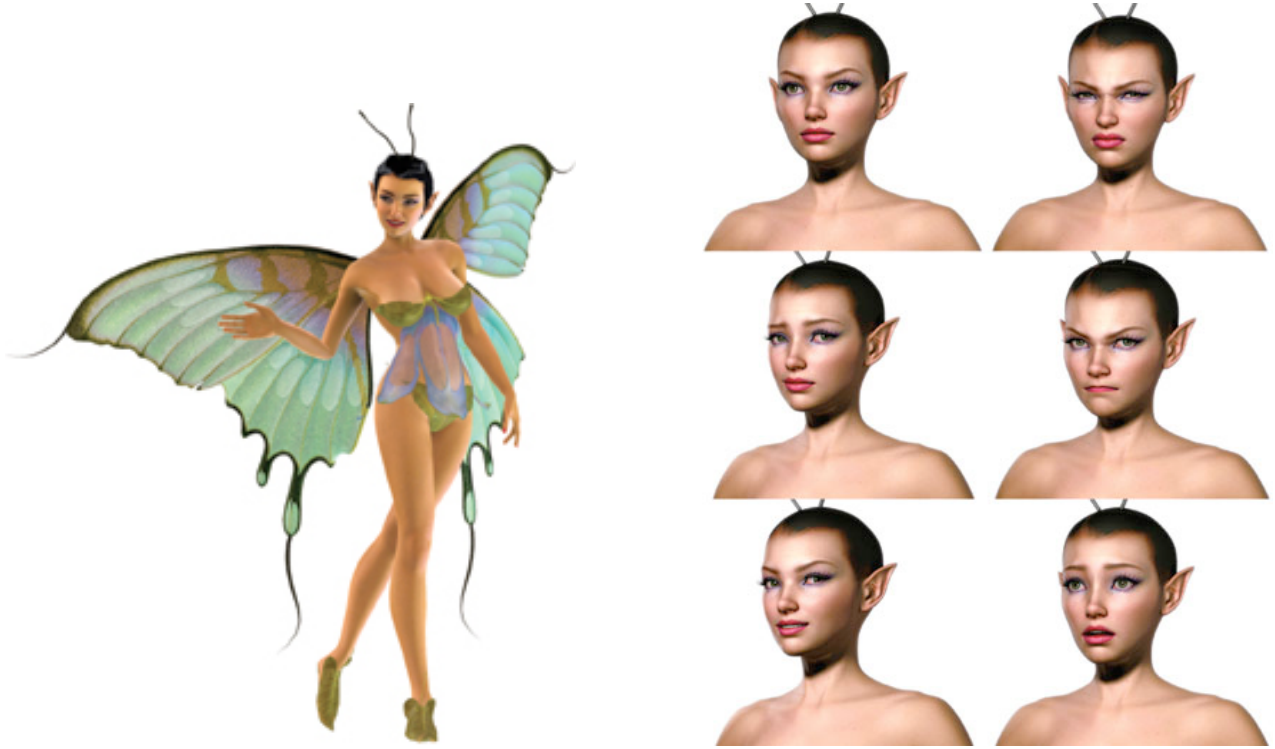


Let’s try it!

How many blendshapes?

Dave Model from Turbosquid

How many blendshapes?



50 blendshapes

Nvidia “Dawn” Demo, 2003

How many blendshapes?

>900 blendshapes

© Weta Digital

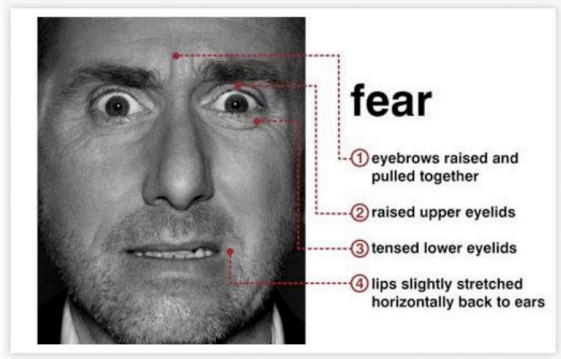
How many blendshapes?

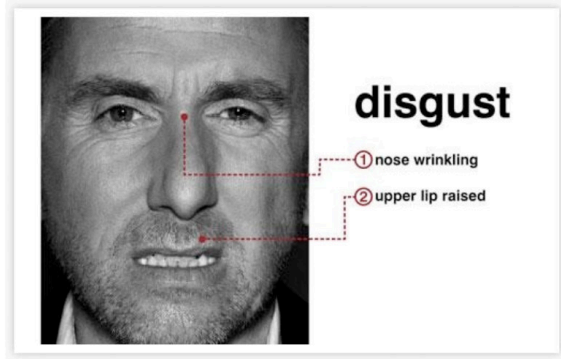
Meet Mike, SIGGRAPH 2017

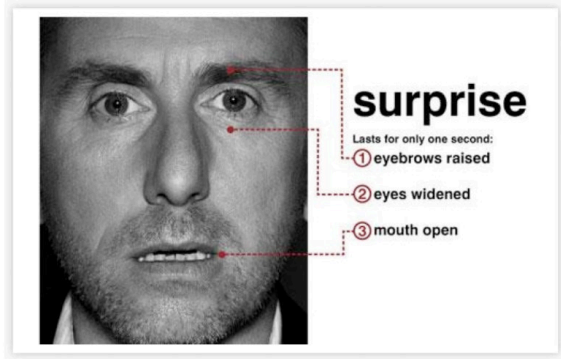
>750 blendshapes

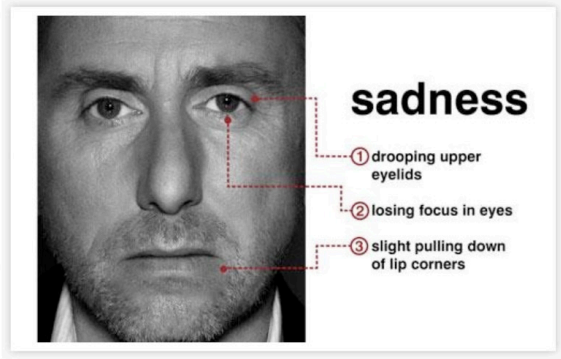
Facial Action Coding System (FACS)

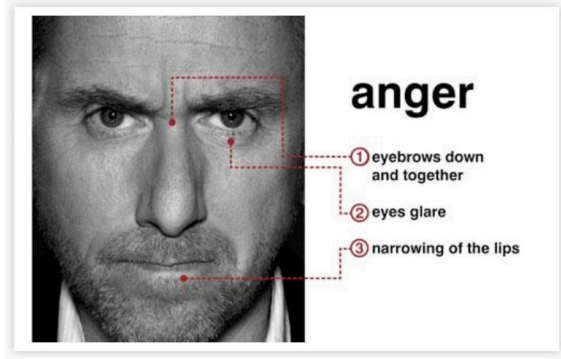
- Developed by Paul Ekman & Wallace Friesen, 1978
- Standard for categorizing facial expressions
- Defines 46 *action units*, related to facial muscles
- Facial expressions are combined from action units

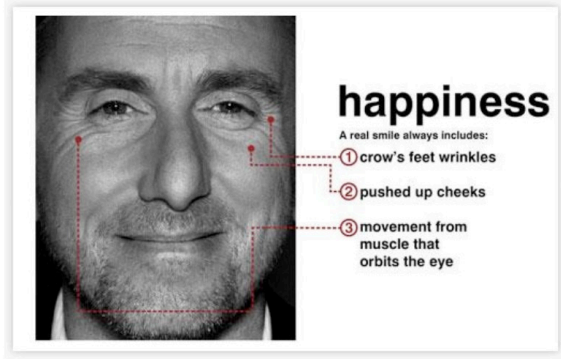

fear
1 eyebrows raised and pulled together
2 raised upper eyelids
3 tensed lower eyelids
4 lips slightly stretched horizontally back to ears


disgust
1 nose wrinkling
2 upper lip raised


surprise
Lasts for only one second:
1 eyebrows raised
2 eyes widened
3 mouth open


sadness
1 drooping upper eyelids
2 losing focus in eyes
3 slight pulling down of lip corners


anger
1 eyebrows down and together
2 eyes glare
3 narrowing of the lips


happiness
A real smile always includes:
1 crow's feet wrinkles
2 pushed up cheeks
3 movement from muscle that orbits the eye

Facial Action Coding System (FACS)

Happiness = 6+12

ID	Description
0	Neutral face
1	Inner brow raiser
2	Outer brow raiser
4	Brow lowerer
5	Upper lid raiser
6	**Cheek raiser**
7	Lid tightener
8	Lips toward each other
9	Nose wrinkler
10	Upper lip raiser
11	Nasolabial deepener
12	**Lip corner puller**
13	Sharp lip puller
14	Dimpler
15	Lip corner depressor
16	Lower lip depressor
17	Chin raiser
18	Lip pucker
19	Tongue show
20	Lip stretcher
21	Neck tightener
22	Lip funneler
23	Lip tightener

ID	Description
24	Lip pressor
25	Lips part
26	Jaw drop
27	Mouth stretch
28	Lip suck
29	Jaw thrust
30	Jaw sideways
31	Jaw clencher
32	Lip bite
33	Cheek blow
34	Cheek puff
35	Cheek suck
36	Tongue bulge
37	Lip wipe
38	Nostril dilator
39	Nostril compressor
40	Glabella lowerer
41	Lid droop
42	Inner eyebrow lowerer
43	Eyes closed
44	Eyebrow gatherer
45	Blink
46	Wink

Facial Action Coding System (FACS)

Sadness = 1+4+15

ID	Description
0	Neutral face
1	**Inner brow raiser**
2	Outer brow raiser
4	**Brow lowerer**
5	Upper lid raiser
6	Cheek raiser
7	Lid tightener
8	Lips toward each other
9	Nose wrinkler
10	Upper lip raiser
11	Nasolabial deepener
12	Lip corner puller
13	Sharp lip puller
14	Dimpler
15	**Lip corner depressor**
16	Lower lip depressor
17	Chin raiser
18	Lip pucker
19	Tongue show
20	Lip stretcher
21	Neck tightener
22	Lip funneler
23	Lip tightener

ID	Description
24	Lip pressor
25	Lips part
26	Jaw drop
27	Mouth stretch
28	Lip suck
29	Jaw thrust
30	Jaw sideways
31	Jaw clencher
32	Lip bite
33	Cheek blow
34	Cheek puff
35	Cheek suck
36	Tongue bulge
37	Lip wipe
38	Nostril dilator
39	Nostril compressor
40	Glabella lowerer
41	Lid droop
42	Inner eyebrow lowerer
43	Eyes closed
44	Eyebrow gatherer
45	Blink
46	Wink

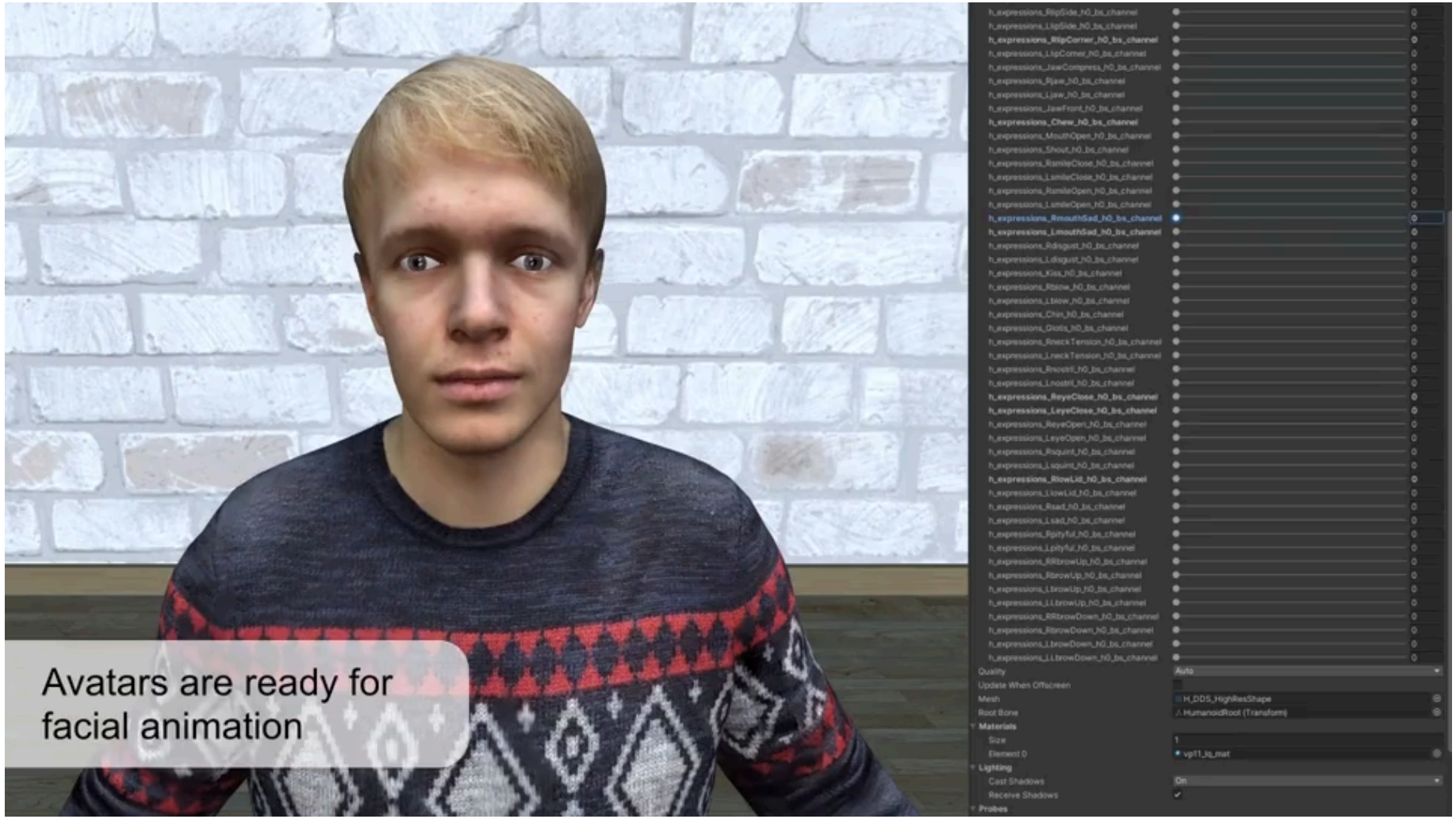
Facial Action Coding System (FACS)

Anger = 4+5+7+23

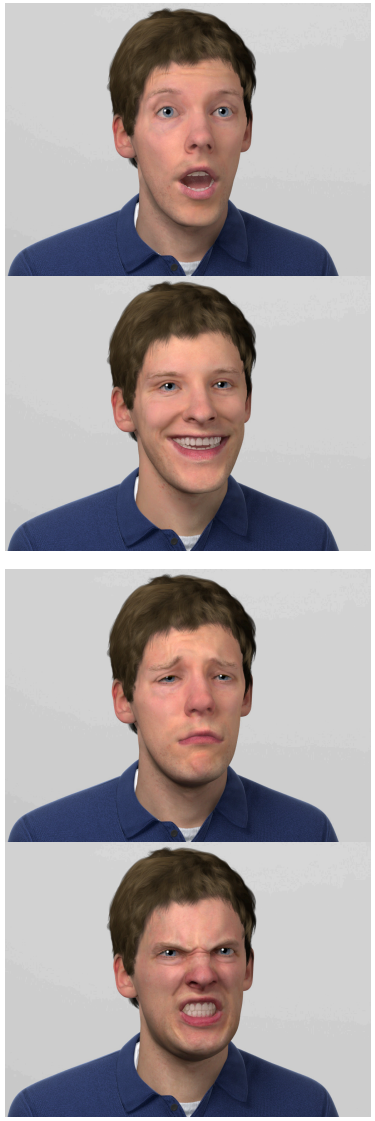
ID	Description
0	Neutral face
1	Inner brow raiser
2	Outer brow raiser
4	**Brow lowerer**
5	**Upper lid raiser**
6	Cheek raiser
7	**Lid tightener**
8	Lips toward each other
9	Nose wrinkler
10	Upper lip raiser
11	Nasolabial deepener
12	Lip corner puller
13	Sharp lip puller
14	Dimpler
15	Lip corner depressor
16	Lower lip depressor
17	Chin raiser
18	Lip pucker
19	Tongue show
20	Lip stretcher
21	Neck tightener
22	Lip funneler
23	**Lip tightener**

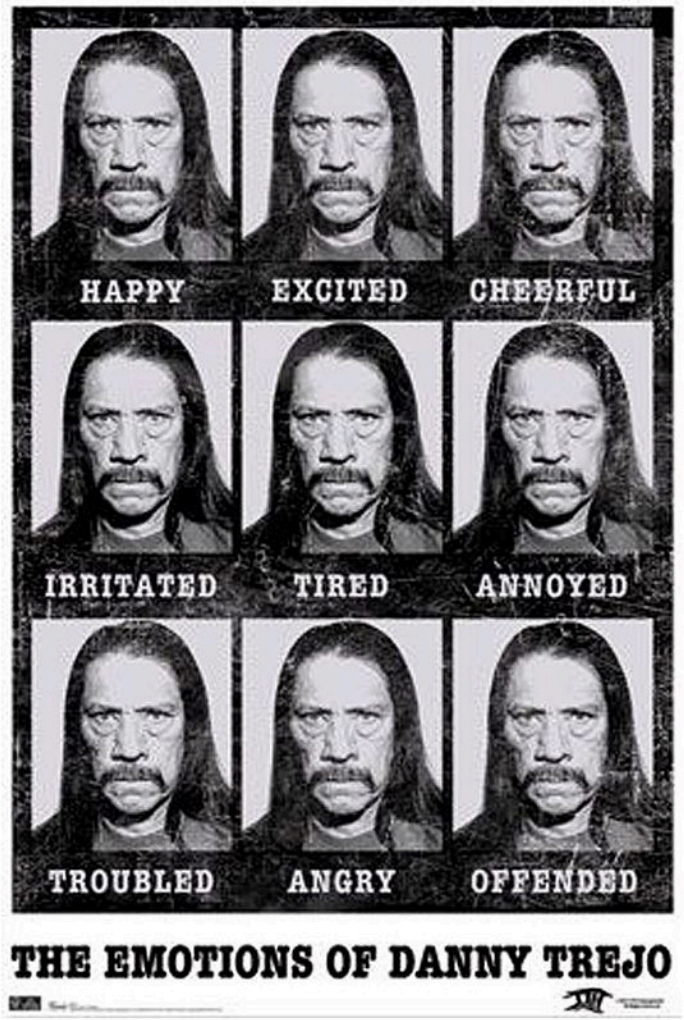
ID	Description
24	Lip pressor
25	Lips part
26	Jaw drop
27	Mouth stretch
28	Lip suck
29	Jaw thrust
30	Jaw sideways
31	Jaw clencher
32	Lip bite
33	Cheek blow
34	Cheek puff
35	Cheek suck
36	Tongue bulge
37	Lip wipe
38	Nostril dilator
39	Nostril compressor
40	Glabella lowerer
41	Lid droop
42	Inner eyebrow lowerer
43	Eyes closed
44	Eyebrow gatherer
45	Blink
46	Wink

Face Animation in Unity



Scan Actor in FACS Expressions?





Blendshapes Summary

👍 Very simple & efficient computations

👍 Supported by all modeling tools

👍 Can also be used for speech synthesis

👍 Standardized by FACS

👎 Expressions outside “blendshape space” not possible

👎 Requires a large number of blend shapes

👎 Requires a large number of controllers/sliders

Let’s try it!

Literature

- **Skeleton Animation**
  - Kavan et al, *Skinning with Dual Quaternions*, Symposium on Interactive 3D Graphics and Games 2007
  - Jacobson et al, *Skinning: Real-time Shape Deformation*, Course at SIGGRAPH 2014
- **Face Animation**
  - Parke: *A parametric model for human faces*, PhD thesis, University of Utah, 1974.
  - Lewis et al: Practice and Theory of Blendshape Facial Models, Eurographics State of the Art Report, 2014.

Quiz: Blendshapes vs. Delta-Blendshapes

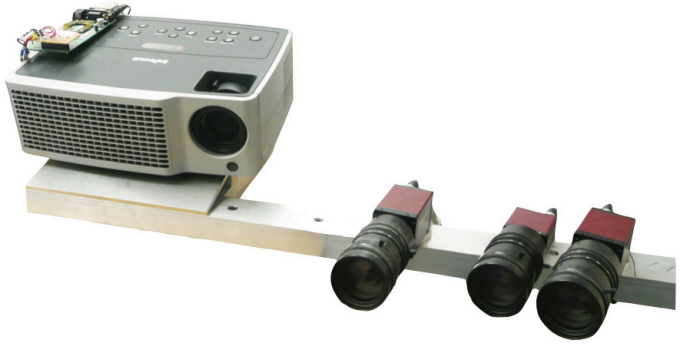
Which method is more expressive, i.e., can produces more/richer expressions?

A: Blendshapes

B: Delta-Blendshapes

C: Both can produce equivalent expressions

Faceshift

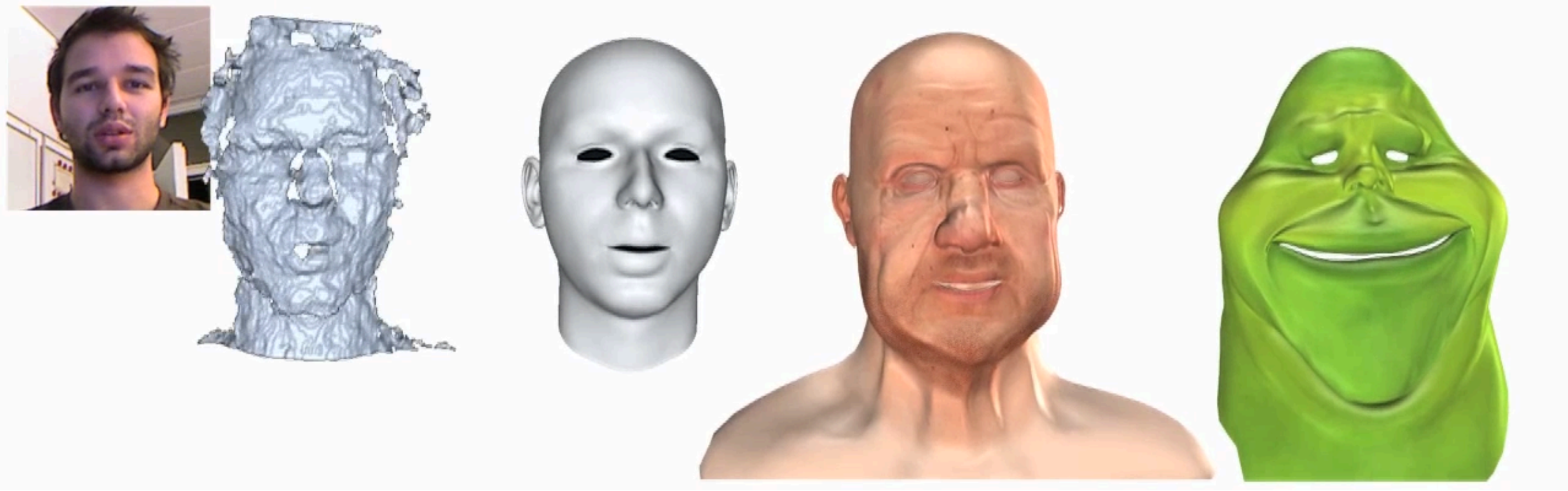


KINECT
for XBOX 360

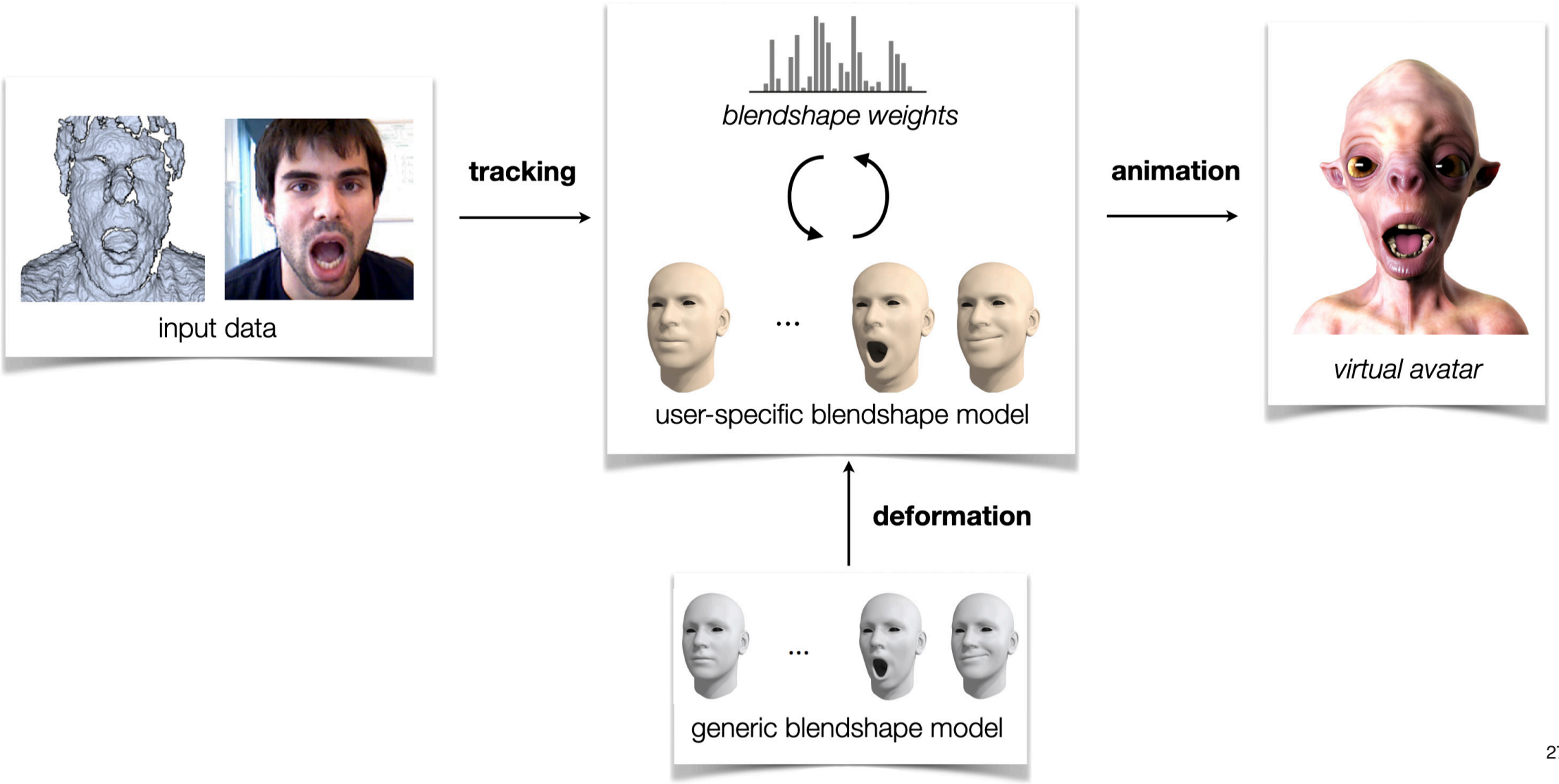
Faceshift

ASUS
faceshift
AFFORDABLE:
PUT ONE ON EVERY DESK
EVERYWHERE:
SUPPORT WIN64

Faceshift



Faceshift - Overview



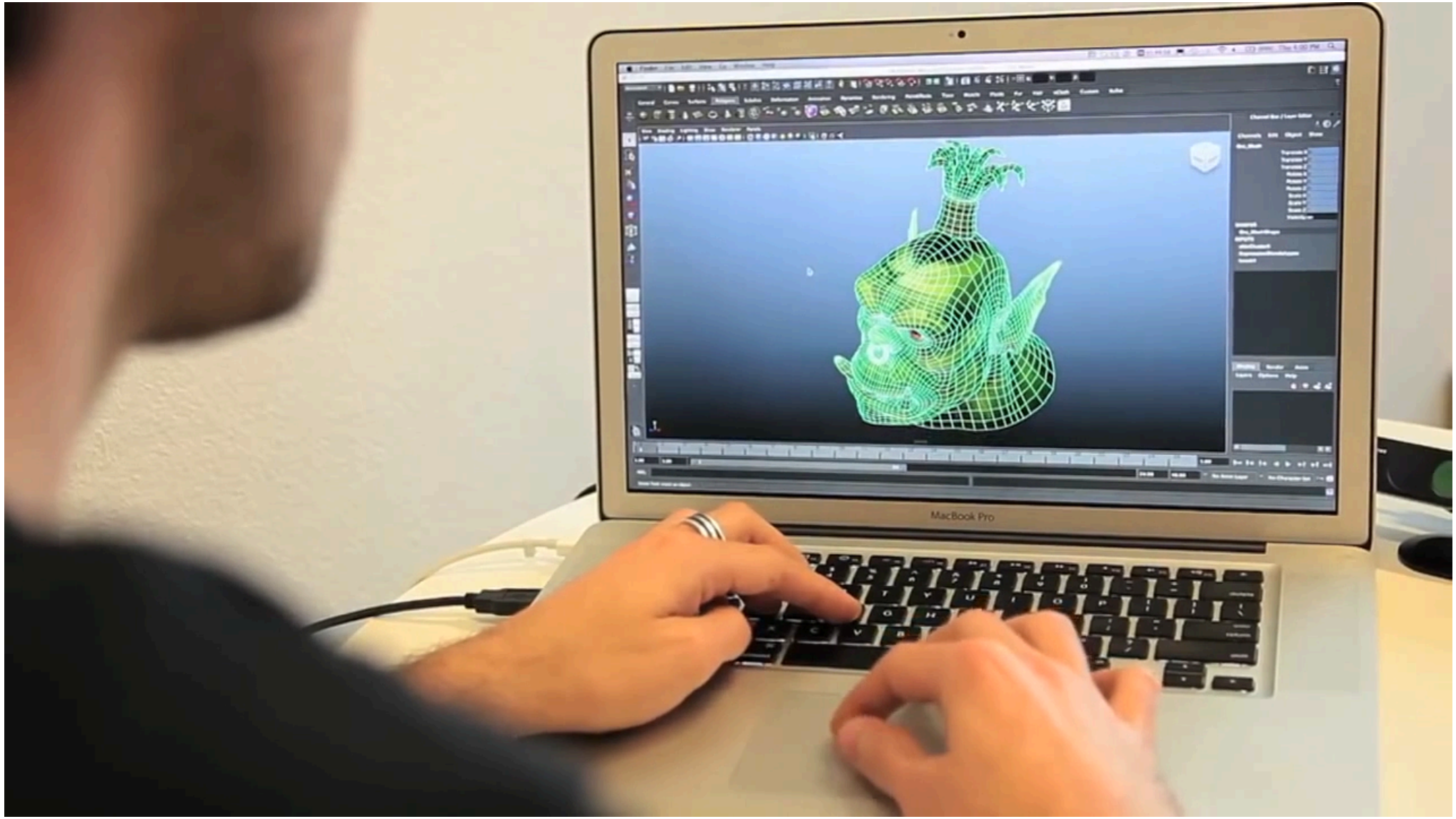
Avatar Creation

Ichim, Bouaziz, Pauly, Dynamic Facial Avatar Creation using Handheld Cameras, ACM SIGGRAPH 2015

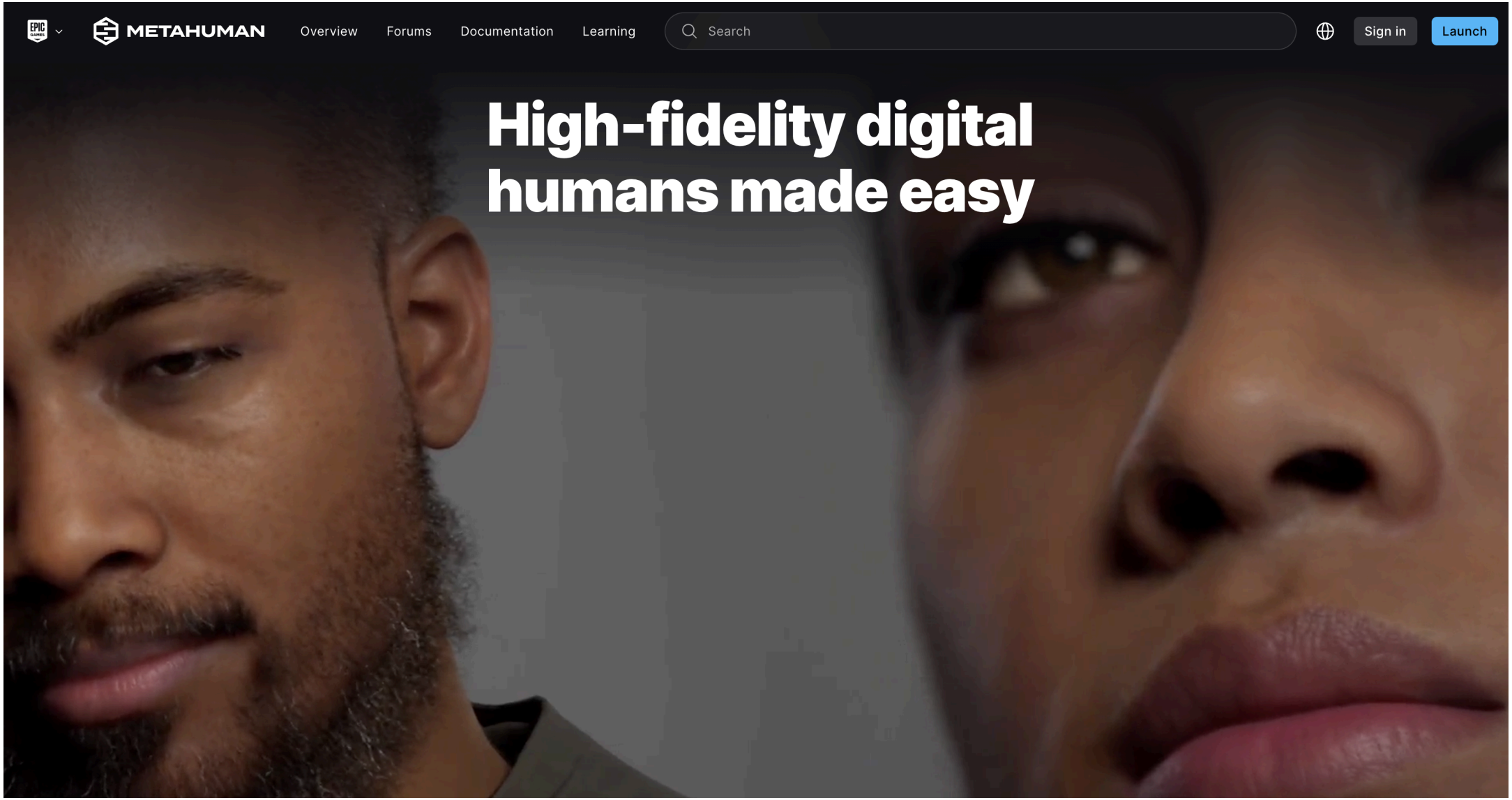
Hand Tracking

Tagliasacchi, Schroder, Tkach, Bouaziz, Botsch, Pauly, Robust Articulated-ICP for Real-Time Hand Tracking, SGP 2015

Faceshift



Unreal Engine - Meta Human



https://www.unrealengine.com/en-US/metahuman