

H-Anim Facial Animation (Updates)

SC24 WG9 and Web3D Meetings

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Jung-Ju Choi (Ajou University) and
Myeong Won Lee (The University of Suwon)

The face in H-Anim (4.9.4)

- There are seven “_joint”s rooted at skullbase
 - l_eyeball_joint and r_eyeball_joint: to change eye gaze
 - l_eyebrow_joint and r_eyebrow_joint
 - l_eyelid_joint and r_eyelid_joint: to open/close eyes
 - temporomandibular: to open/close mouth
- These represent the facial animation of a ventriloquist’s figure
 - Facial animation without expression
- Facial animation with expression
 - Implemented by Displacer objects for face vertices
 - Pointed out by Joe Williams in January
 - There may be a Displacer object for each facial expression (According to 4.7)

About facial expression

- Facial Action Coding System (FACS)

- Emotion consists of action units (AUs)

- Happiness = 6+12, Sadness = 1+4+15, e.g.

- How many emotions?

- <Plutchik's wheel of emotion>, e.g.

- How many AUs are defined in FACS?

- 47 main codes, such as “inner brow raiser”, “lip stretcher”, etc.

- AU vs. Displacer

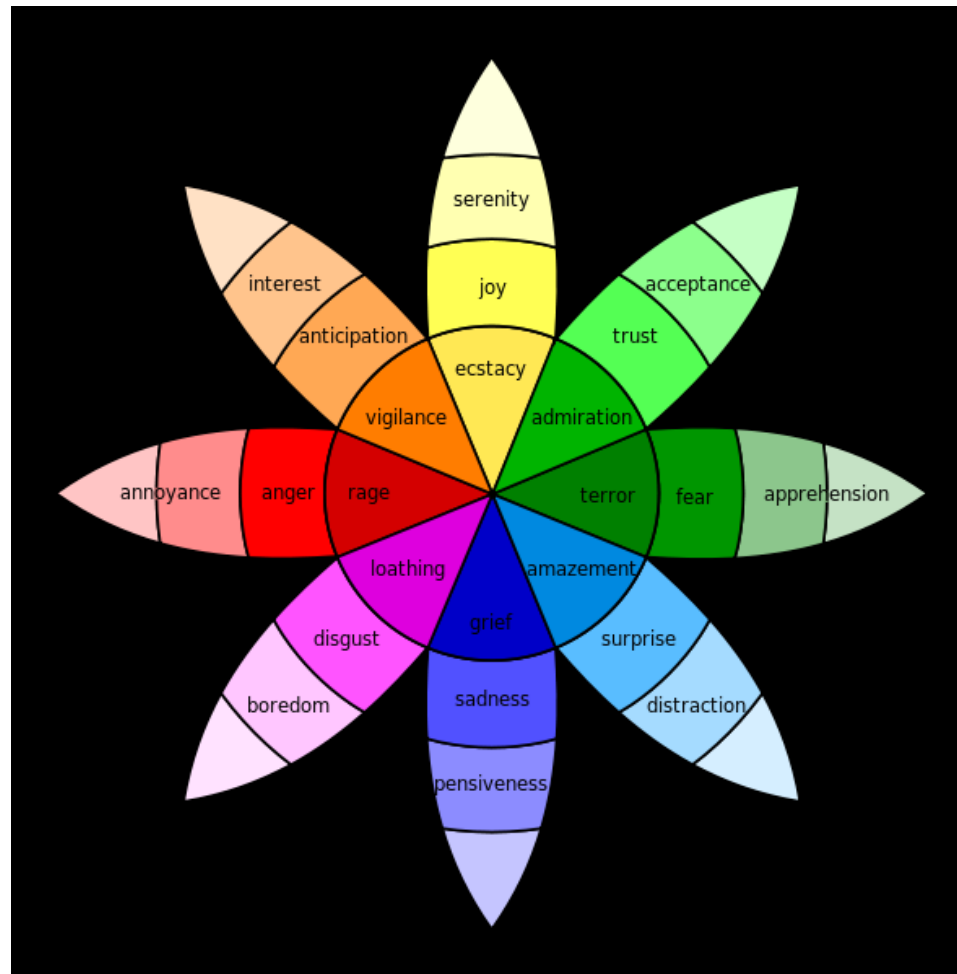
- Each AU can be defined by a Displacer object, as in 6.6, such as

```
Displacer {
  coordIndex [7, 12, 21, 18]
  displacements [0 0.0025 0, 0 0.005 0, 0 0.0025 0, 0 0.001
0]
  name "l_eyebrow_raiser_action"
}
```

- A collection of Displacer objects represents a facial expression

About facial expression

- Plutchik's wheel of emotion

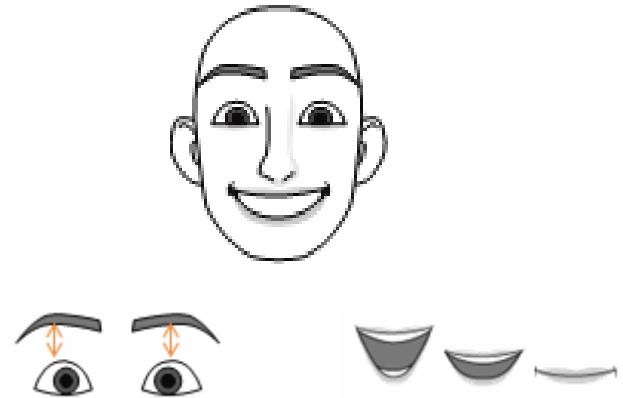


Conveying **emotion** to H-Anim

- For each emotion, we can define a set of Displacer objects and/or joint angles

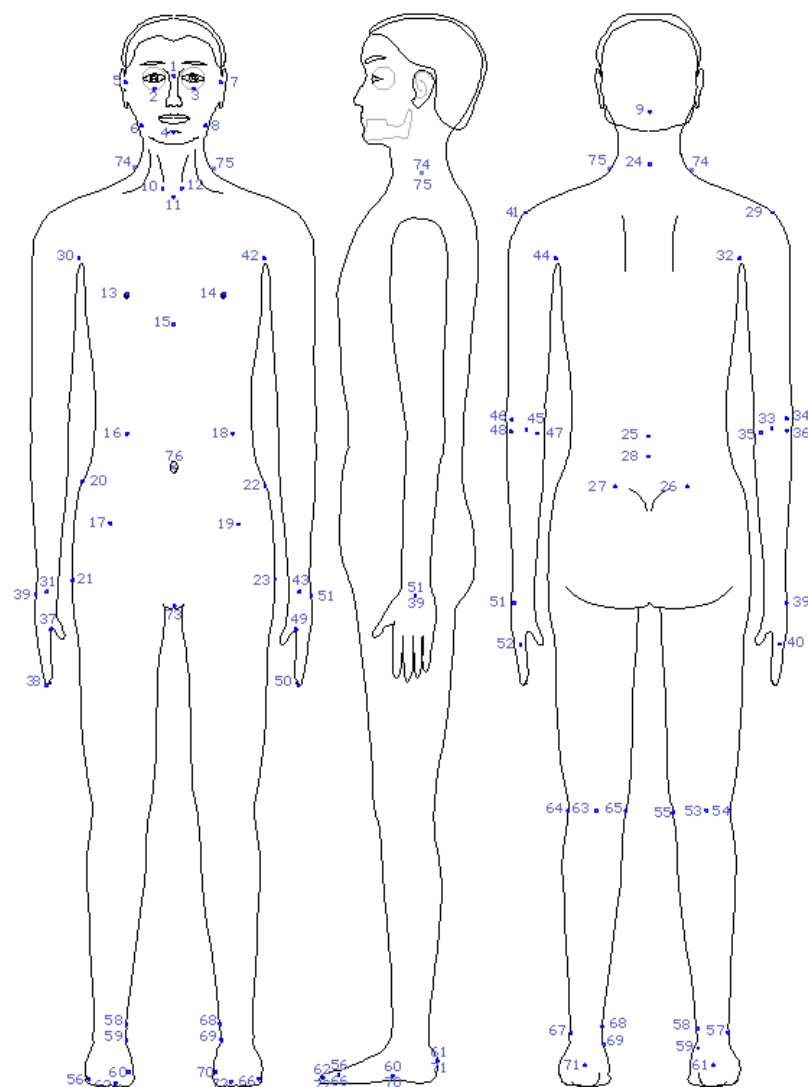
- Joy, e.g.

- AU1: inner brow raiser
 - AU2: outer brow raiser
 - AU5: upper lid raiser
 - AU12: lip corner puller
 - AU20: lip stretcher
 - AU25: lip parter
 - AU26: jaw drop ← by temporomandibular joint angle
 - AU27: mouth stretcher
- A Displacer object defines which vertices to move
 - An action unit defines which features to move (or morph)



Features in H-Anim

- Only eight facial features in H-Anim
- For all 47 main AUs, more features on a face are probably required
- MPEG4 FPs?
 - 38 facial feature points (FPs) affected by FAPs, excluding tongue and nose



Facial animation to H-Anim

- Facial vertex animation
 - Define the motion of selected vertices using Displacers
 - How many vertices to select?
 - Compute the motion of other vertices



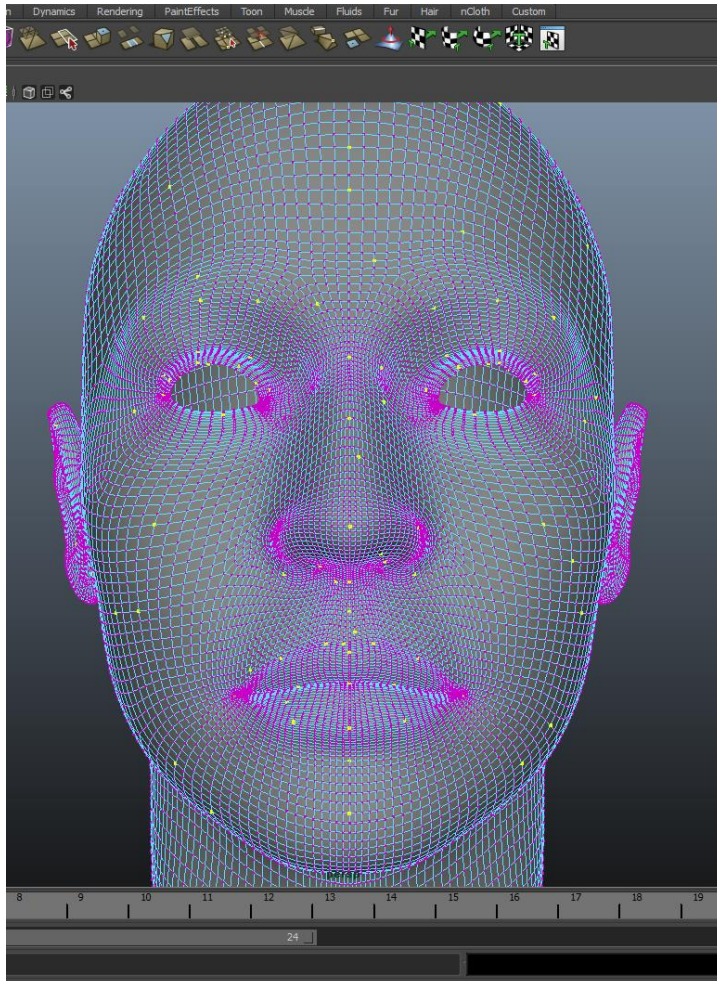
23,728 vertices
Width: 163.035
Height: 214.229
Depth: 128.017

Facial animation to H-Anim

- Adequate to define several thousands of Displacers?
- Grouping vertices into a set of meaningful regions
 - Regions can be obtained from facial features, or we can define the regions as facial features
 - Define a few Displacer objects for each region
 - Parameterize the motion of region boundary from Displacers
 - From existing example animation
 - Reconstruct the position of other vertices from region boundary

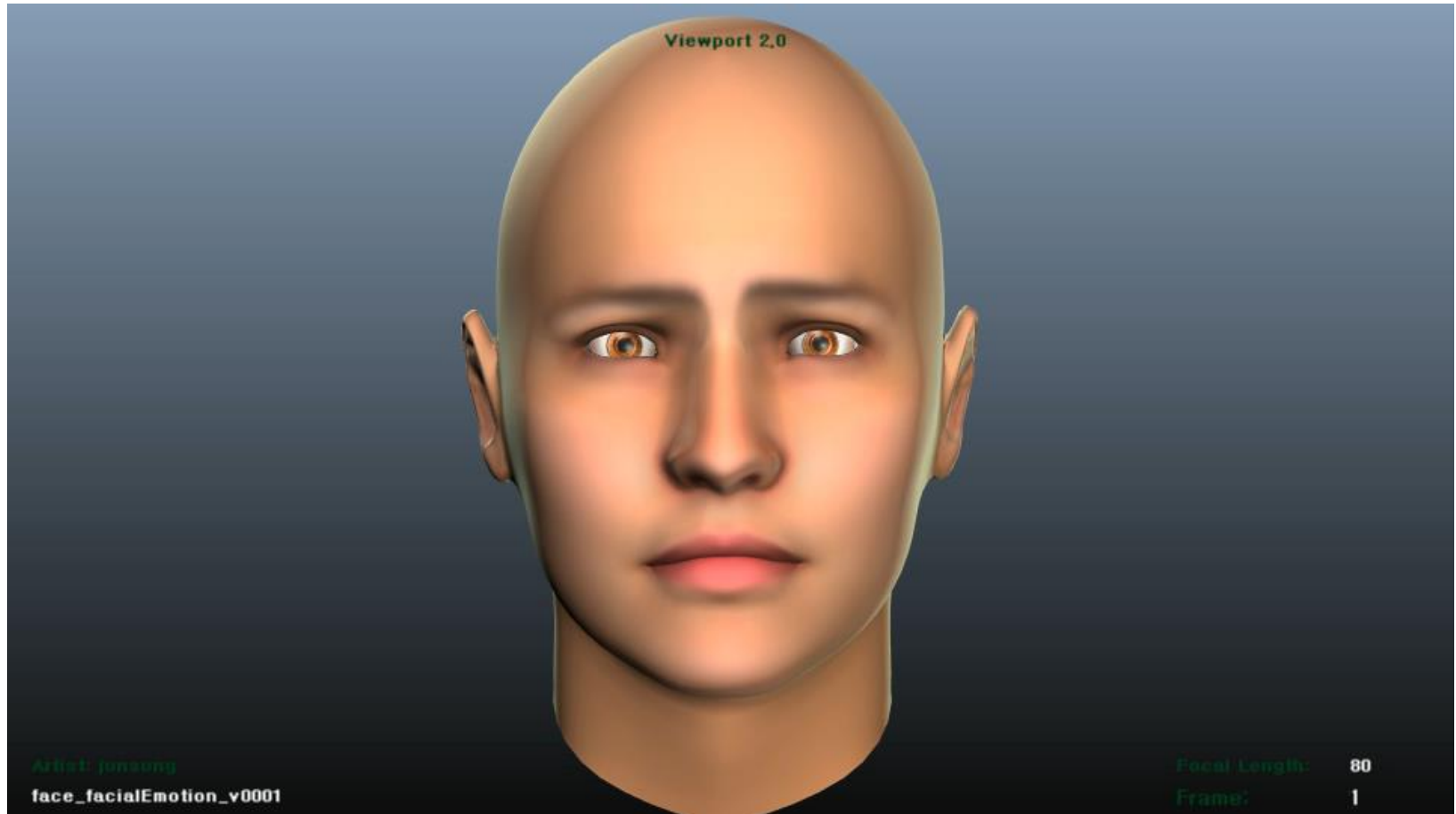


Reference model and animation

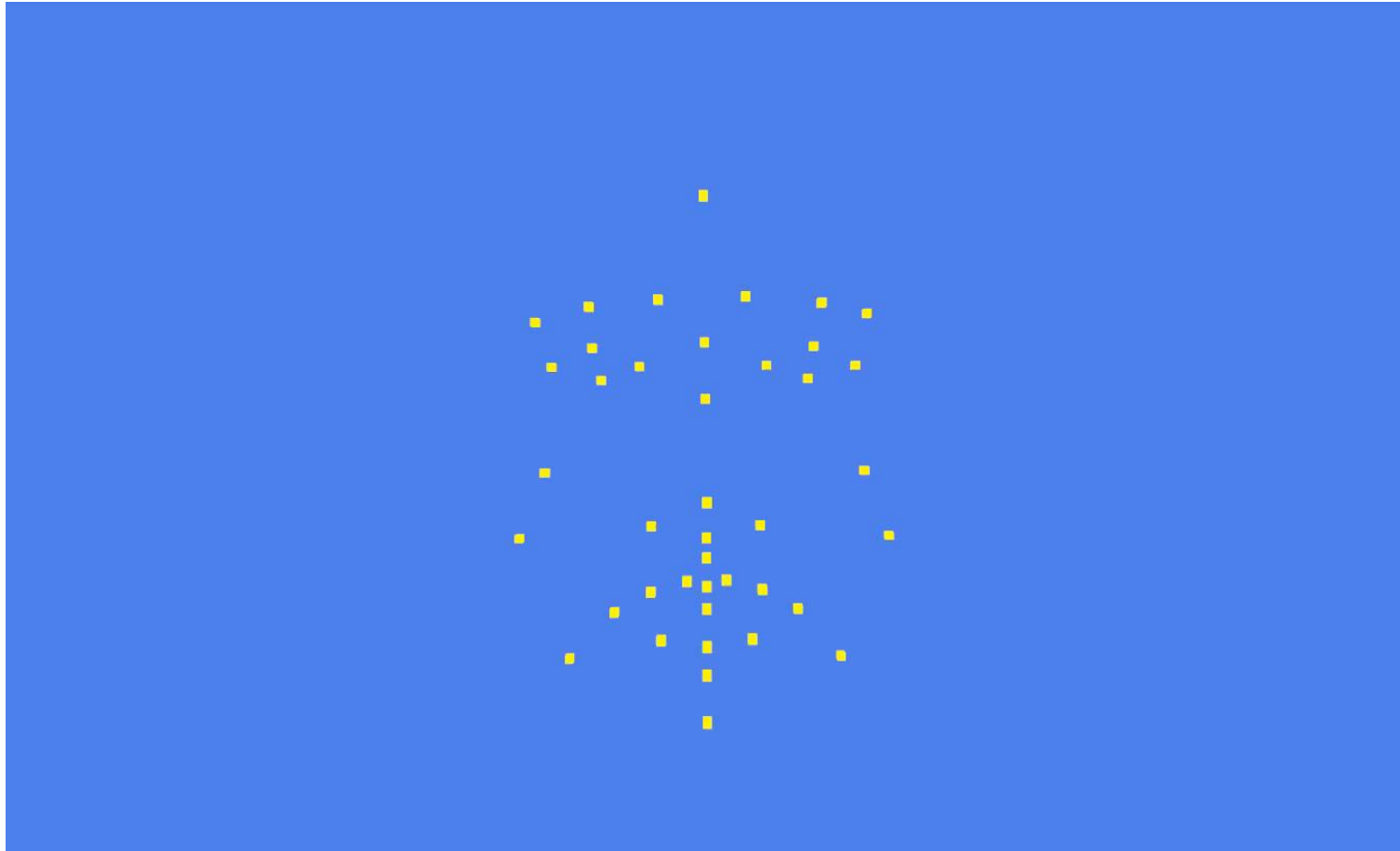


afraid, angry, disgusted, laughing, sad, surprised,
winkLeft, winkRight, lipsLeft, lipsRight

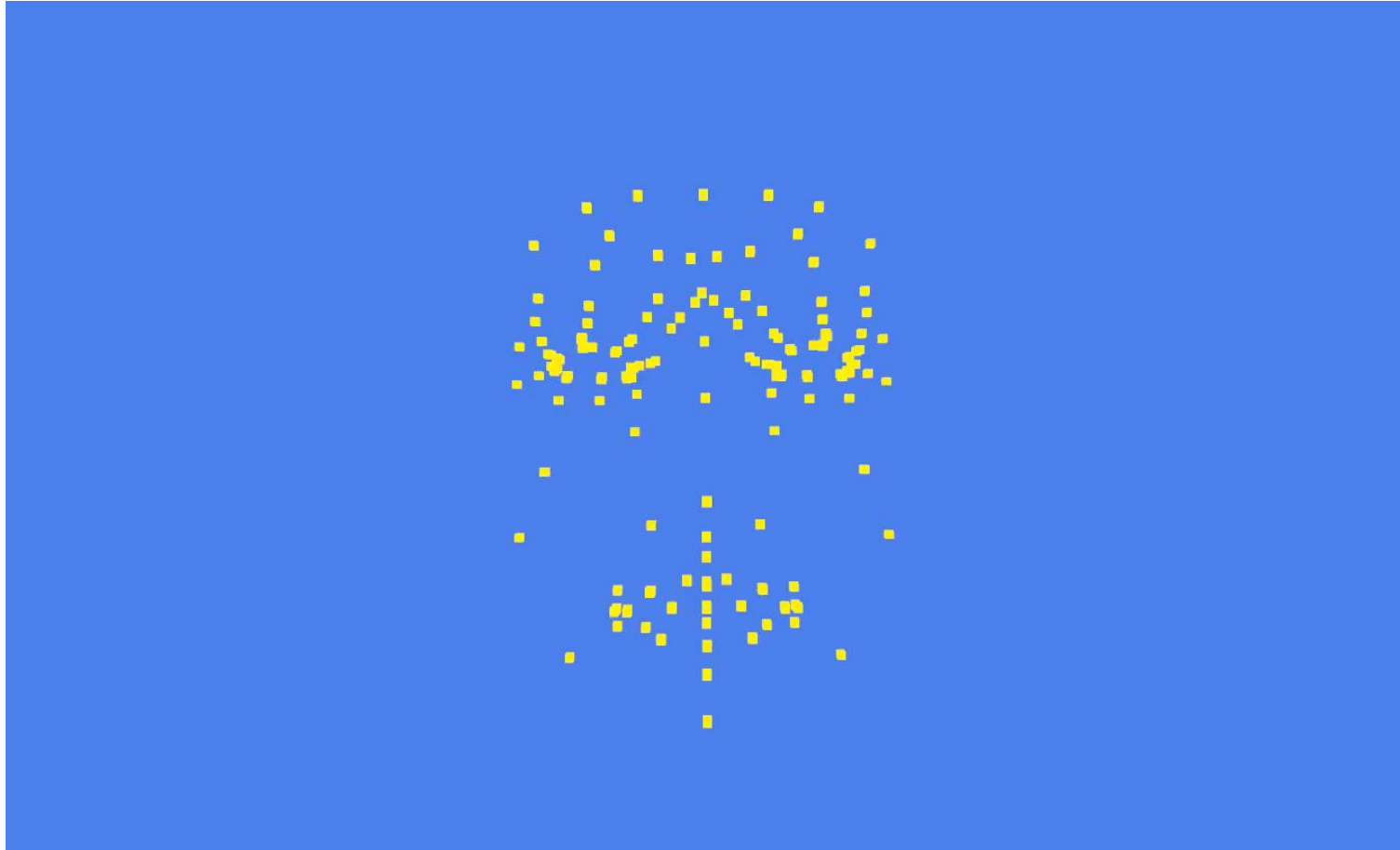
Reference facial animation



Landmark animation



Feature points animation



Facial feature animation



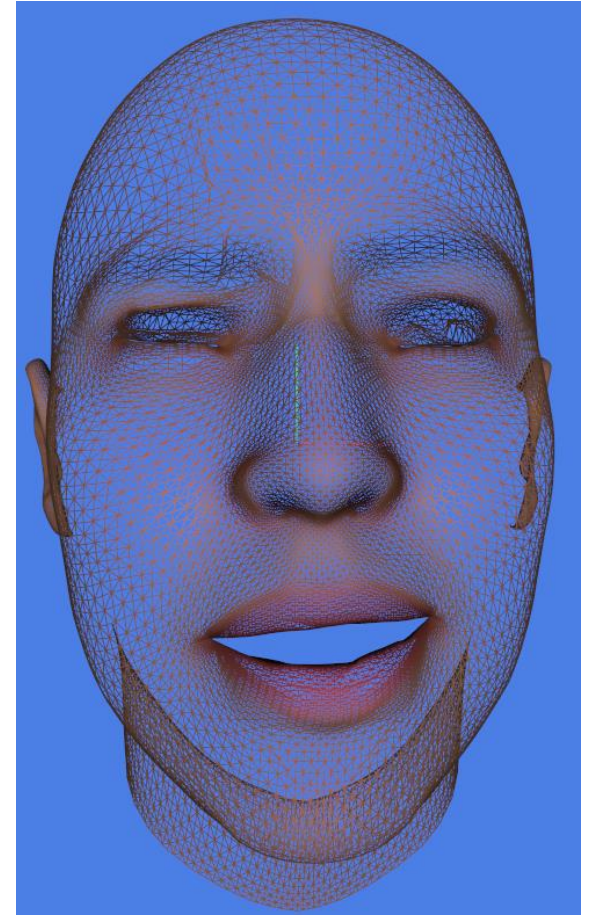
Reconstructed facial animation



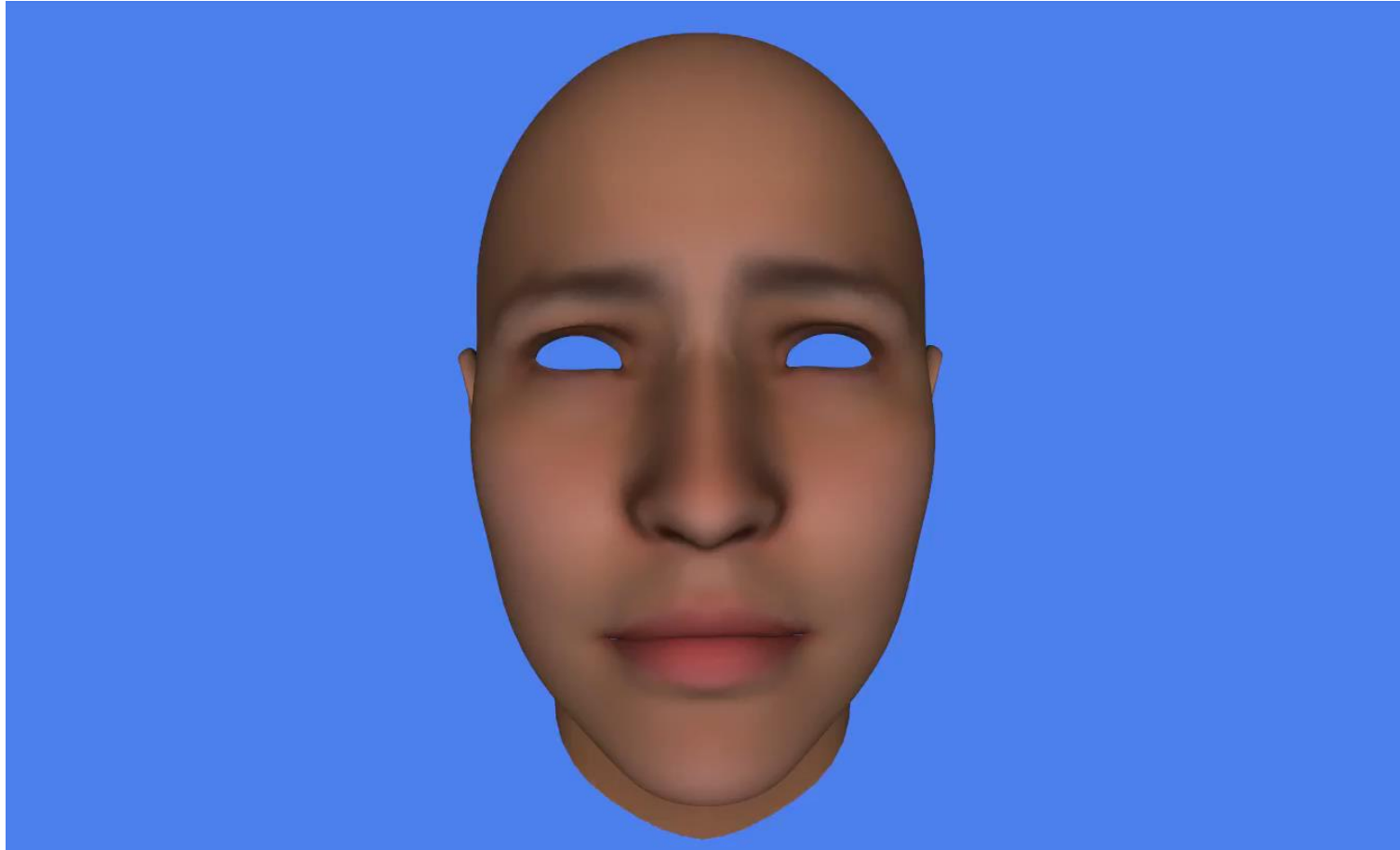
Ground truth



Reconstructed

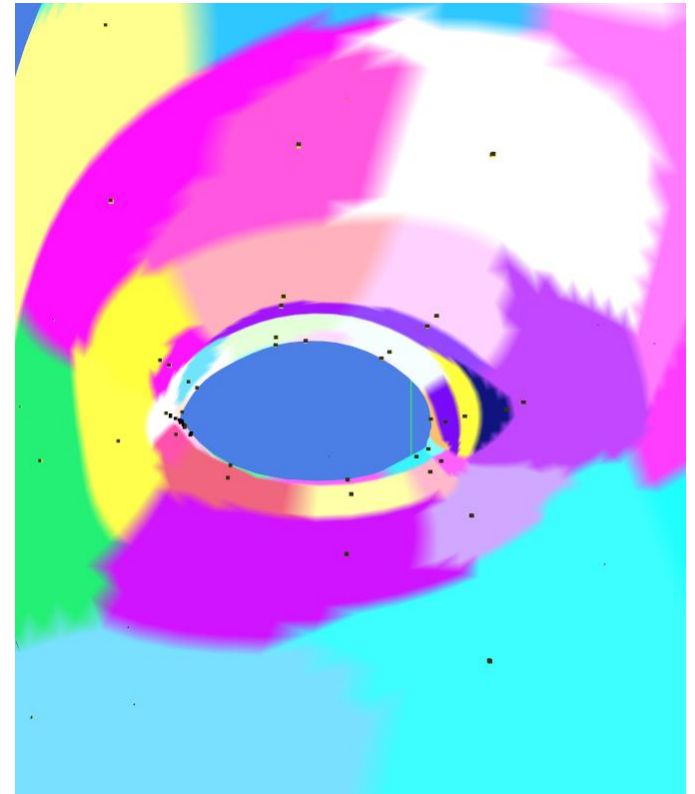
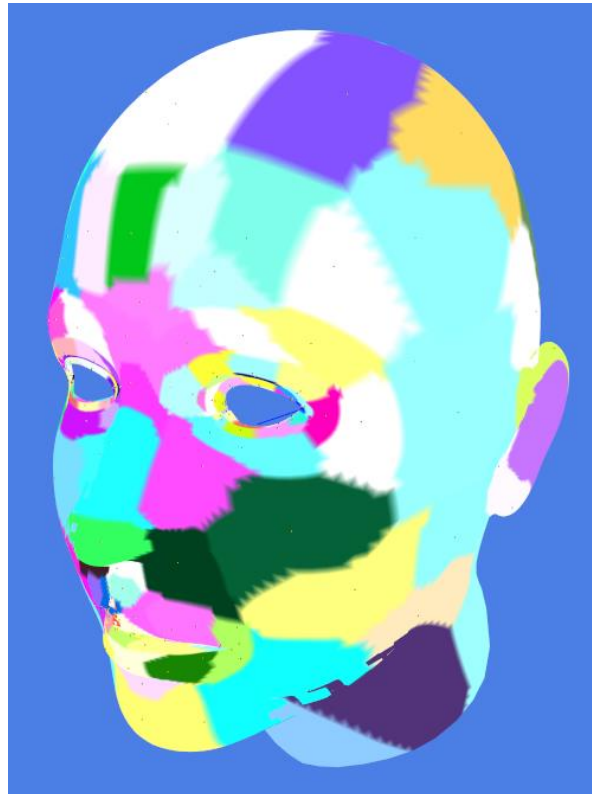
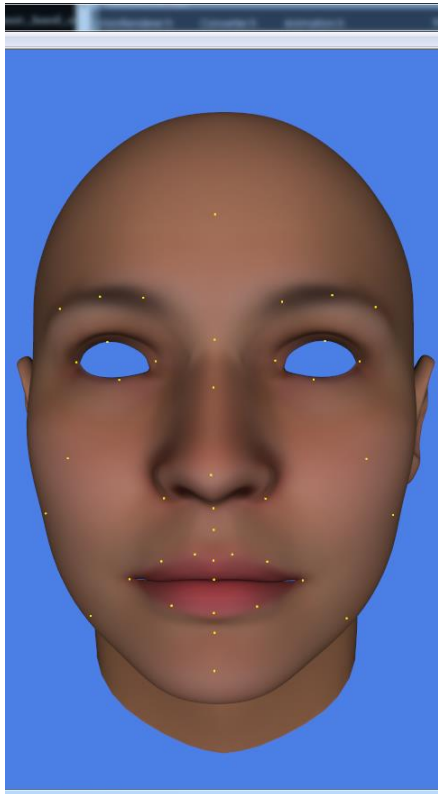


Reconstructed animation



Face regions: trying various configurations

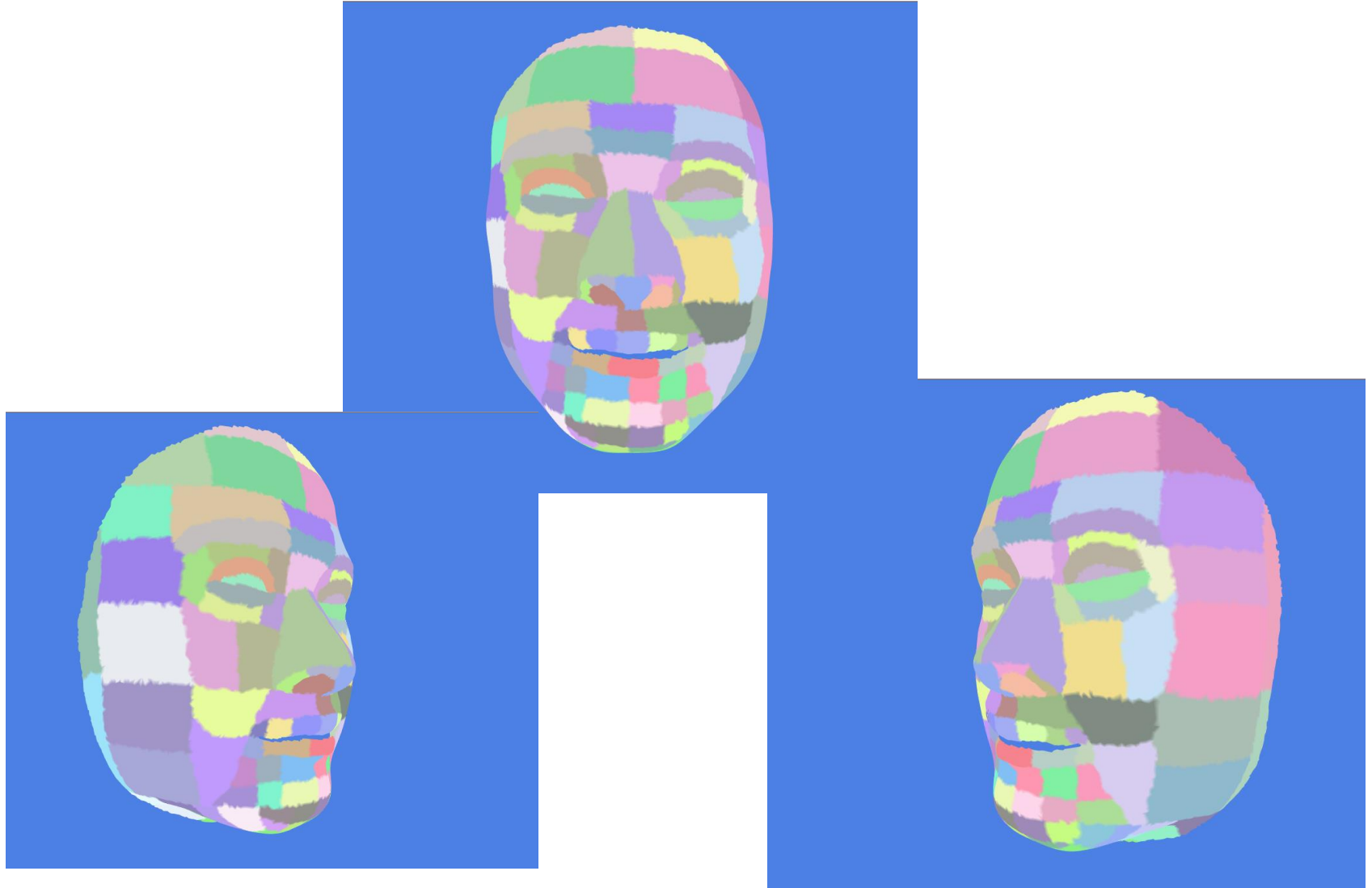
- 165 regions (including 45 landmark positions)



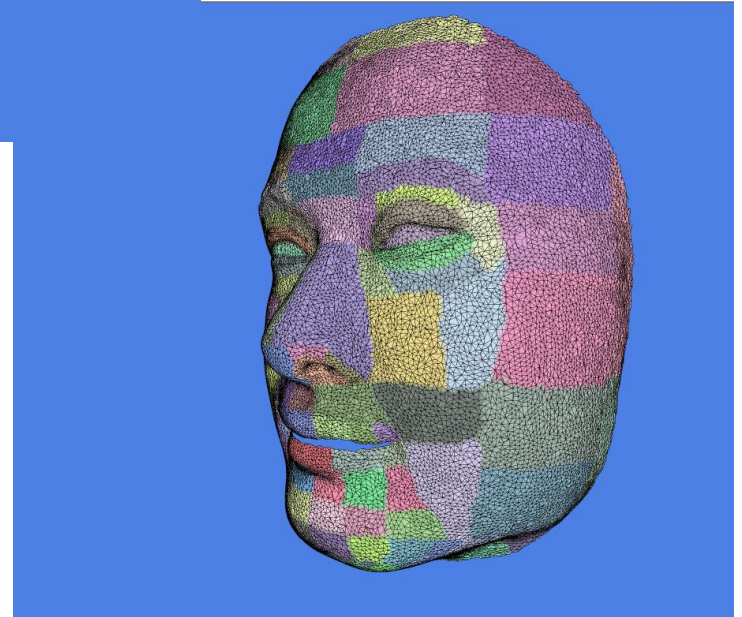
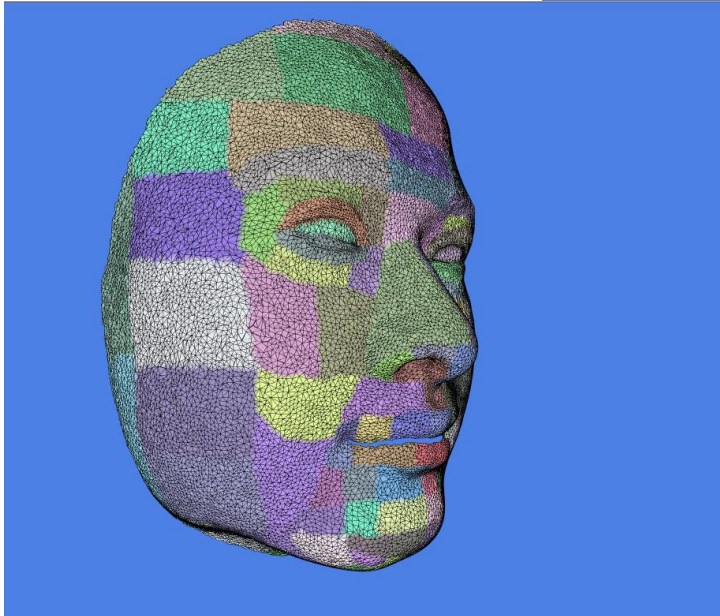
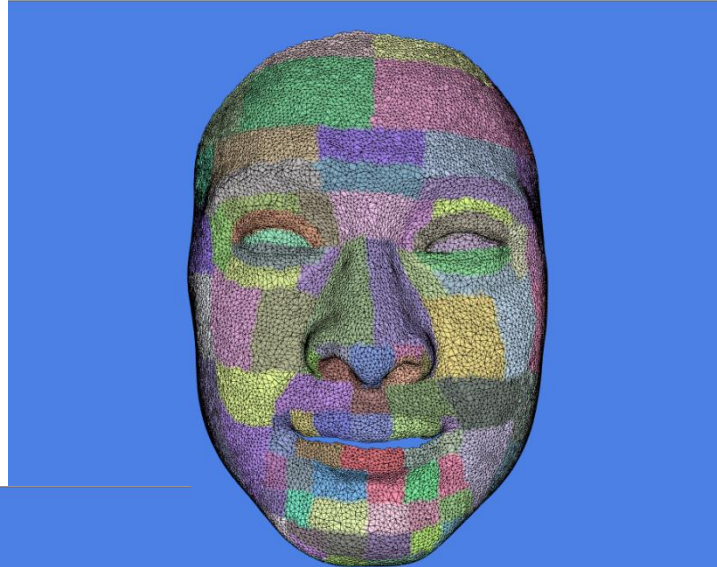
Facial region and landmark representation



Facial regions

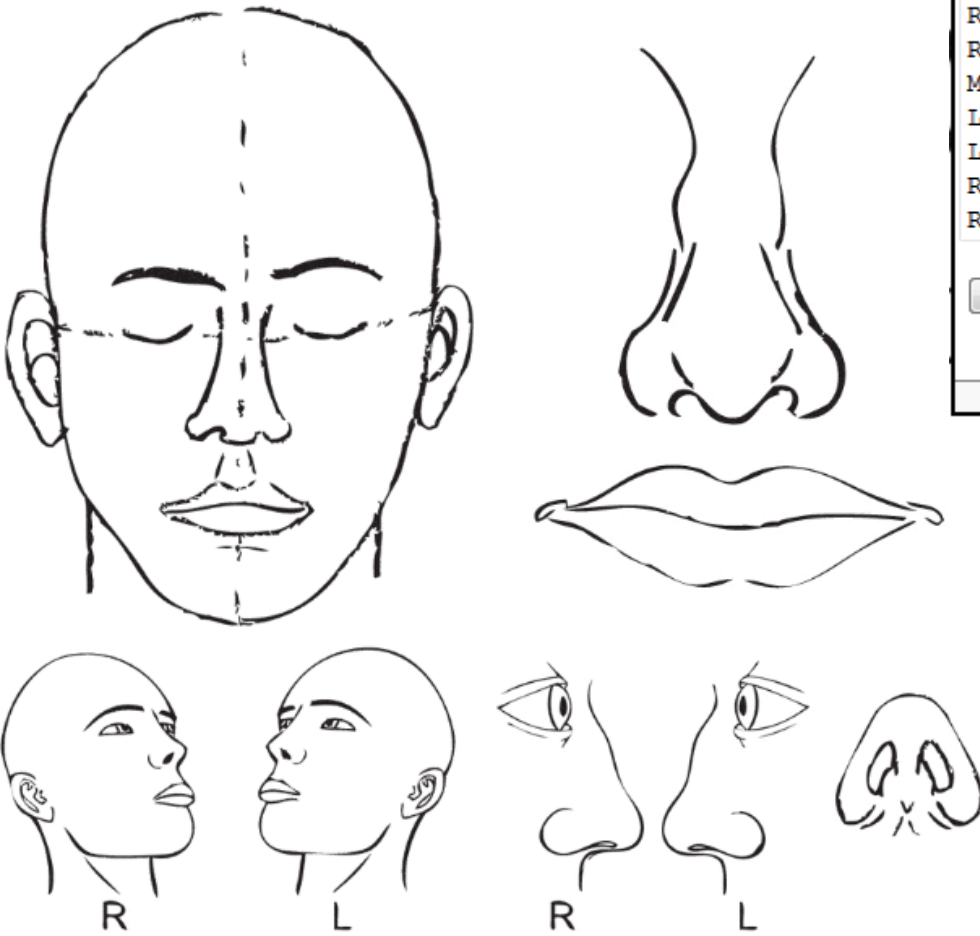


Facial regions and meshes



Human Surface Anatomy Labeling System

<http://www.anatomymapper.com/#>

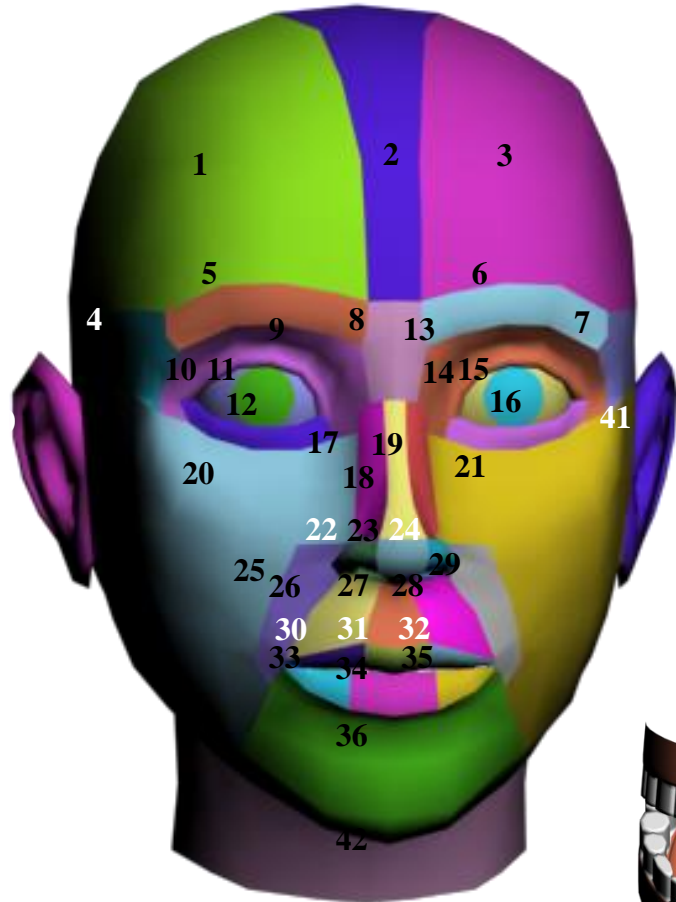


Selected Locations

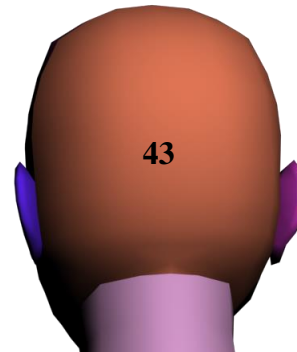
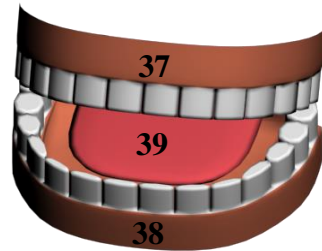
- Right Lateral Frontal Scalp
- Right Paramedian Frontal Scalp
- Mid Frontal Scalp
- Left Paramedian Frontal Scalp
- Left Lateral Frontal Scalp
- Right Lateral Upper Forehead
- Right Paramedian Upper Forehead

Clear Text Biopsy List Treated Sites List

Facial landmark names: LOE1 (Level of Expression)

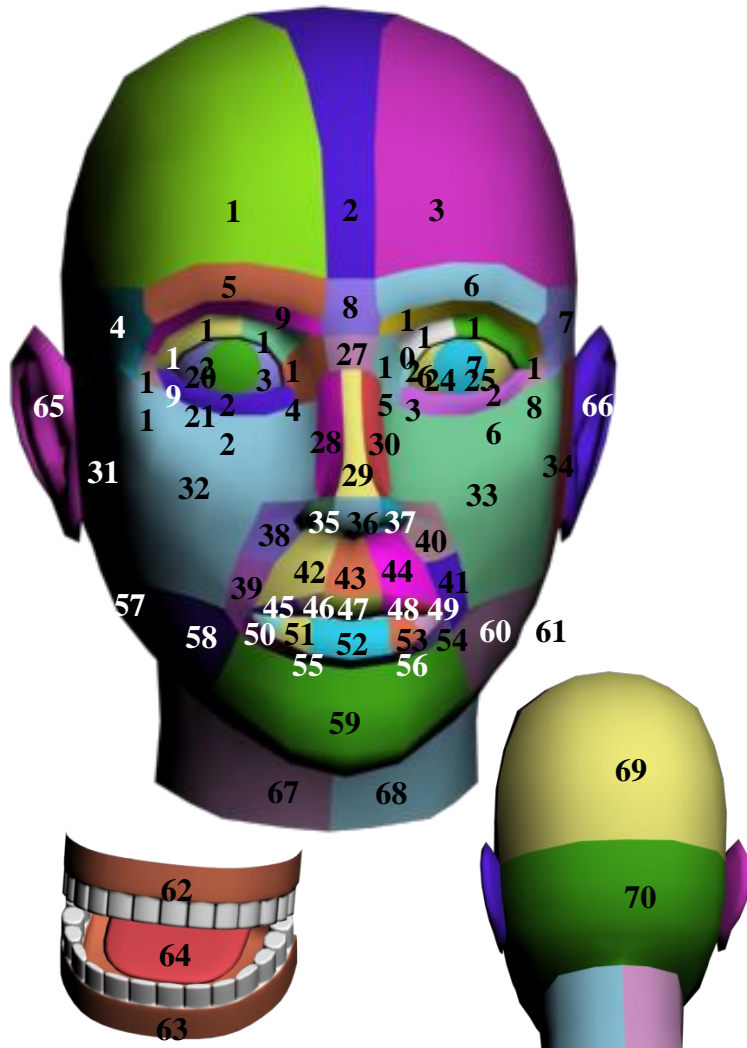


Right face	Middle face	Left face
Right forehead(1)	Mid forehead(2)	Left forehead(3)
Right Temple(4)		Left Temple(7)
Right eyebrow(5)	Glabella(8)	Left eyebrow(6)
Right Upper Eyelid(9) Right Bulbar Conjunctiva(10) Right Pupil(11) Right Lower Eyelid(12)		Left Upper Eyelid Left Bulbar Conjunctiva Left Pupil Left Lower Eyelid
Right Dorsum(17)	Mid Nasal Dorsum(18)	Left Dorsum(19)
Right Cheek(20)		Left Cheek(21)
Right Nostril(22)	Nasal tip(23)	Left Nostril(24)
Right Nasolabial Cheek(25)		Left Nasolabial Cheek(29)
Right Upper Cutaneous Lip(26)	Philtrum(27)	Left Upper Cutaneous Lip(28)
Right upper vermilion lip(30)	Mid Upper Vermillion Lip(31)	Left upper vermilion lip(32)
Right lower vermilion lip(33)	Center lower vermillion lip(34)	Left lower vermillion lip(35)
	Chin(36)	
upper teeth(37)	Tongue(39)	lower teeth(38)
Right Ear(40)		Left Ear(41)
	Neck(42) Occipital Scalp(43)	



Reference for facial landmark names:
<http://www.anatomymapper.com/#>

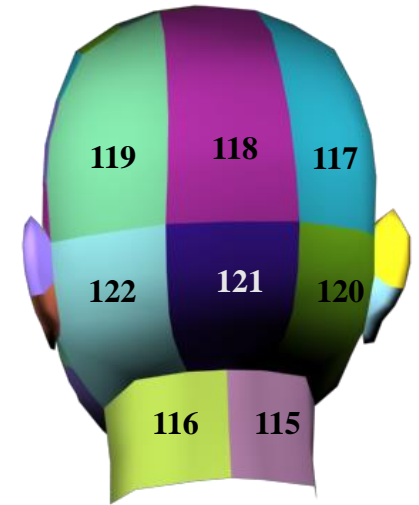
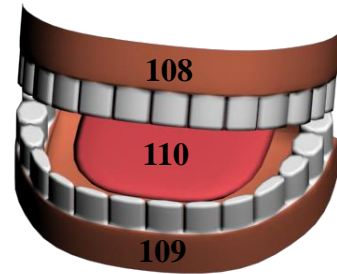
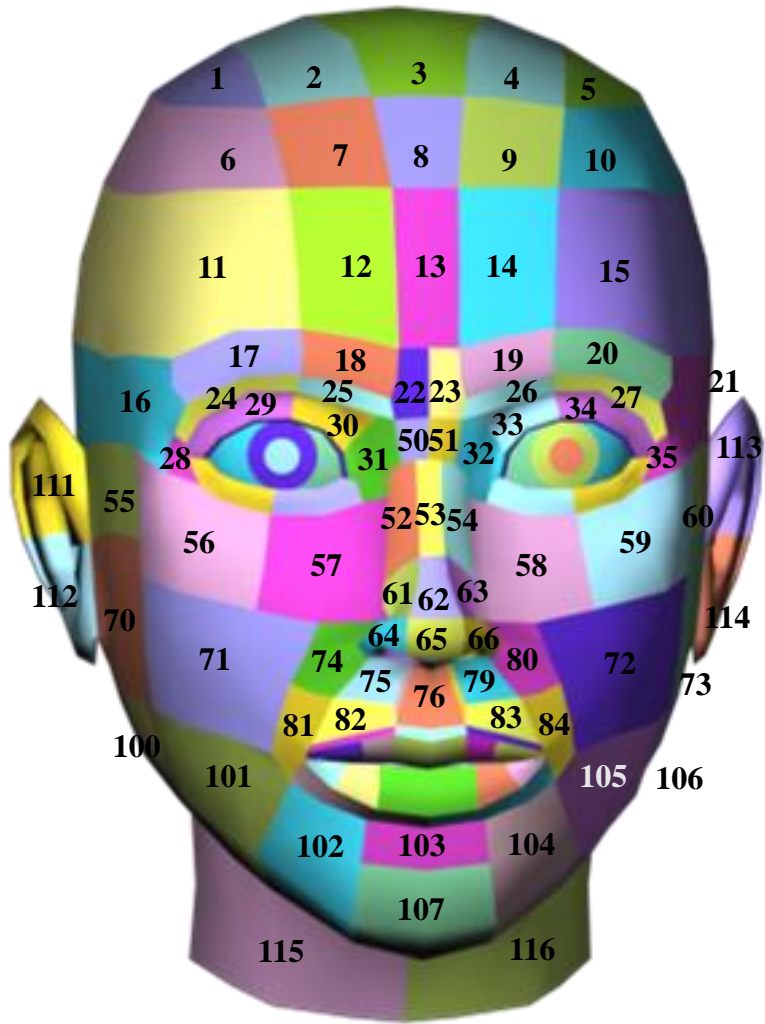
Facial landmark names: LOE2



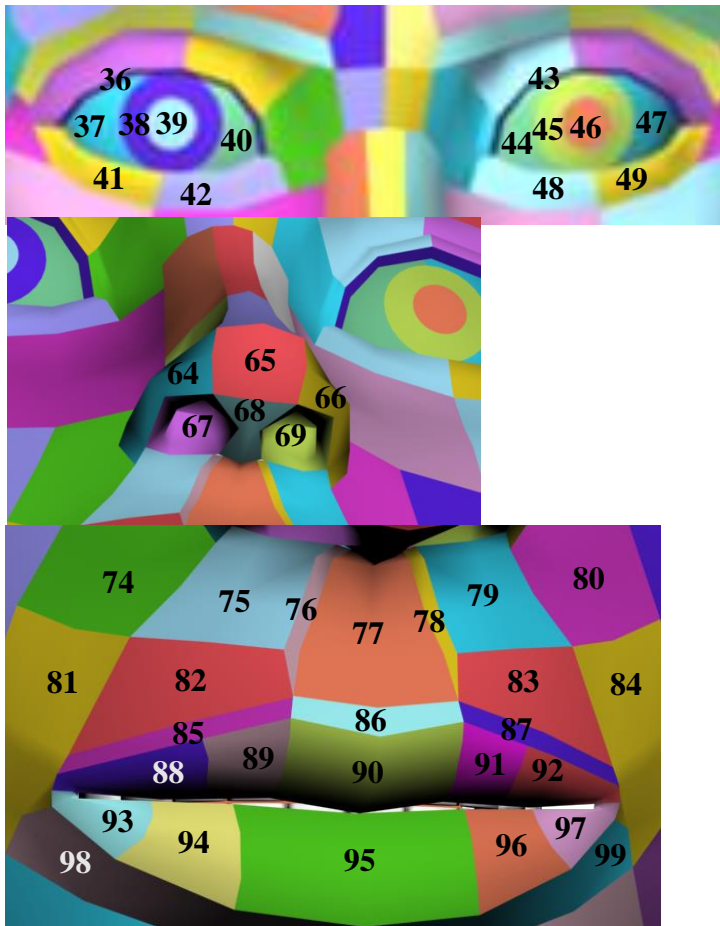
Right face	Middle face	Left face
Right forehead(1)	Mid Forehead(2)	Left forehead(3)
Right Temple(4)		Left Temple(7)
Right eyebrow(5)	Glabella(8)	Left eyebrow(6)
Right Superior Upper Eyelid(9)		Left Superior Upper Eyelid(10)
Right Lateral Canthus(11) Right Inferior Lateral Upper Eyelid(12) Right Inferior Medial Upper Eyelid(13) Right Medial Canthus(14)		Left Medial Canthus(15) Left Inferior Medial Upper Eyelid(16) Left Inferior Lateral Upper Eyelid(17) Left Lateral Canthus(18)
Right Upper Eyelid(19) Right Bulbar Conjunctiva(20) Right Pupil(21) Right Lower Eyelid(22)		Left Upper Eyelid(23) Left Bulbar Conjunctiva(24) Left Pupil(25) Left Lower Eyelid(26)
	Nasal Root(27)	
Right Dorsum(28)	Mid Nasal Dorsum(29)	Left Dorsum(30)
Right Pre-Auricular Cheek(31) Right Cheek(32)		Left Cheek(33) Left Pre-Auricular Cheek(34)
Right Nostril(35)	Nasal tip(36)	Left Nostril(37)
Right Superior Nasolabial Cheek(38) Right Nasolabial Cheek(39)		Left Superior Nasolabial Cheek(40) Left Nasolabial Cheek(41)
Right Upper Cutaneous Lip(42)	Philtrum(43)	Left Upper Cutaneous Lip(44)
Far Right upper vermillion lip(45) Right upper vermillion lip(46)	Mid Upper Vermillion Lip(47)	Left upper vermillion lip(48) Far left upper vermillion lip(49)
Right lower oral commissure(50) Right lower vermillion lip(51)	Center lower vermillion lip(52)	Left lower vermillion lip(53) Left lower oral commissure(54)
Right Lower Cutaneous Lip(55)		Left Lower Cutaneous Lip(56)
Right Cheek near Angle of Jaw(57) Right Inferior Lower Cheek(58)	Chin(59)	Left Inferior Lower Cheek(60) Left Cheek near Angle of Jaw(61)
upper teeth(62)	Tongue(64)	lower teeth(63)
Right Ear(65)		Left Ear(66)
Right Neck(67)		Left Neck(68)
	Superior Occipital Scalp(69) Inferior Occipital Scalp(70)	

Reference for facial landmark names:
<http://www.anatomymapper.com/#>

Facial landmark names: LOE3



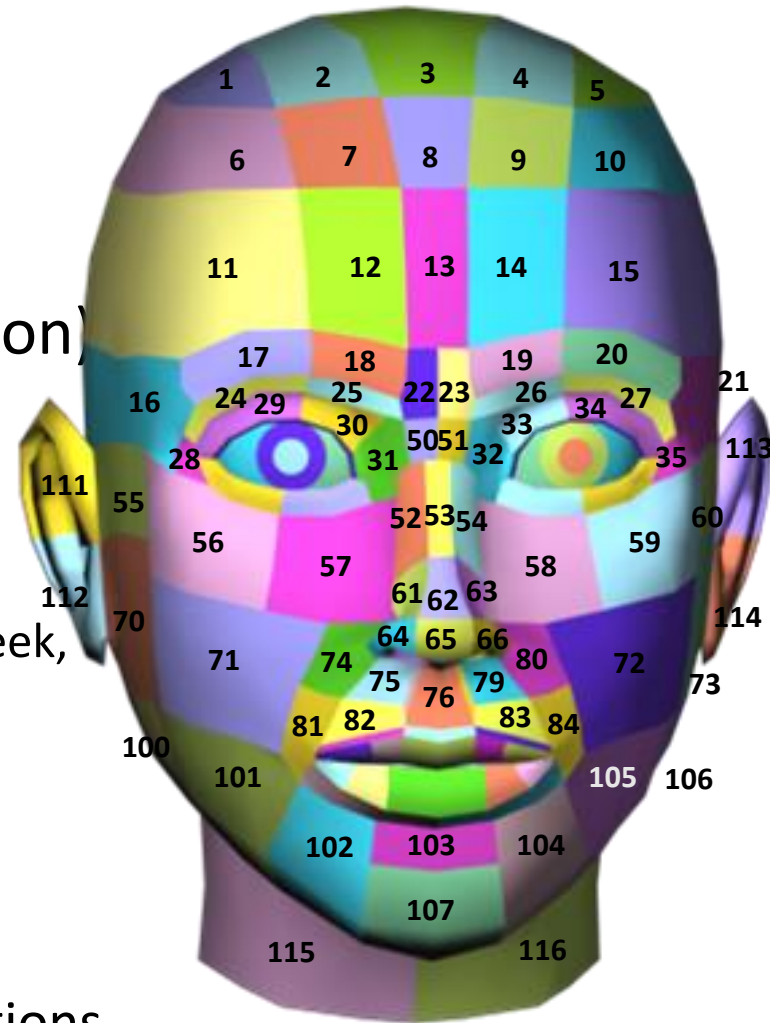
Reference for facial landmark names:
<http://www.anatomymapper.com/#>



Right face	Middle face	Left face
Right Lateral Frontal Scalp(1) Right Medial Frontal Scalp(2)	Mid Frontal Scalp(3)	Left Medial Frontal Scalp(4) Left Lateral Frontal Scalp(5)
Right Lateral Upper Forehead(6) Right Medial Upper Forehead(7)	Mid Upper Forehead(8)	Left Medial Upper Forehead(9) Left Lateral Upper Forehead(10)
Right Lateral Lower Forehead(11) Right Medial Lower Forehead(12)	Mid Frontal Scalp(13)	Left Medial Lower Forehead(14) Left Lateral Lower Forehead(15)
Right Temple(16)		Left Temple(21)
Right Lateral Eyebrow(17) Right Medial Eyebrow(18)		Left Medial Eyebrow(19) Left Lateral Eyebrow(20)
Right Glabella(22)		Left Glabella(23)
Right Superior Lateral Upper Eyelid(24) Right Superior Medial Upper Eyelid(25)		Left Superior Medial Upper Eyelid(26) Left Superior Lateral Upper Eyelid(27)
Right Lateral Canthus(28) Right Inferior Lateral Upper Eyelid(29) Right Inferior Medial Upper Eyelid(30) Right Medial Canthus(31)		Left Medial Canthus(32) Left Inferior Medial Upper Eyelid(33) Left Inferior Lateral Upper Eyelid(34) Left Lateral Canthus(35)
Right Upper Eyelid(36) Right Lateral Bulbar Conjunctiva(37) Right Iris(38) Right Pupil(39) Right Medial Bulbar Conjunctiva(40) Right Lateral Lower Eyelid(41) Right Medial Lower Eyelid(42)		Left Upper Eyelid(43) Left Medial Bulbar Conjunctiva(44) Left Iris(45) Left Pupil(46) Left Lateral Bulbar Conjunctiva(47) Left Medial Lower Eyelid(48) Left Lateral Lower Eyelid(49)
Right Nasal Root(50) Right Superior Nasal Dorsum(52)	Mid Nasal Dorsum(53)	Left Nasal Root(51) Left Superior Nasal Dorsum(54)
Right Superior Pre-Auricular Cheek(55) Right Malar Cheek(56) Right Supramedial Cheek(57)		Left Supramedial Cheek(58) Left Malar Cheek(59) Left Superior Pre-Auricular Cheek(60)
Right Inferior Nasal Dorsum(61) Right Nasal Ala(64) Right Nostril(67)	Inferior Nasal Dorsum(62) Nasal Tip(65) Inferior Nasal Tip(68)	Left Inferior Nasal Dorsum(63) Left Nasal Ala(66) Left Nostril(69)
Right Inferior Pre-Auricular Cheek(70) Right Medial Mid Cheek(71)		Left Medial Mid Cheek(72) Left Inferior Pre-Auricular Cheek(73)
Right Superior Nasolabial Cheek(74) Right Infranasal Upper Cutaneous Lip(75) Right Philtral Column(76)	Philtrum(77)	Left Philtral Column(78) Left Infranasal Upper Cutaneous Lip(79) Left Superior Nasolabial Cheek(80)
Right Inferior Nasolabial Cheek(81) Right Upper Cutaneous Lip(82)		Left Upper Cutaneous Lip(83) Left Inferior Nasolabial Cheek(84)
Right Vermillion Border of Upper Lip(85)	Cupid's Bow at Vermillion Border of Upper Lip(86)	Left Vermillion Border of Upper Lip(87)
Far Right upper vermilion lip(88) Right upper vermilion lip(89)	Mid Upper Vermillion Lip(90)	Left upper vermilion lip(91) Far left upper vermilion lip(92)
Right lower oral commissure(93) Right lower vermilion lip(94)	Center lower vermilion lip(95)	Left lower vermilion lip(96) Left lower oral commissure(97)
Right Lower Cutaneous Lip(98)		Left Lower Cutaneous Lip(99)
Right Cheek near Angle of Jaw(100) Right Inferior Lower Cheek(101) Right Chin(102)	Median Chin near Mental Crease(103) Mid Chin(107)	Left Chin(104) Left Inferior Lower Cheek(105) Left Cheek near Angle of Jaw(106)
upper teeth(108)	Tongue(110)	lower teeth(109)
Right Superior Ear(111) Right Inferior Ear(112)		Left Superior Ear(113) Left Inferior Ear(114)
Right Neck(115)		Left Neck(116)
Right Superior Occipital Scalp(117) Right Inferior Occipital Scalp(120)	Midline Superior Occipital Scalp(118) Midline Inferior Occipital Scalp(121)	Left Superior Occipital Scalp(119) Left Inferior Occipital Scalp(122)

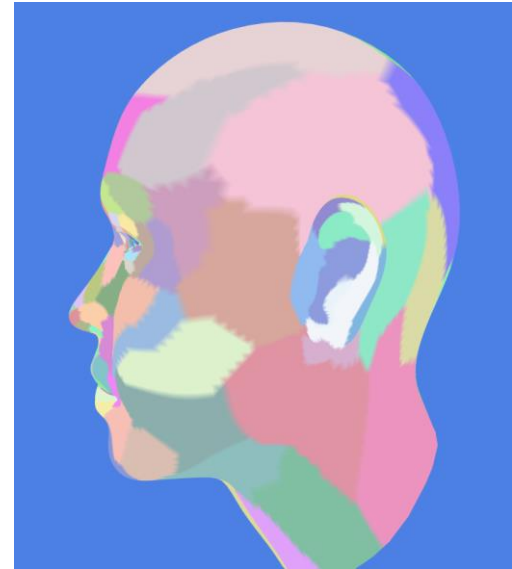
Work in progress (1)

- Facial region LOE (Level of Expression)
 - 122 regions and landmarks → LOE 3
 - 70 regions and landmarks → LOE2
 - Expression with eye, nose, and mouse
 - 43 regions and landmarks → LOE1
 - Expression with eye, nose, mouse, cheek, and jaw
- H-Anim representation
 - Specify facial regions
 - LOE 1, LOE 2, LOE 3
 - Specify facial landmarks
 - Specify Skin coordinates for facial regions
 - Determine if **Displacer** nodes are necessary



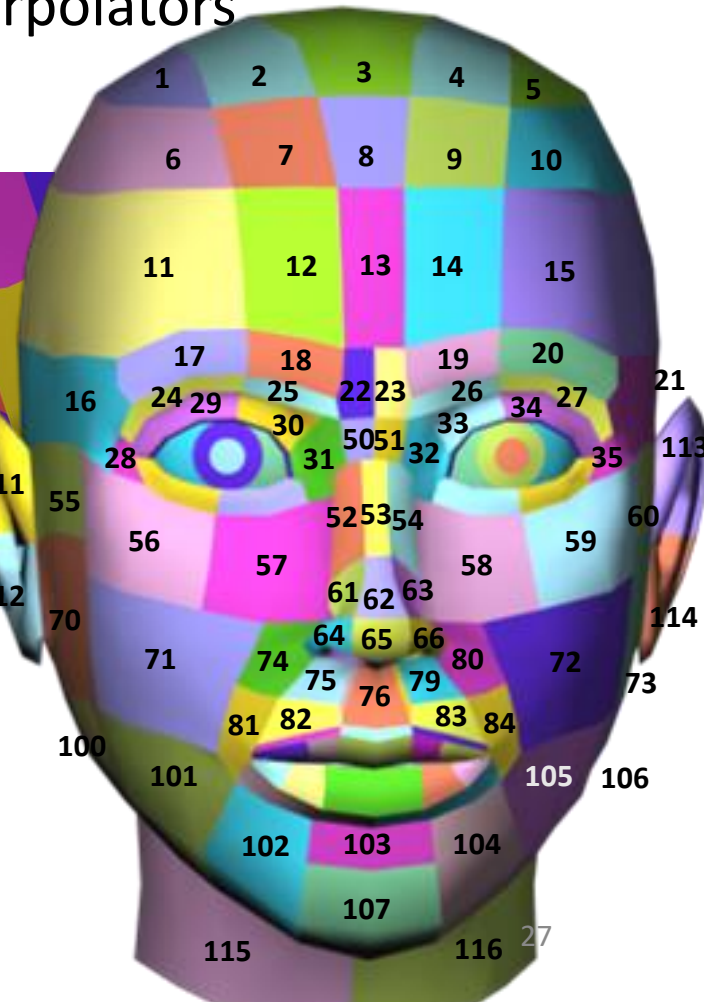
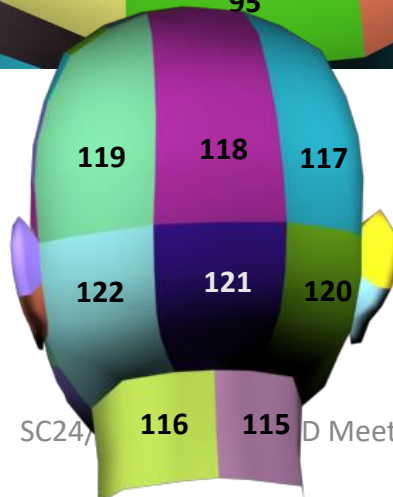
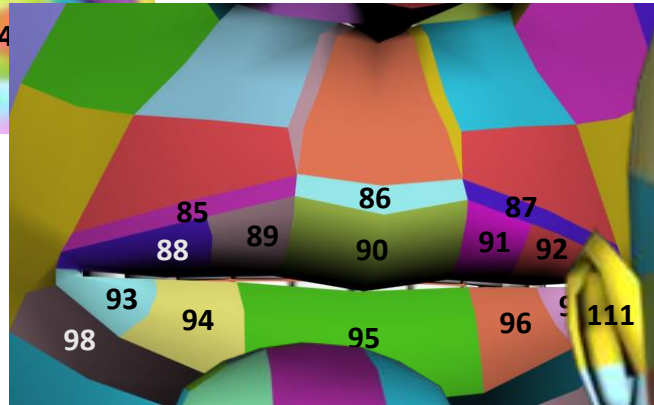
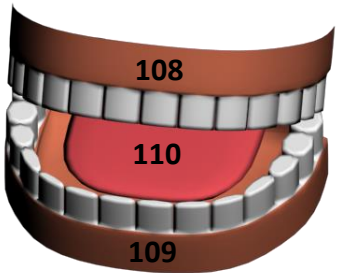
Work in progress (2)

- Face and head modelling with LOE
 - Combine face and head in 3D
 - Define all regions for a head



Work in progress (3)

- Region based facial animation
 - LOE3 Facial animation using X3D interpolators



LOE3 Facial Animation using X3D Interpolators

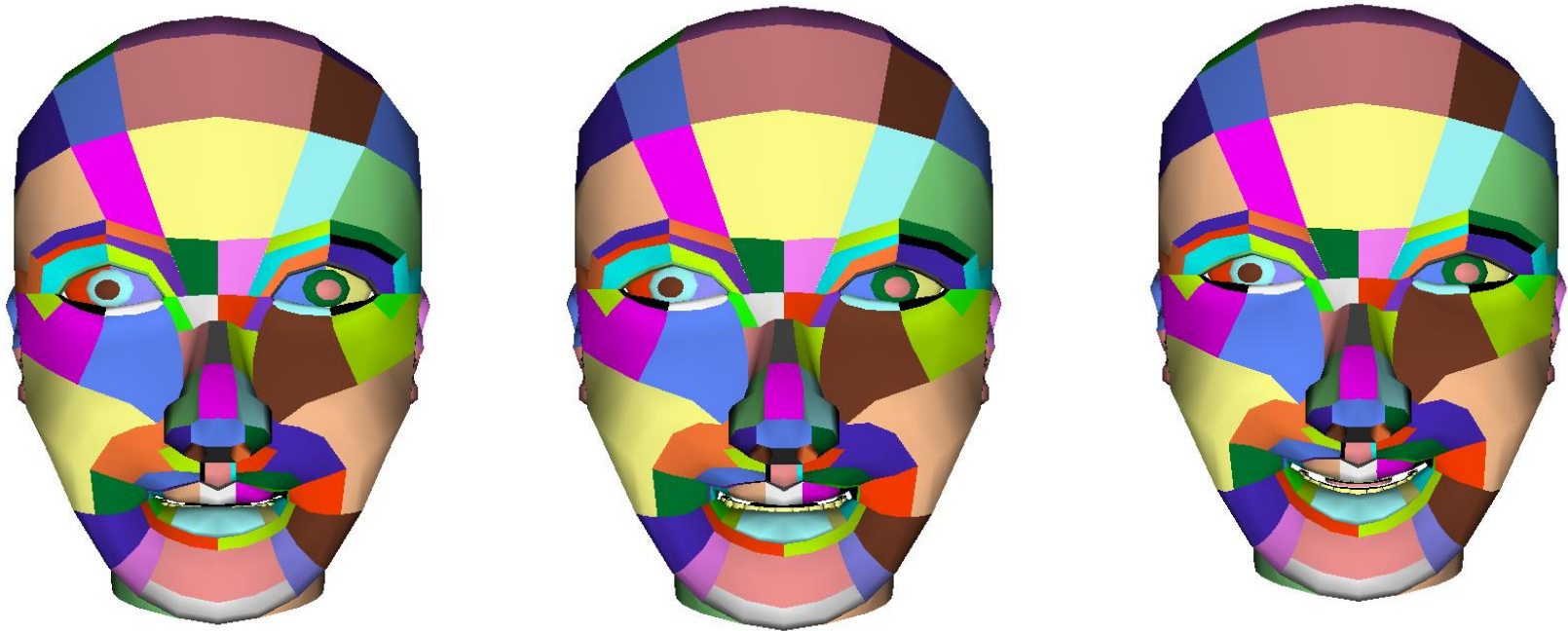
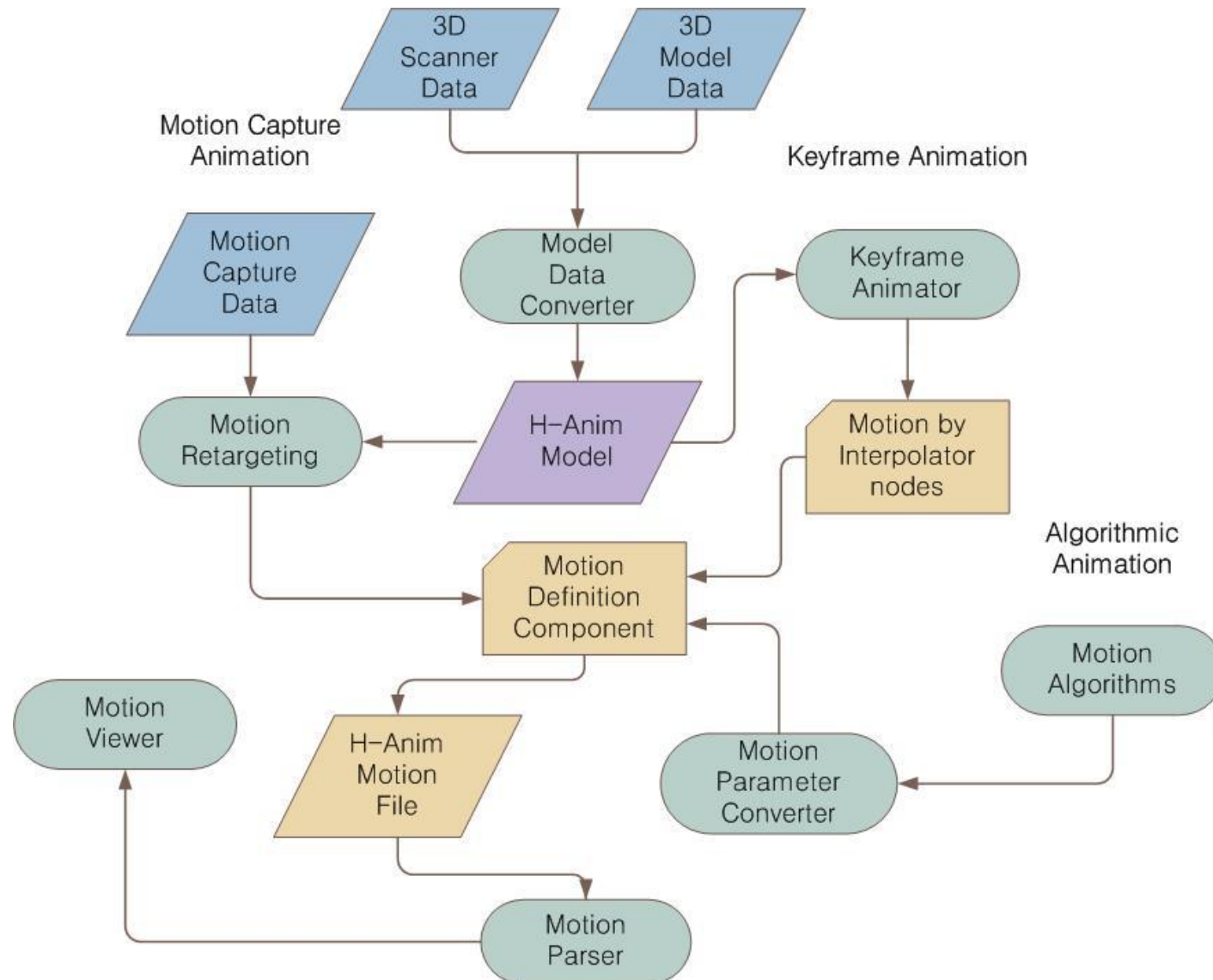


Figure 4.1 – Procedure of humanoid animation



LOE3 Facial Animation using X3D Interpolators (1)



LOE3 Facial Animation using X3D Interpolators (2)

```
<Transform DEF="Left_lower_vermillion_lip" translation="-1.363E-5 23.02
45.76">
  <Shape >
    <Appearance >
      <Material ambientIntensity="1.0" transparency="0.0"
shininess="0.145" diffuseColor="0.588 0.588 0.588" specularColor="0.0 0.0
0.0"/>
      <ImageTexture url=""LOE_v1_map.jpg""/>
    </Appearance>
    <IndexedFaceSet creaseAngle="3.14159"
DEF="Left_lower_vermillion_lip-FACES" coordIndex=" 3 0 1 -1 1 2 3 -1 5 4 2
-
```

LOE3 Facial Animation using X3D Interpolators (3)

```
<CoordinateInterpolator DEF='Left_lower_vermillion_lip-MORP' key='0  
0.5 1' keyValue='12.52 -53.95 -0.1401, 11.2 -52.85 0.8364, 6.483 -55.51  
3.356, 6.738 -57.14 2.889, 6.353 -52.97 2.639, 10.57 -51.59 0.4045,  
6.353 -51.32 1.038, 11.21 -50.77 -2.374, 16.79 -49.13 -3.673, 15.74 -  
49.38 -3.293, 15.8 -
```


LOE3 Facial Animation using X3D Interpolators (4)

```
<ScalarInterpolator DEF='AnimationAdapter' key='0 0.25 0.5 0.75 1'  
  keyValue='0.5 0 0.5 1 0.5'/>
```

```
<TimeSensor DEF='Clock' cycleInterval='4' enabled='true' loop='true'/>
```

```
<ROUTE fromField='value_changed'  
  fromNode='Left_lower_vermillion_lip-MORP' toField='point'  
  toNode='Left_lower_vermillion_lip-COORD'/>
```

```
<ROUTE fromField='value_changed' fromNode='AnimationAdapter'  
  toField='set_fraction' toNode='Left_lower_vermillion_lip-MORP'/>
```

Discussion (1) – Facial Model

- Problem when adding facial models to LOA 3 facial joint-based modeling:
 - LOA 3 defines seven facial joints
 - The medical profession considers that facial joints do not exist
- Suggested solutions:
 - Location of facial models
 - Add the facial region-based model to the LOA Skullbase joint
 - Face region definition
 - Instead of LOA 3 facial joints, define region-based facial model based on LOA hierarchy models

Discussion (2) – Facial Model

- Face region definition

```
<Scene>
```

```
  <HAnimFace>
```

```
    <HAnimFaceRegion DEF='hanim_right_forehead'  
name='right_forehead' marker = '0 0 0' >
```

```
    <HAnimFaceRegion DEF='hanim_right_forehead'  
name='right_forehead' marker = '0 0 0' >
```

```
  ...
```

```
  </HAnimFace>
```

```
  <HAnimJoint>
```

```
  <HAnimSegment>
```

```
  </HAnimSegment>
```

```
  </HAnimJoint>
```

Discussion (3) – Facial Motion

- Facial motion (expression) definition
 - Using H-Anim 19774
- Facial keyframe animation
 - Using interpolators (ISO/IEC 19774-1)
- Facial motion capture animation
 - Using motion objects (ISO/IEC 19774-2)
- Facial Action Coding System
- Jung-Ju Choi's motion algorithm

H-Anim Facial Animation

- Foreword
- Introduction
- 1. Scope
- 2. Normative references
- 3. Terms and definitions
- 4. Concepts
 - 4.1 General
 - 4.2 H-Anim Facial Model
 - Region based facial modeling
 - LOE 1 (Level of Expression)
 - LOE 2 (Level of Expression)
 - LOE 3 (Level of Expression)
 - Structure of a humanoid
 - 4.3 H-Anim Facial Animation (Expression)
 - H-Anim facial keyframe animation
 - Using Interpolators
 - H-Anim facial motion algorithm based animation
 - Using Motion algorithms
 - Interfaces with motion generation algorithms
 - Interfaces with Facial Action Coding System
 - H-Anim facial motion capture animation
 - Using Motion objects
- 5. Abstract data types
- 6. Object interfaces
- 7. Conformance

Annexes

- A. Examples of interfaces with facial motion algorithm based animation
- B. Examples of interfaces with Facial Action Coding System

Work in progress

- WD text preparation
- Development of LOE 1, 2, and 3 facial models
- H-Anim facial expression using LOE 1, 2, and 3 models
 - Define animation interfaces for generating facial expression
 - Facial animation using interpolators
 - Facial animation using motion capture
- Examples
 - Facial animation using a motion generation algorithm (Jung-Ju Choi)
 - Facial animation using Facial Action Coding System