FACIAL ANIMATIONS

COMPUTER GRAPHICS SEMINAR

PRIIT PALUOJA

OUTLINE

- HUMAN ANATOMY
- GENERAL FRAMEWORK
- DATA-DRIVEN TECHNIQUES
- CONCLUSION

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HUMAN ANATOMY

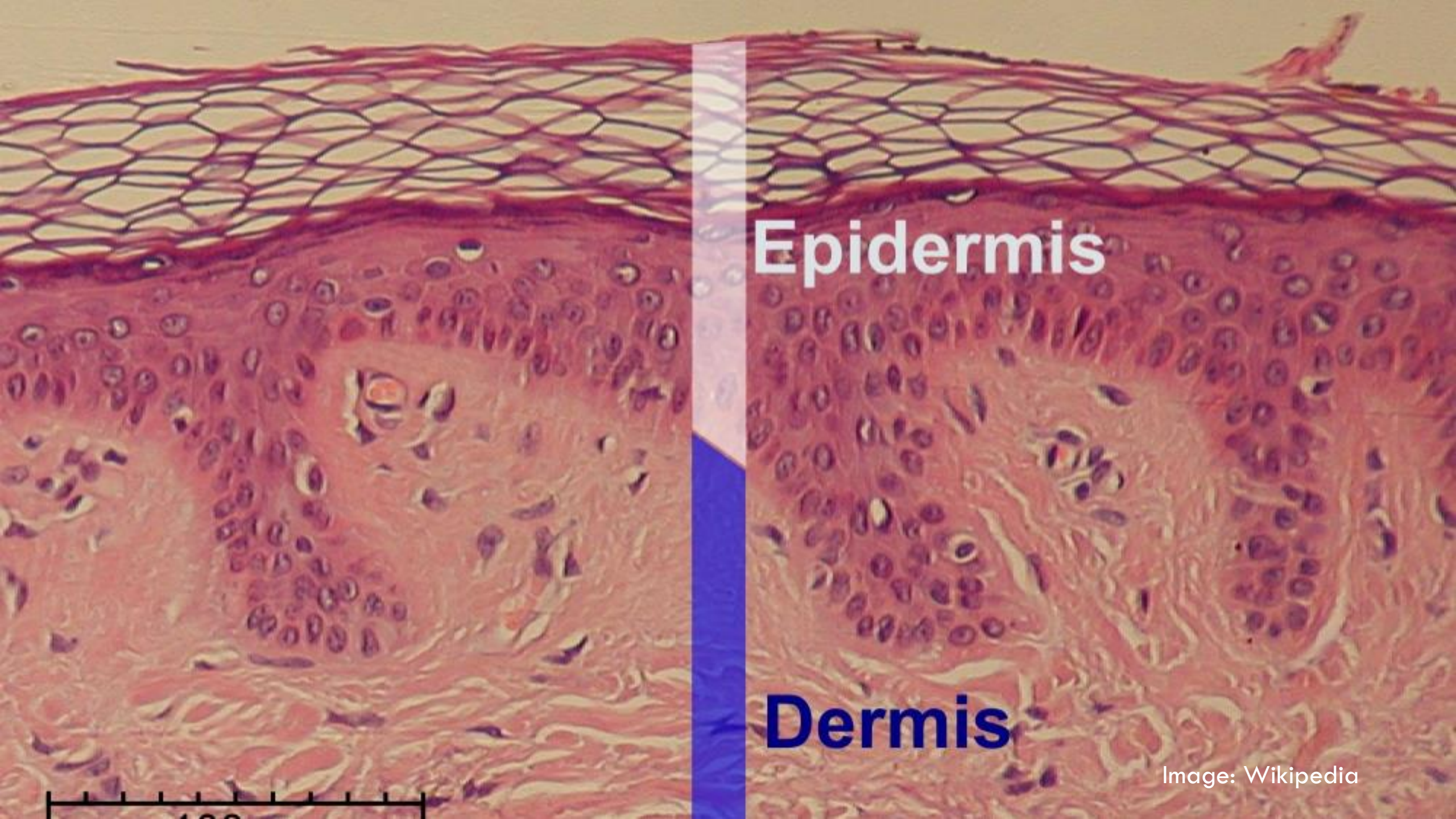


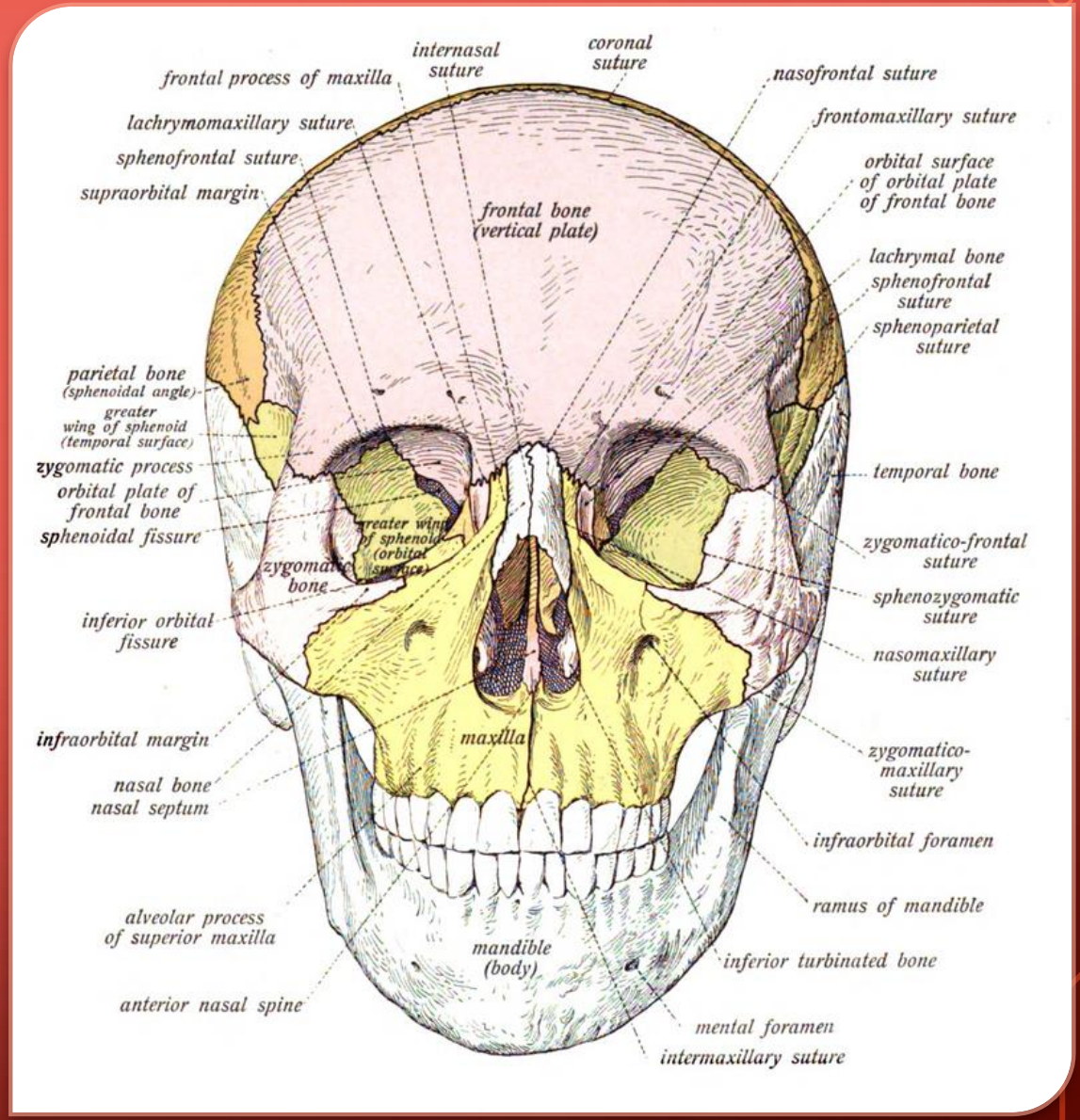
Image: Wikipedia

SKIN [1]

1. Age
2. Sex
3. Race
4. Thickness
5. Environment
6. Disease

SKULL [1]

1. Age
2. Sex
3. Race
4. Geographically distant locations



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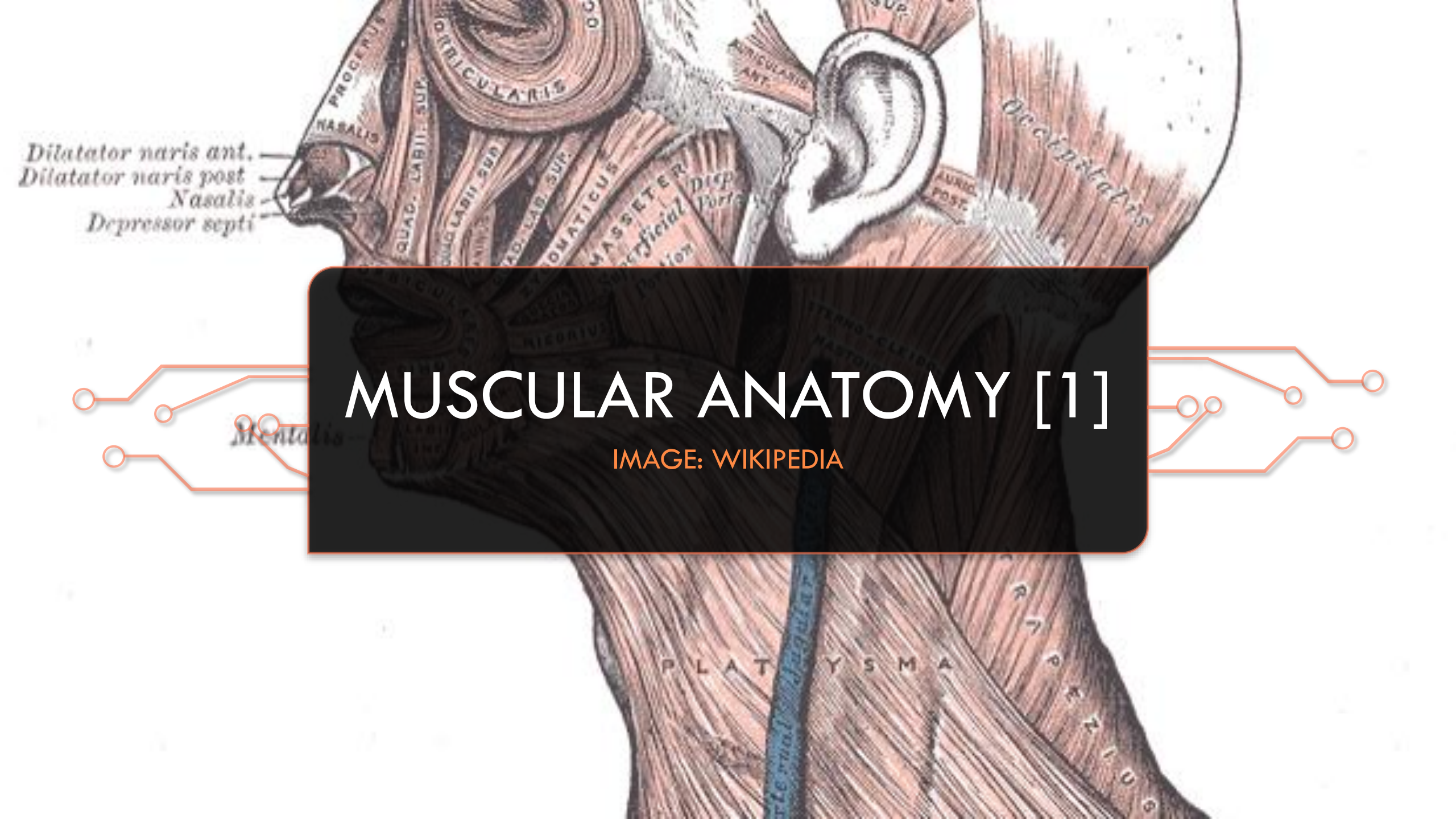

MUSCULAR ANATOMY [1]

IMAGE: WIKIPEDIA

List of muscles [edit]

The facial muscles include:[2]

- Occipitofrontalis muscle
- Temporoparietalis muscle
- Procerus muscle
- Nasalis muscle
- Depressor septi nasi muscle
- Orbicularis oculi muscle
- Corrugator supercilii muscle
- Depressor supercilii muscle
- Auricular muscles (anterior, superior and posterior)
- Orbicularis oris muscle
- Depressor anguli oris muscle
- Risorius
- Zygomaticus major muscle
- Zygomaticus minor muscle
- Levator labii superioris
- Levator labii superioris alaeque nasi muscle
- Depressor labii inferioris muscle
- Levator anguli oris
- Buccinator muscle
- Mentalis

VASCULAR SYSTEMS

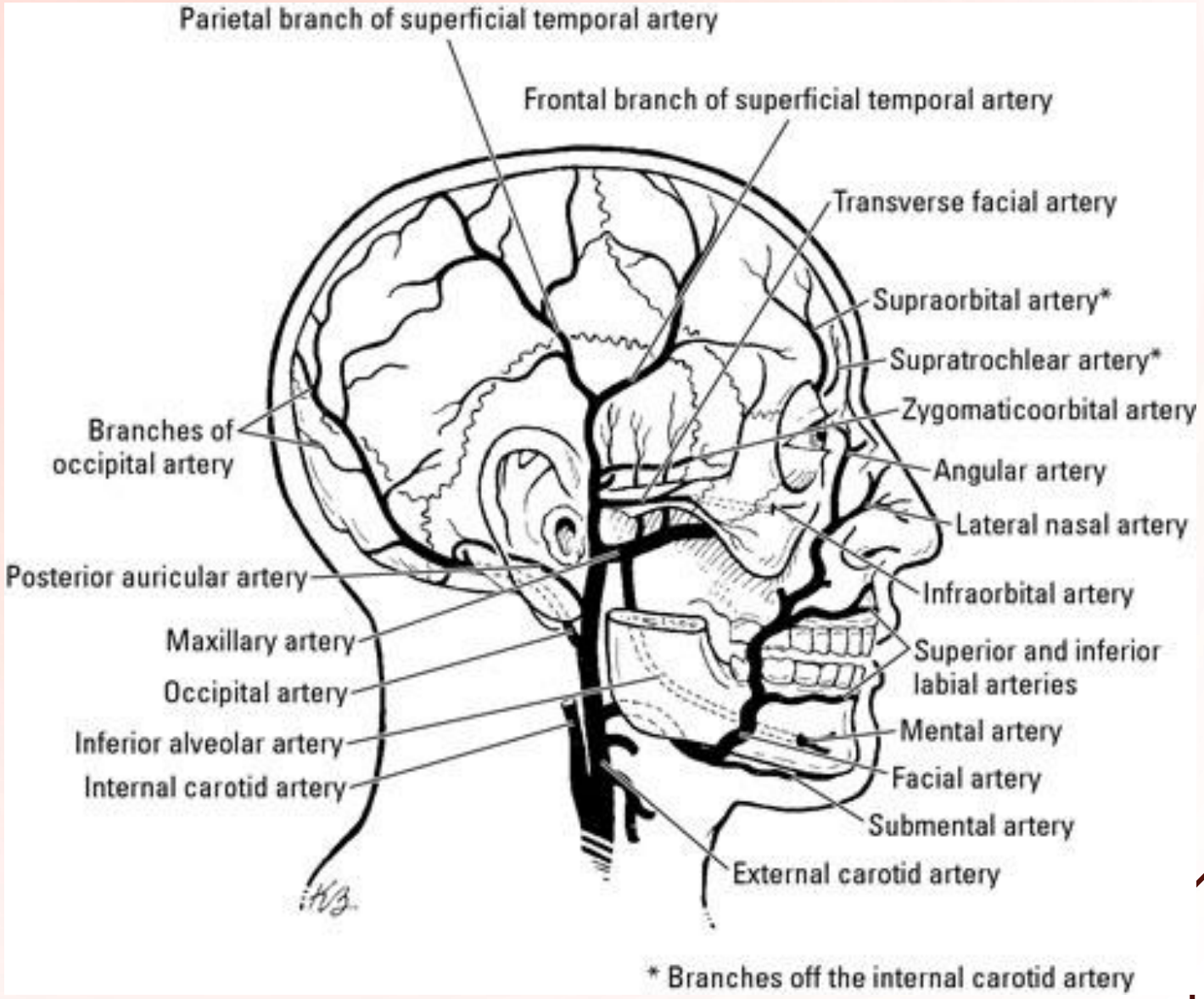

Image: https://www.dummies.com/education/science/anatomy/veins-arteries-and-lymphatics-of-the-face/

NOT COVERED

- Eyes
- Lips
- Teeth
- Tongue

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GENERAL FRAMEWORK

AIM [1]

- Realistic animation in real time
- Minimal manual handling
- Adaptability to any individuals face

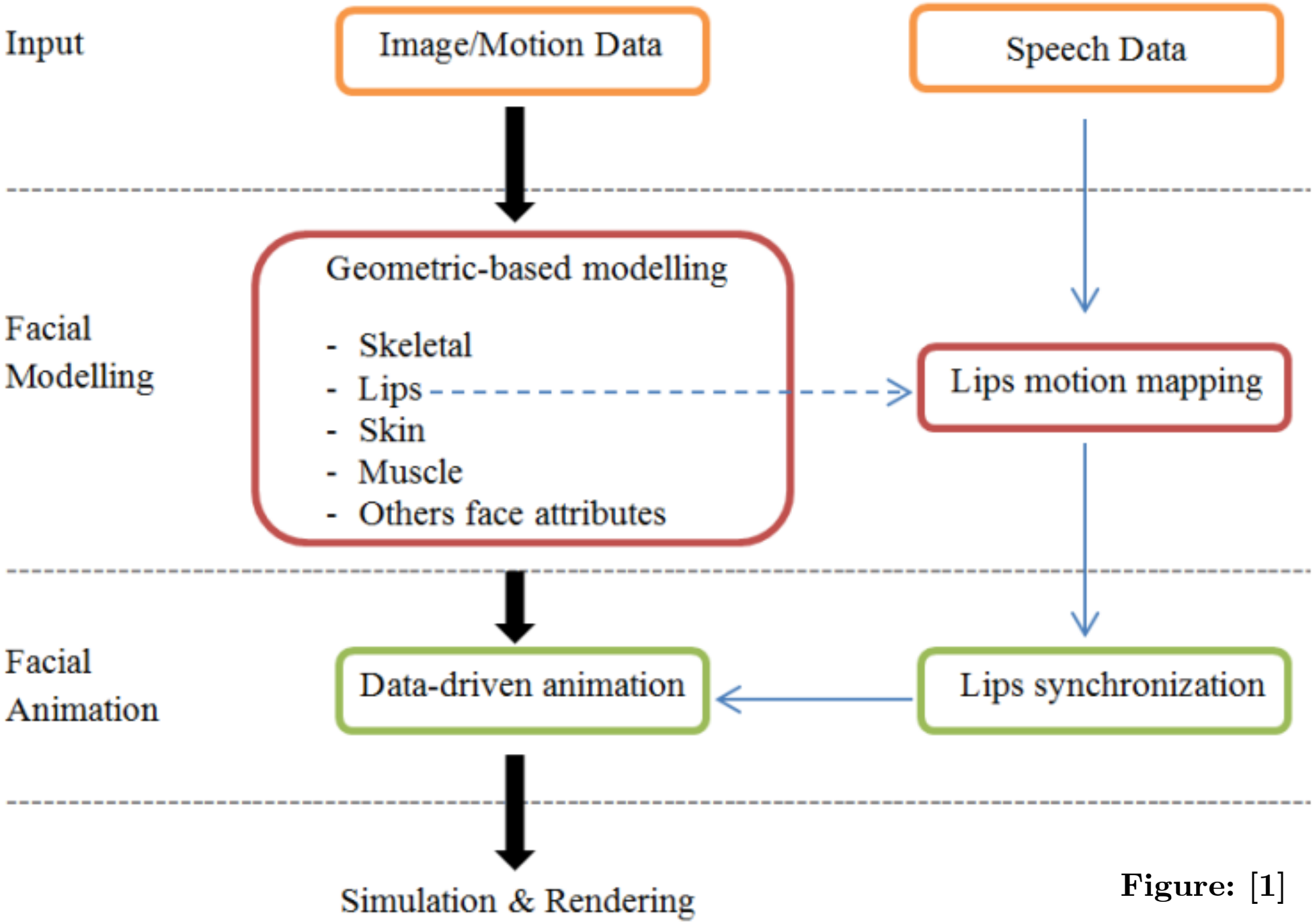

Input
Image/Motion Data
Speech Data
Facial Modelling
Geometric-based modelling
- Skeletal
- Lips
- Skin
- Muscle
- Others face attributes
Lips motion mapping
Facial Animation
Data-driven animation
Lips synchronization
Simulation & Rendering

Figure: [1]

INTERPOLATION

- Addition of a number into the middle of a series [4]
- Calculated based on the numbers before and after it [4]

INTERPOLATION IN COMPUTER GRAPHICS

Fill in frames between the key frames [5]

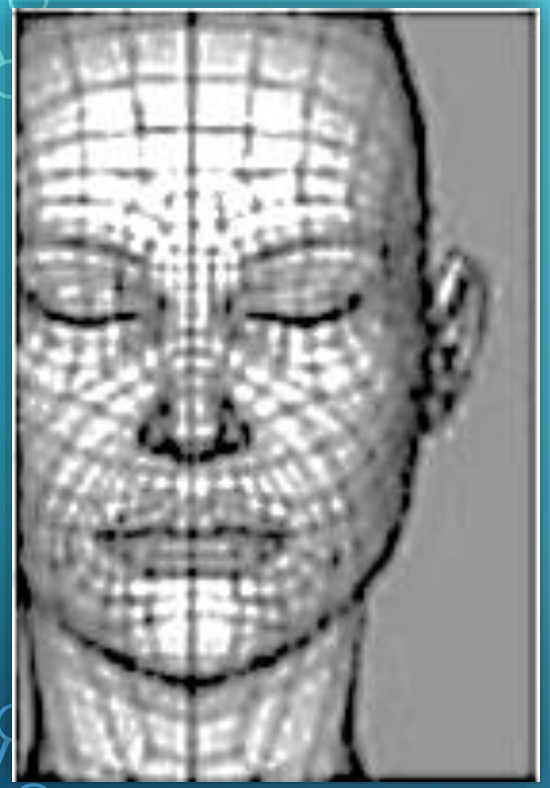


Figure: [1]

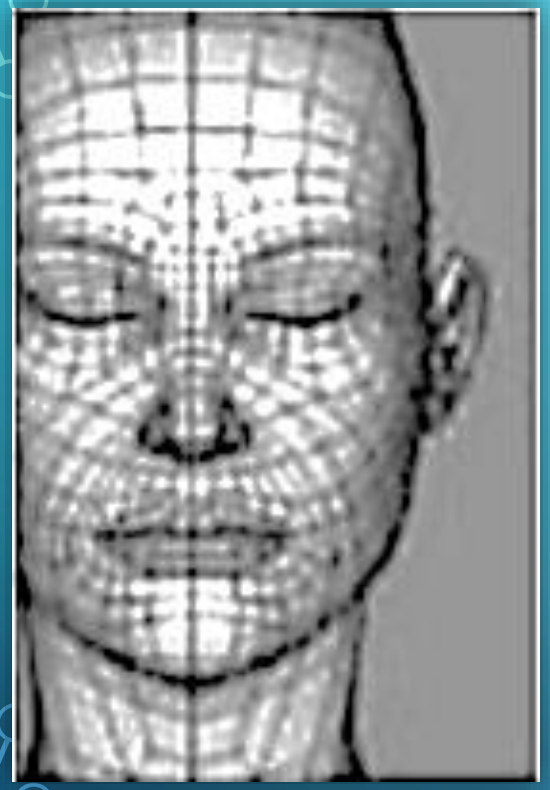
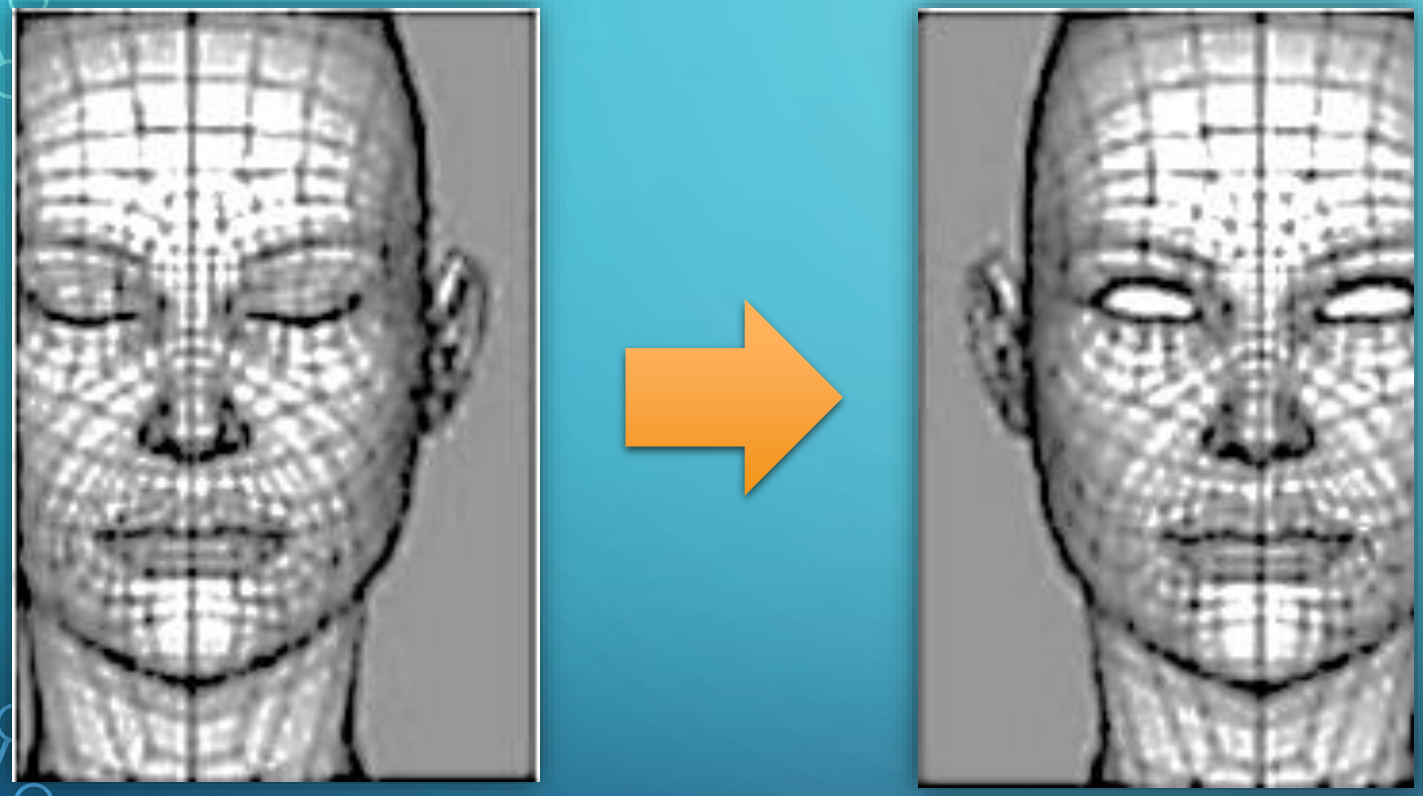


Figure: [1]



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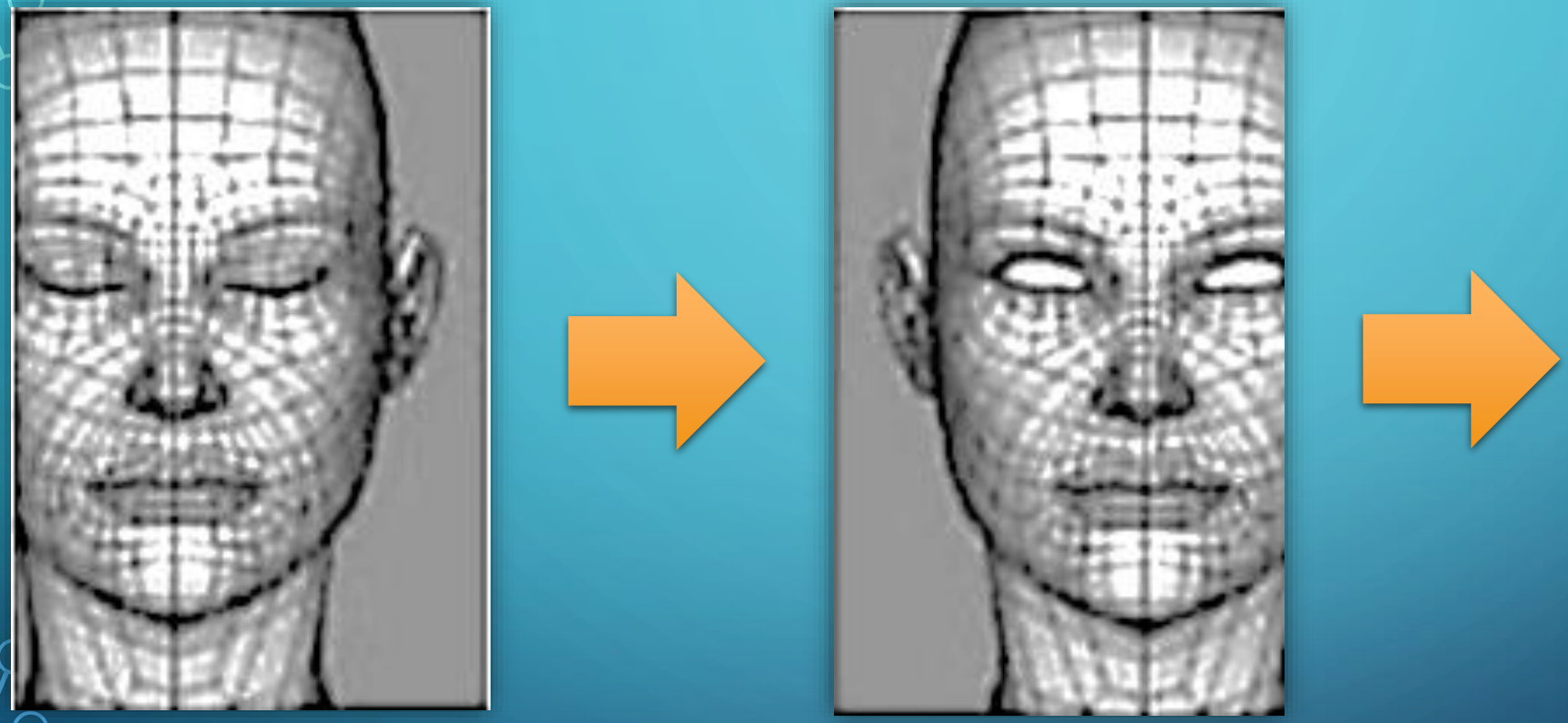


Figure: [1]

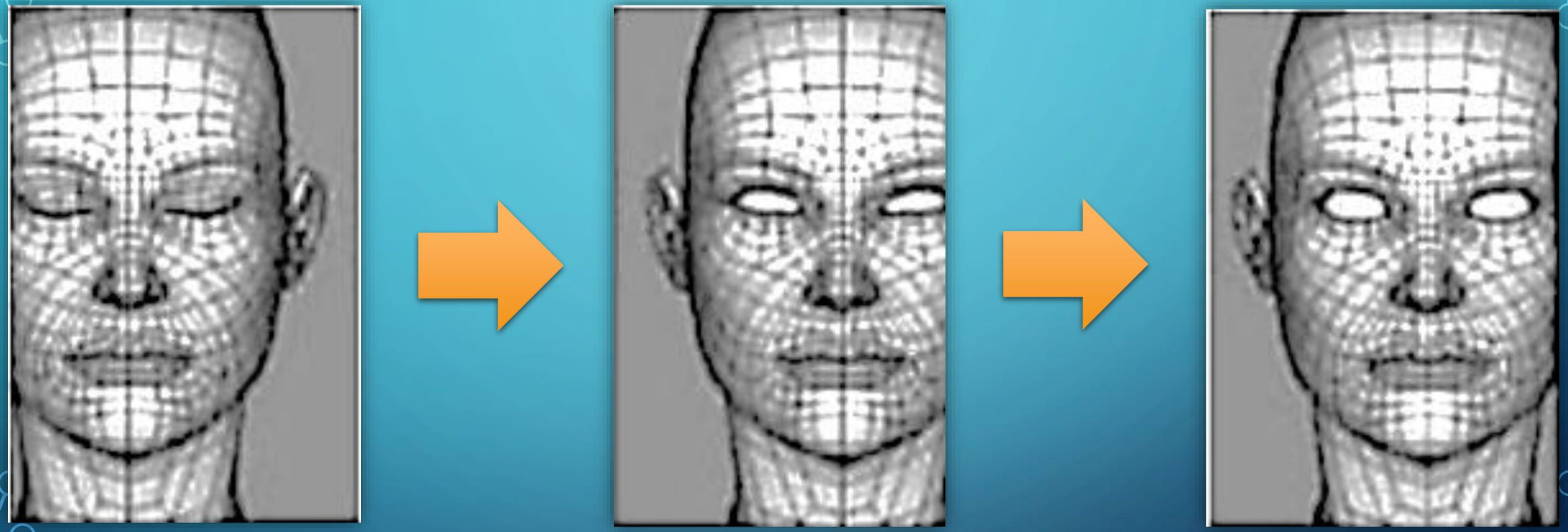


Figure: [1]

SHAPE INTERPOLATION [1]

1. Interpolation over a normalized time interval
2. Polygonal meshes approximate expressions

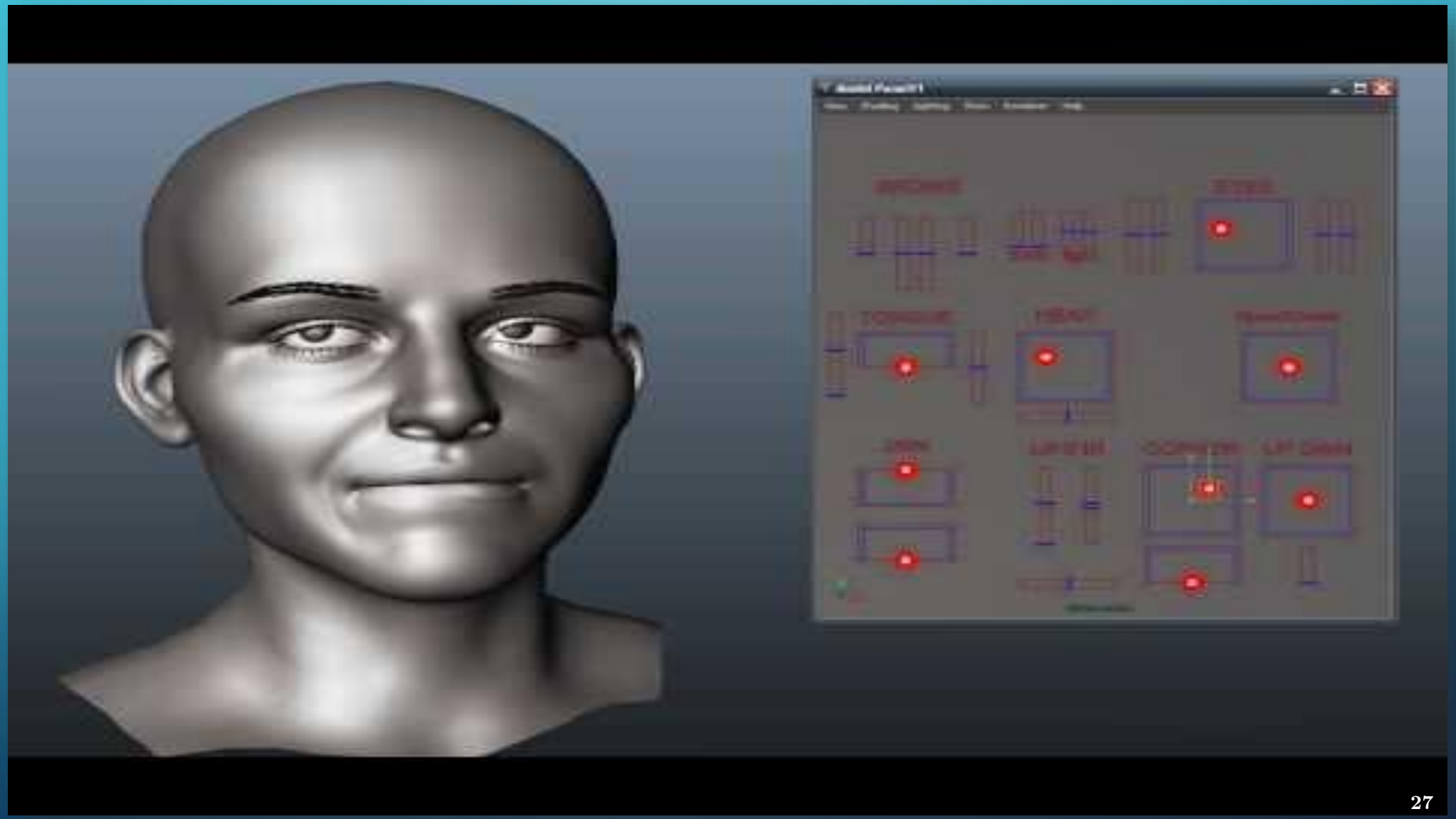
PRACTICAL CONSIDERATIONS?

SHAPE INTERPOLATION [1]

1. Cases which involve scaling or rotating
2. Computationally light
3. Labor intense

PARAMETERIZATION [1]

- Enhancement
- Facial geometry in parts
- Facial configurations
- Not practical in complex models



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CAN WE DO BETTER?

MUSCLE-BASED MODELLING [1]

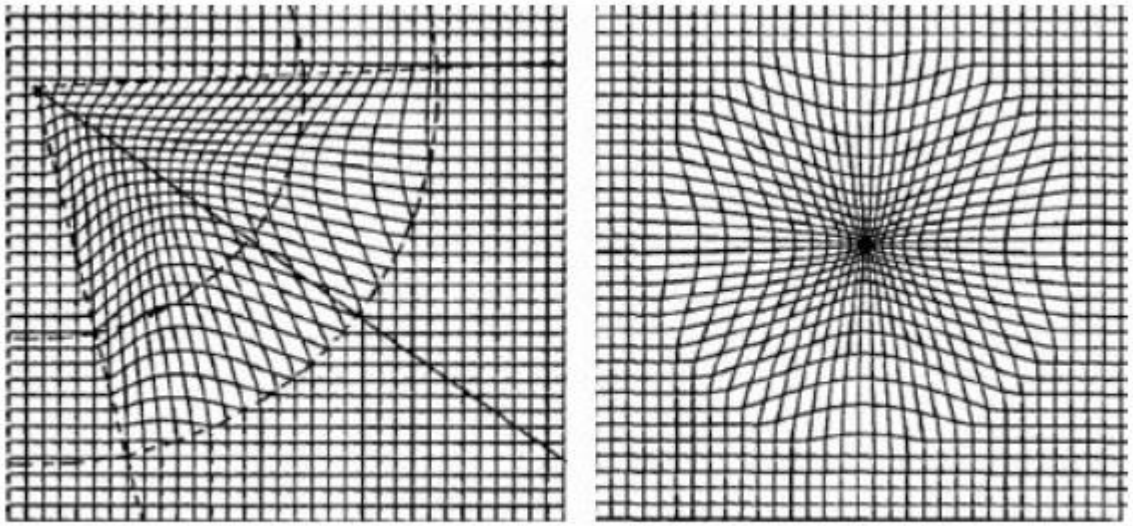


Fig. 3. Waters's muscle model. Linear muscle (left), sphincter muscle (right)

Figure: [1]

Image: en.wikipedia.org/wiki/Spring˙(device)#/media/File:Ressort˙de˙compression.jpg

MUSCLE-BASED MODELLING [1] (1980)

- Mass-spring model
- Connects skin, muscle and bone nodes
- Spring network connects the 38 regional muscles with action units

FACIAL ACTION CODING SYSTEM [6]

1. Allows manually to code nearly any anatomically possible facial expression
2. Specific action units (AU) can produce the expression
3. Manual is over 500 pages in length

List of action units and action descriptors (with underlying facial muscles) [edit]

Main codes [edit]

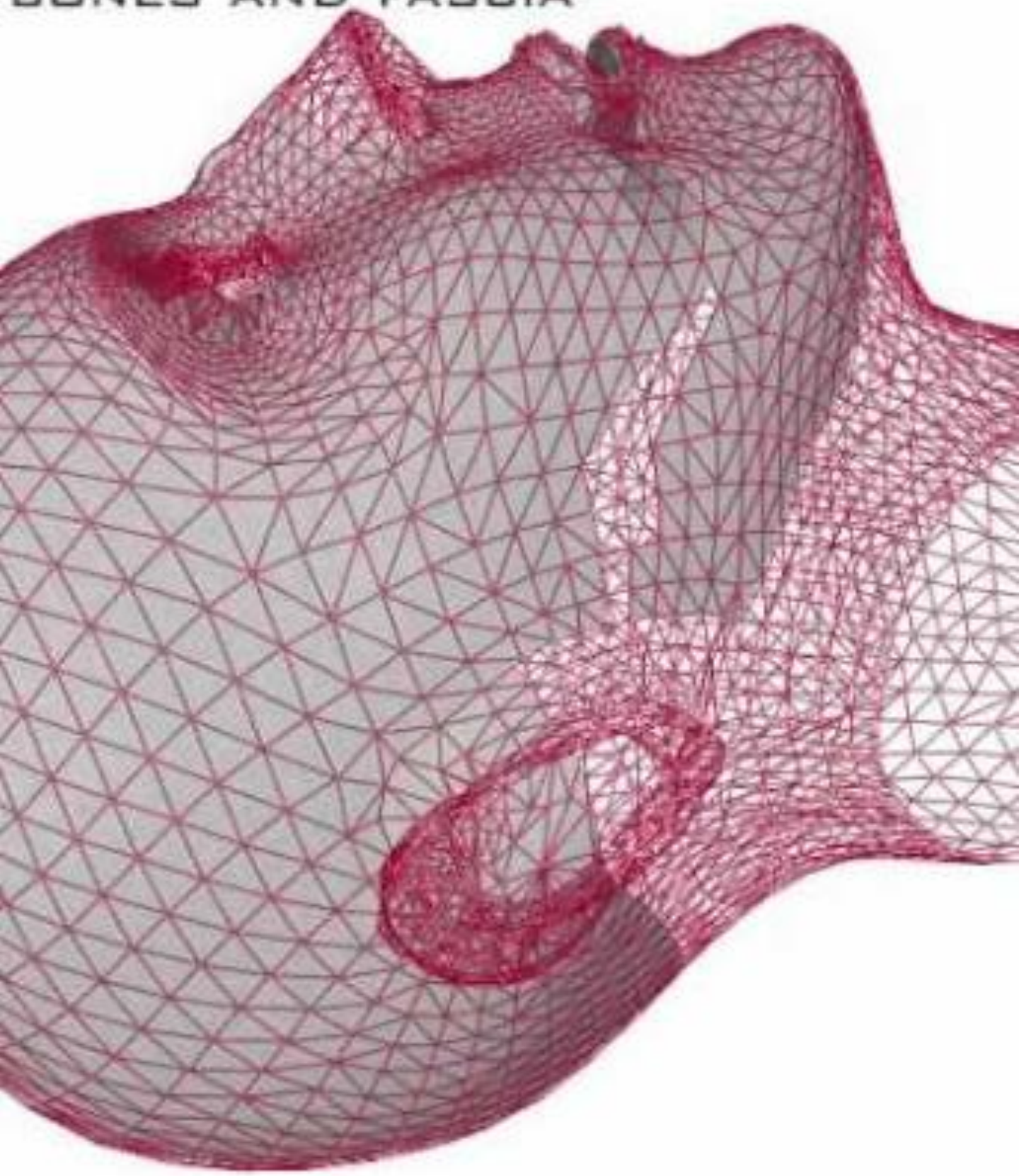
AU number	FACS name	Muscular basis
0	Neutral face	
1	Inner brow raiser	frontalis (pars medialis)
2	Outer brow raiser	frontalis (pars lateralis)
4	Brow lowerer	depressor glabellae, depressor supercilii, corrugator supercilii
5	Upper lid raiser	levator palpebrae superioris, superior tarsal muscle
6	Cheek raiser	orbicularis oculi (pars orbitalis)
7	Lid tightener	orbicularis oculi (pars palpebralis)
8	Lips toward each other	orbicularis oris
9	Nose wrinkler	levator labii superioris alaeque nasi
10	Upper lip raiser	levator labii superioris, caput infraorbitalis
11	Nasolabial deepener	zygomaticus minor
12	Lip corner puller	zygomaticus major
13	Sharp lip puller	levator anguli oris (also known as caninus)

Source: Wikipedia

MUSCLE-BASED MODELLING [1] (1990)

1. Anatomically-based muscle and physically-based tissue model
2. Spring mesh: skin, fatty tissues and muscles

BONES AND FASCIA



PRACTICAL EXAMPLE

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- DATA-DRIVEN TECHNIQUES
- CONCLUSION

DATA-DRIVEN TECHNIQUES [1]

1. Image-Based Techniques
2. Speech-Driven Techniques
3. Performance-Driven Animation

IMAGE-BASED TECHNIQUES

1. Facial surface and position data is captured from images
2. The depth of the model can be calculated

THE MATRIX RELOADED [2]

Image: [2]

MOTIVATION [2]

- Create a 3-d recording of the real actor's performance that could be played back from various angles and lighting conditions
- This allows to extract geometry, texture, light and movement

THE MATRIX RELOADED [2]

- Array of five synchronized cameras
- Sony/Panavision HDW-F900 cameras with workstations
- Images in uncompressed digital format
- Hard disks at data rates close 1G/sec

THE MATRIX RELOADED [2]

1. Project a vertex of the model into each of the cameras
2. Track the motion of the vertex in 2-d
3. At each frame estimate the 3-d position
4. Measure flow error and propagate

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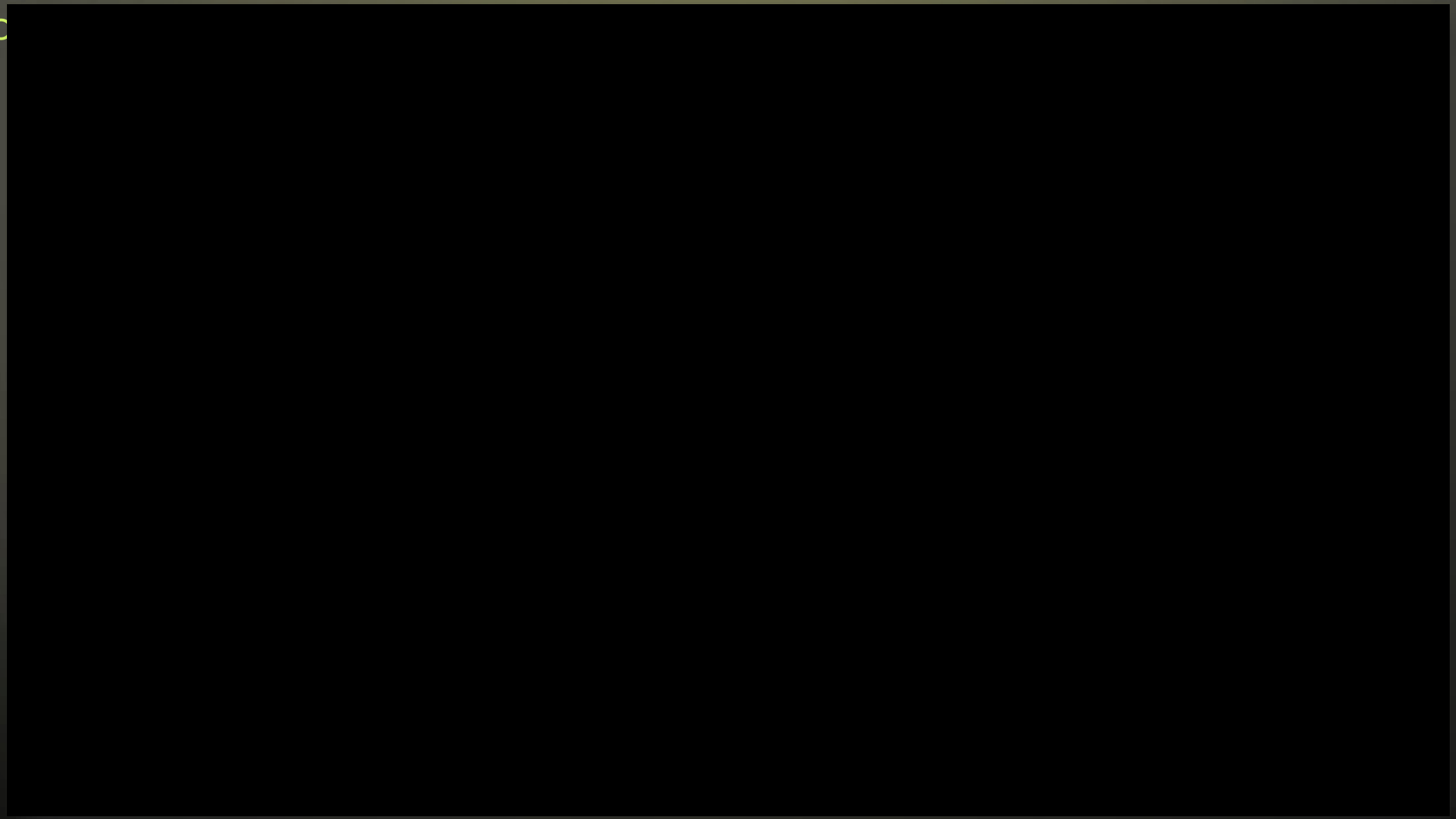
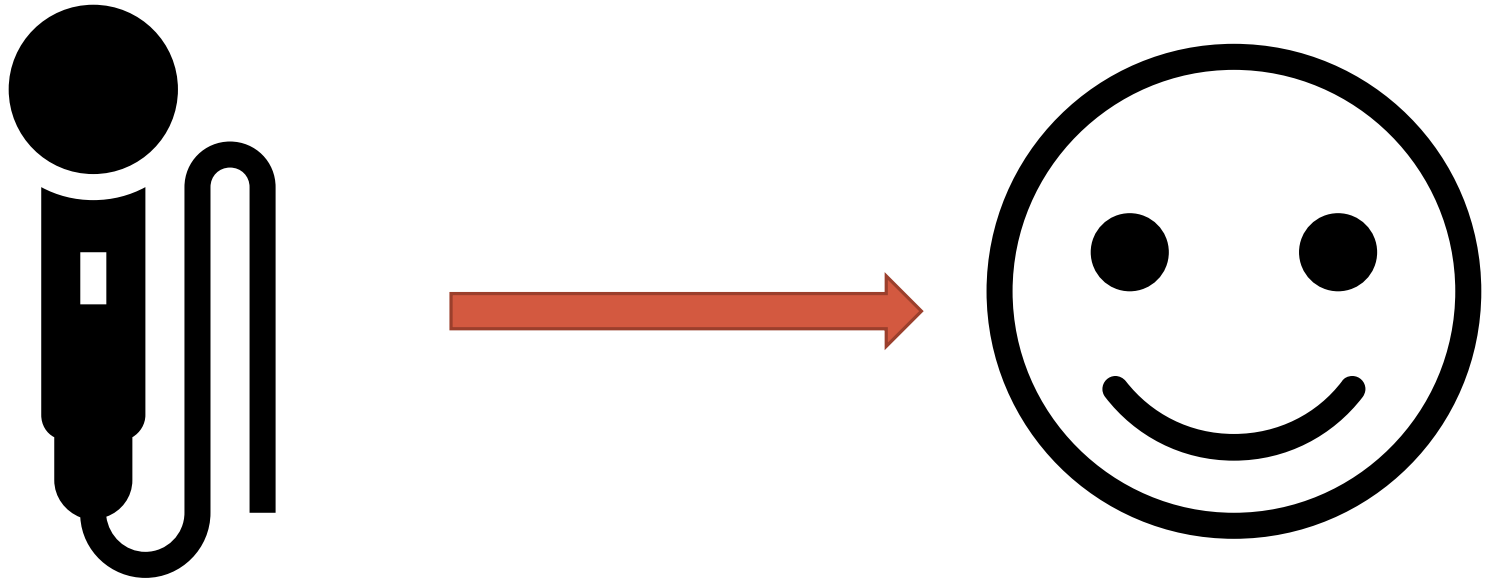
RESULT [2]

Reconstruction of the path of each vertex though 3-d space over time





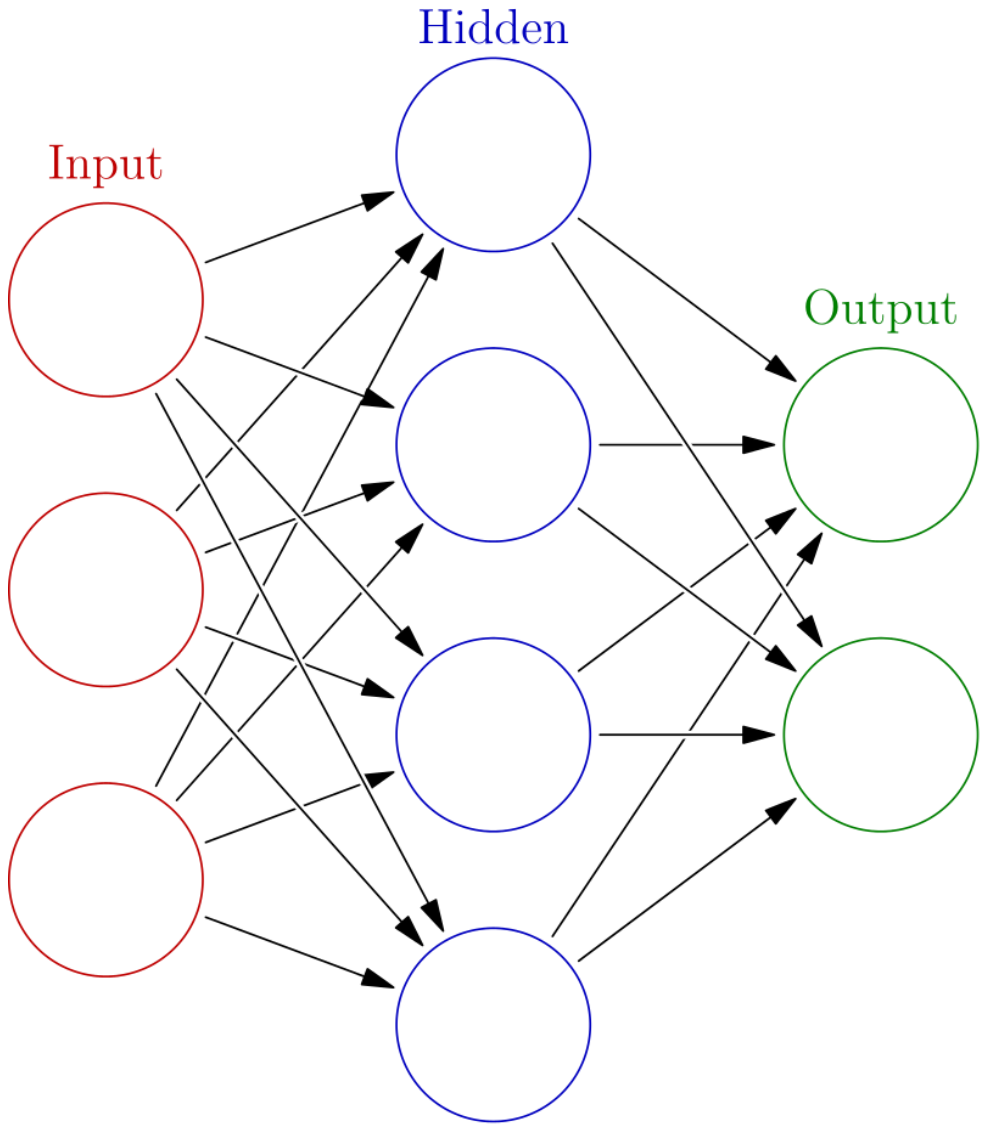
WHAT IF?

SPEECH

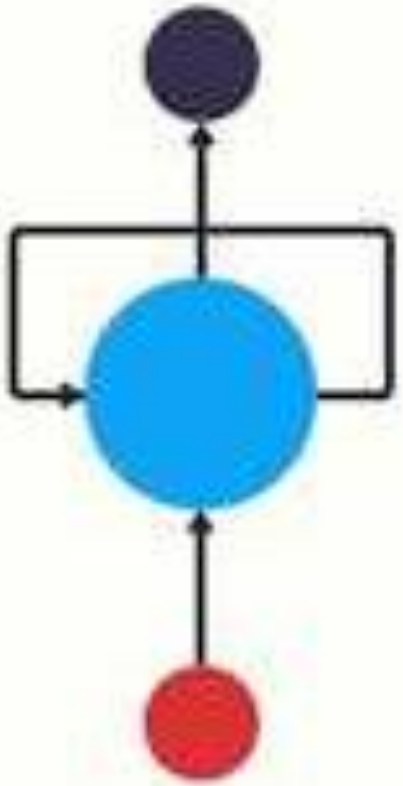
END-TO-END LEARNING FOR 3D FACIAL ANIMATION FROM SPEECH [3]

1. Input: sequence of speech spectrograms
2. Output: facial action unit intensities

ARTIFICIAL NEURAL NETWORKS



- **Figure: https://en.wikipedia.org/wiki/Artificial˙neural˙network#/media/File:Colored˙neural˙network.svg**



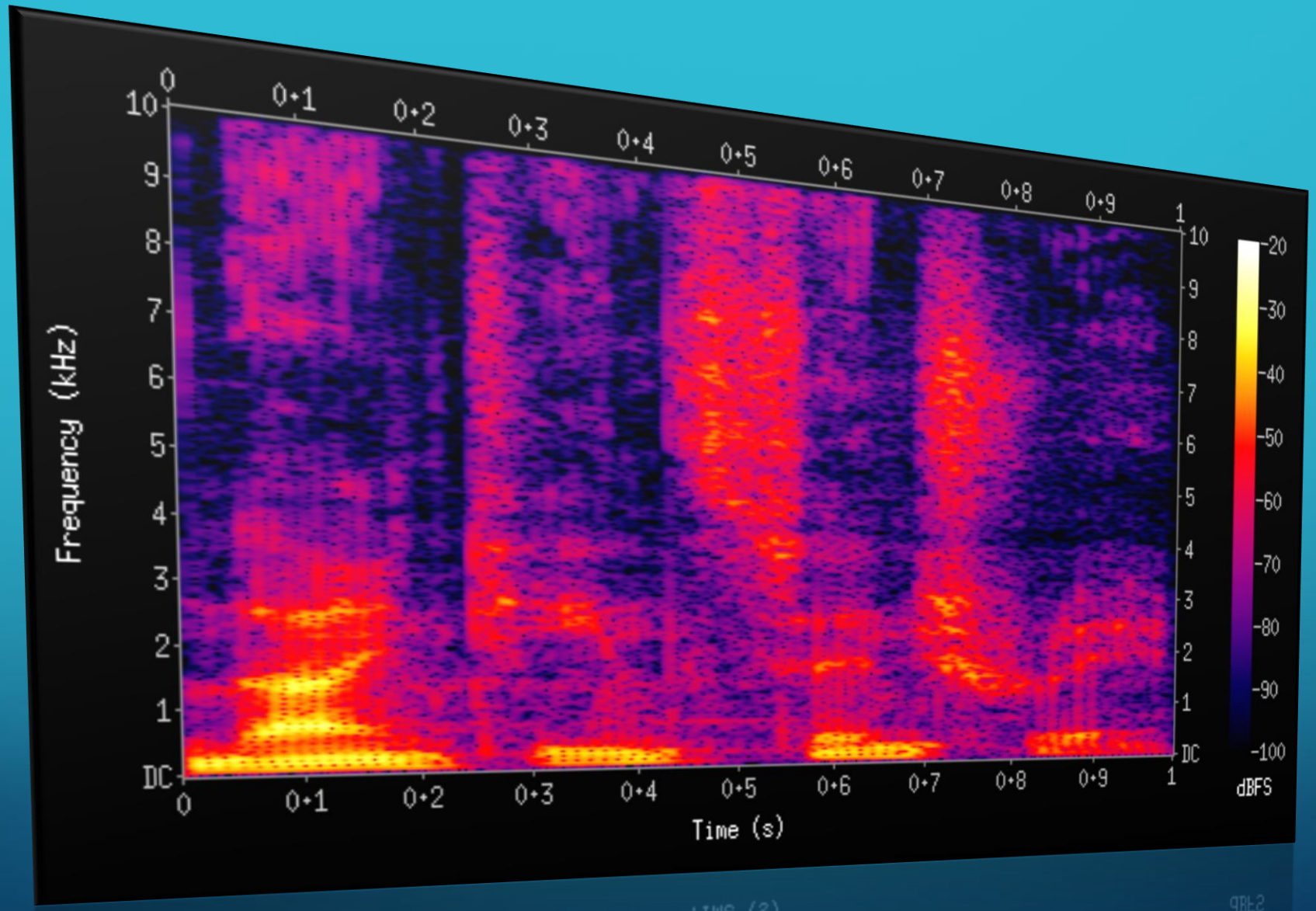


Image: Wikipedia

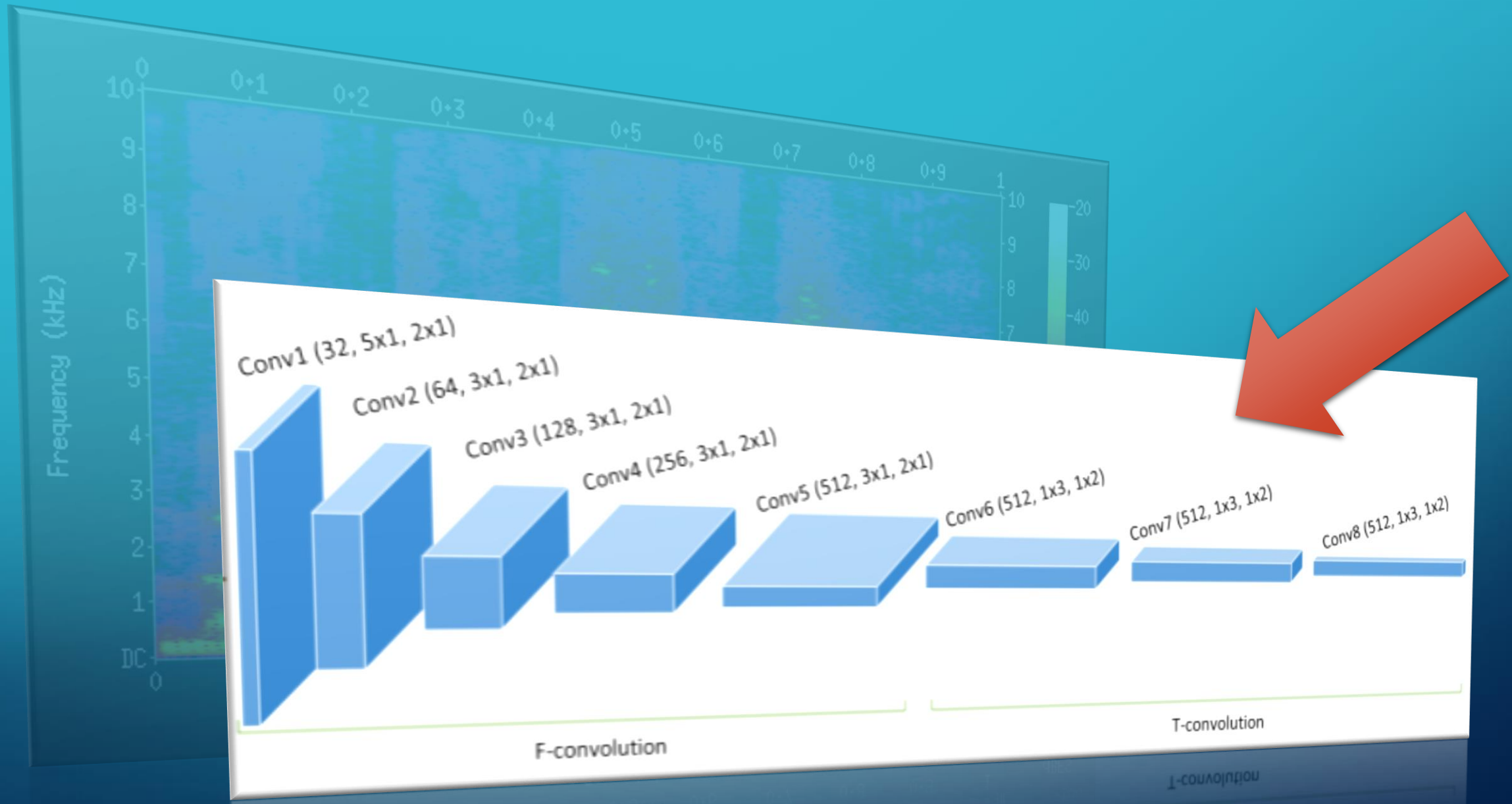

Frequency (kHz)
Conv1 (32, 5x1, 2x1)
Conv2 (64, 3x1, 2x1)
Conv3 (128, 3x1, 2x1)
Conv4 (256, 3x1, 2x1)
Conv5 (512, 3x1, 2x1)
Conv6 (512, 1x3, 1x2)
Conv7 (512, 1x3, 1x2)
Conv8 (512, 1x3, 1x2)
F-convolution
T-convolution

Figure: [3]

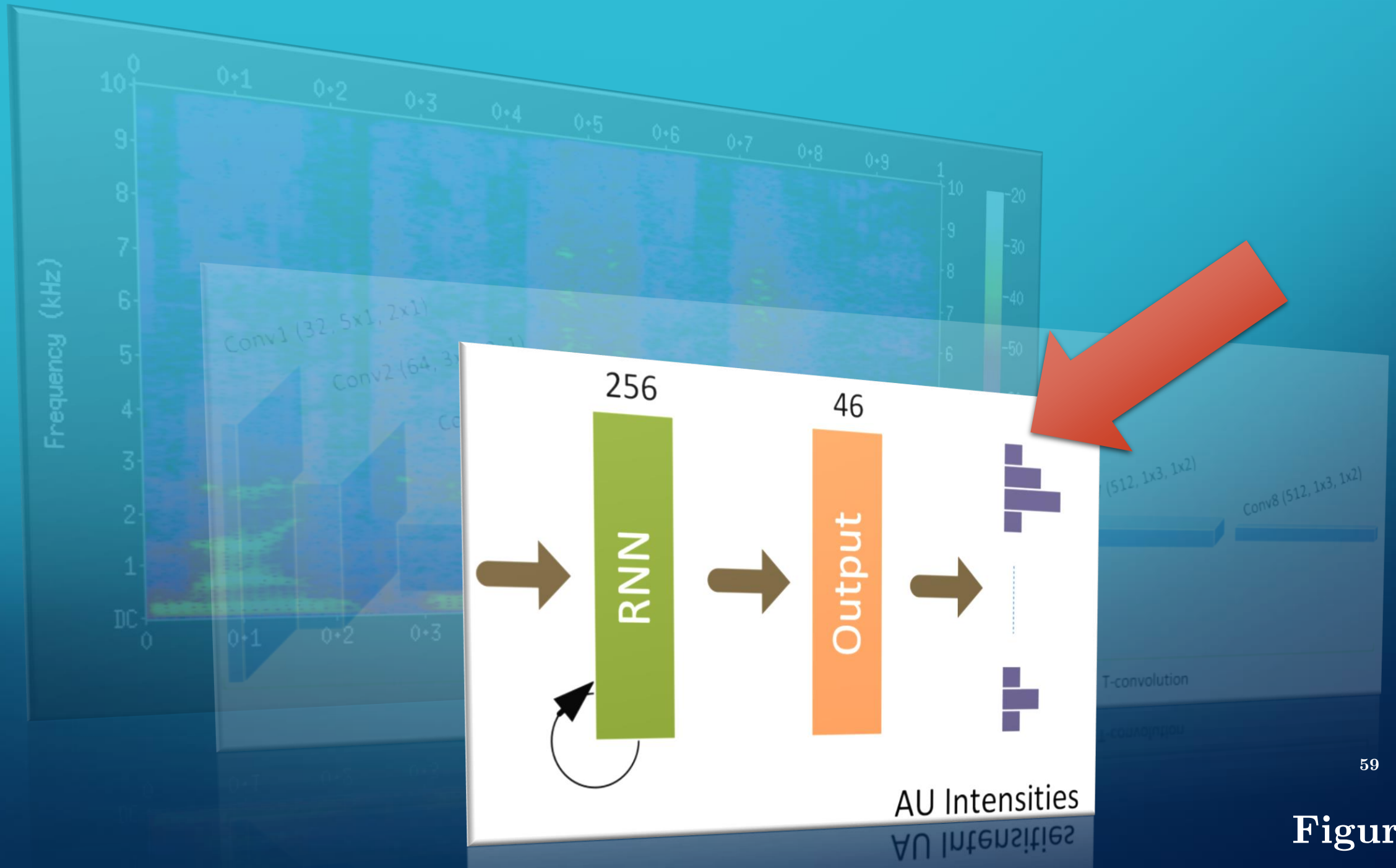

256
46
RNN
Output
AU Intensities
Frequency (kHz)
Conv1 (32, 5x1, 2x1)
Conv8 (512, 1x3, 1x2)
T-convolution

Figure: [3]

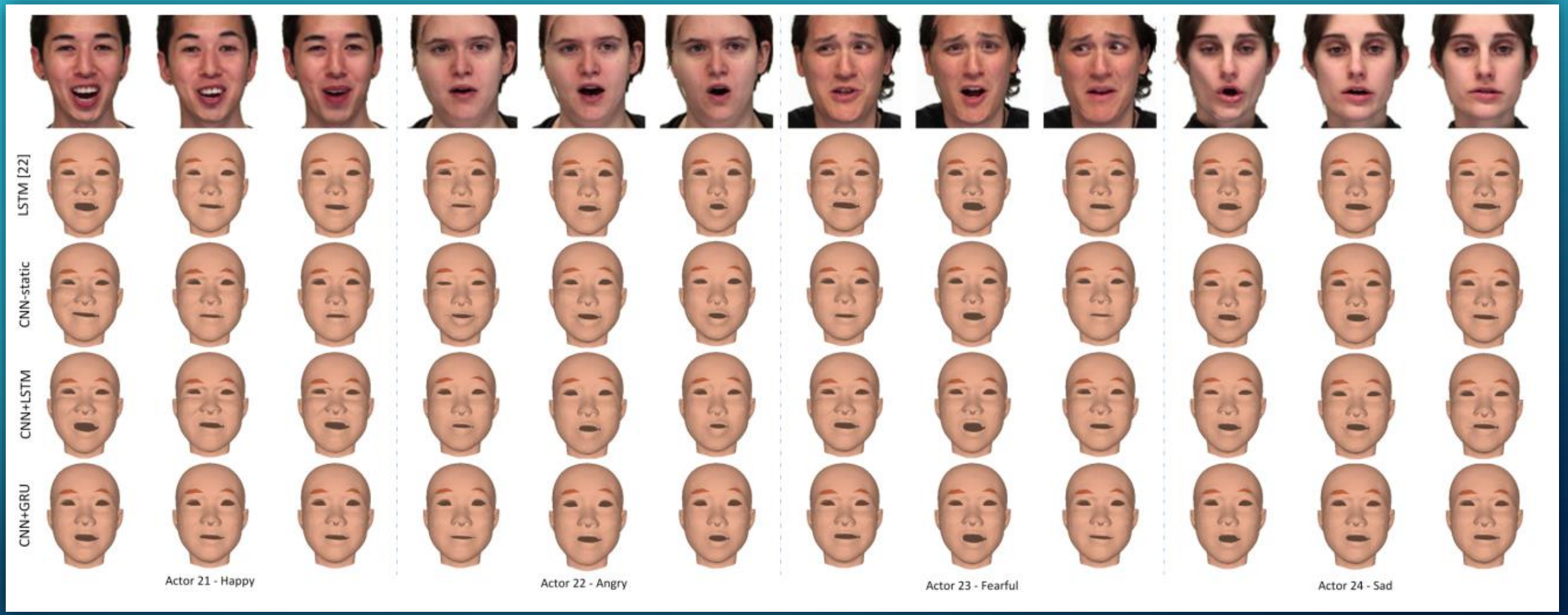

LSTM [22]
CNN-static
CNN+LSTM
CNN+GRU
Actor 21 - Happy
Actor 22 - Angry
Actor 23 - Fearful
Actor 24 - Sad

Figure: [3]

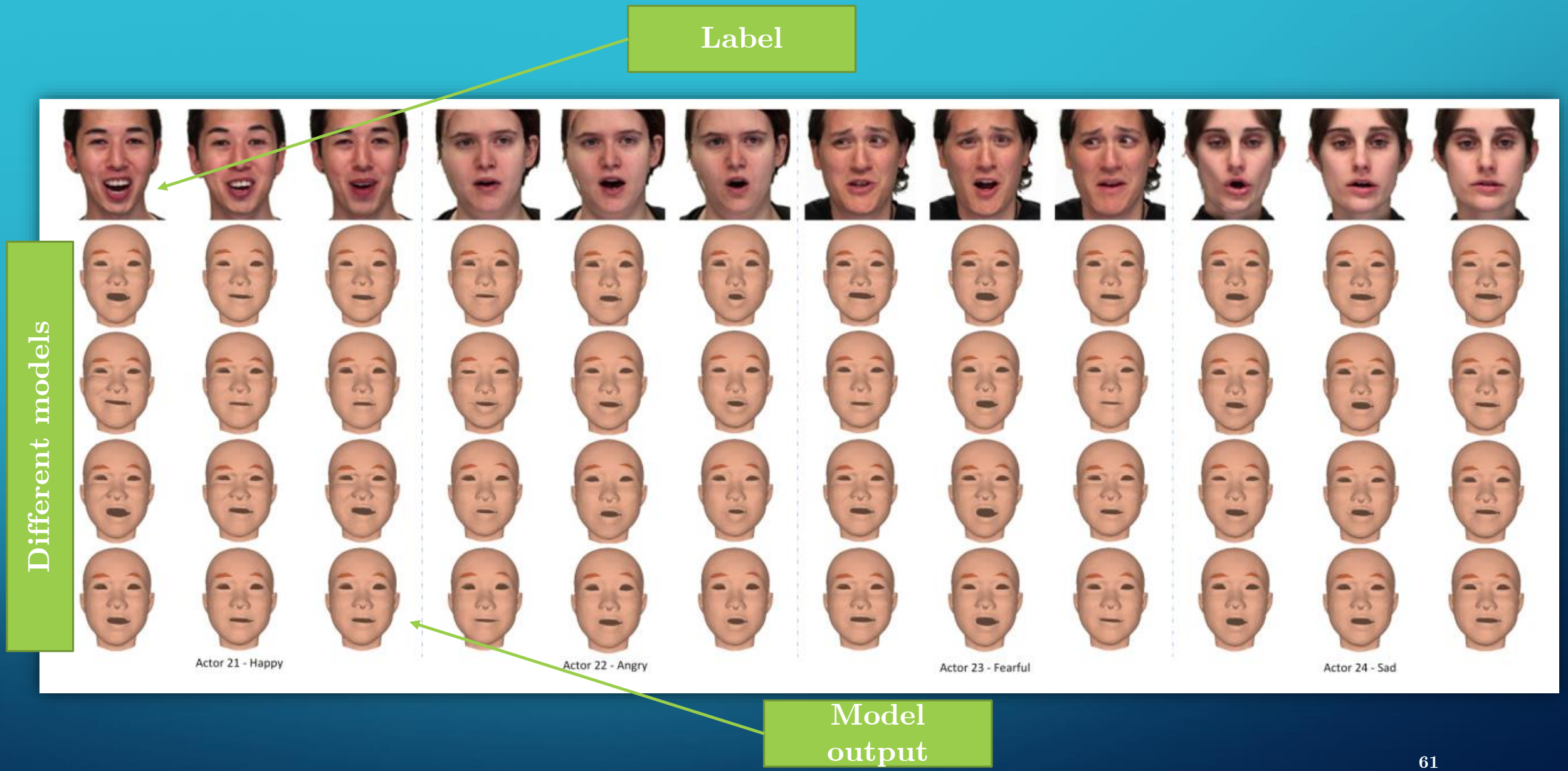
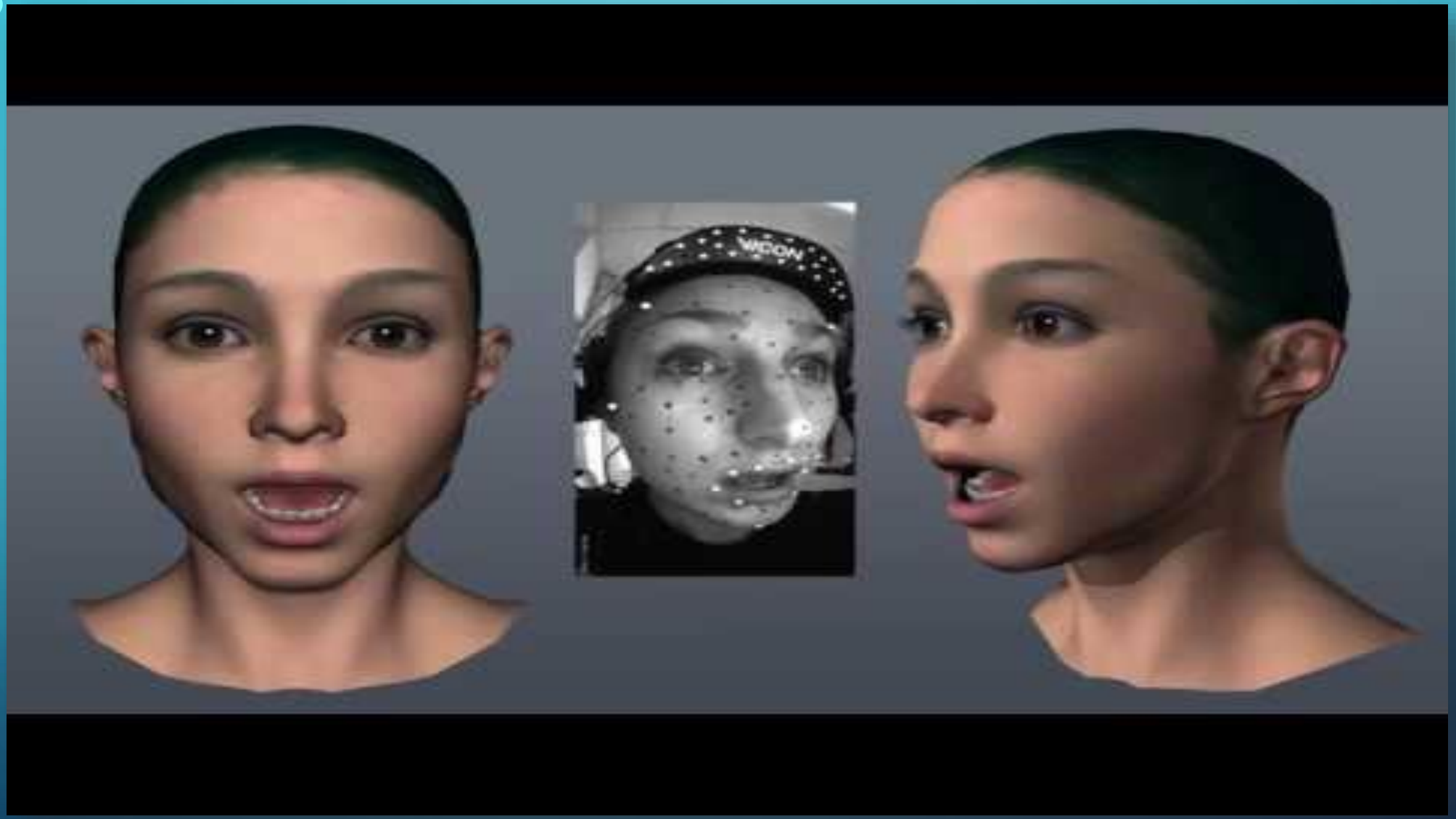

Label
Different models
Actor 21 - Happy
Actor 22 - Angry
Actor 23 - Fearful
Actor 24 - Sad
Model output

Figure: [3]

TWO MINUTE
PAPERS
WITH KÁROLY ZSOLNAI-FEHÉR (KZF)
AI CREATES FACIAL ANIMATION
FROM AUDIO
Disclaimer: I was not part of this research project, I am merely providing commentary on this work.

PERFORMANCE-DRIVEN ANIMATION

Based on motion data



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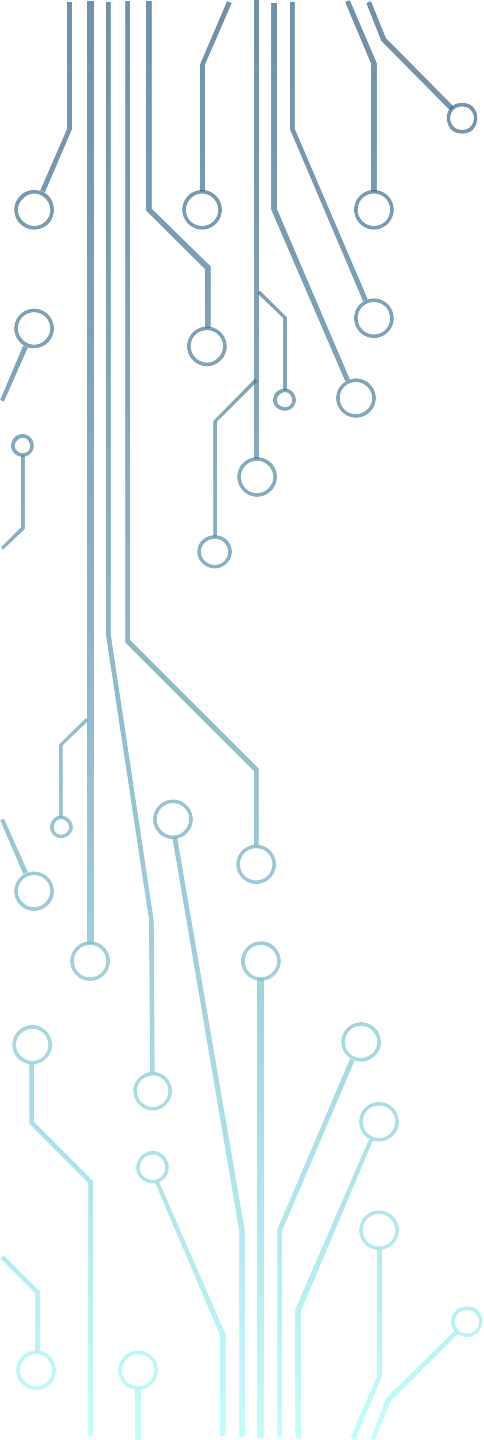
CONCLUSION

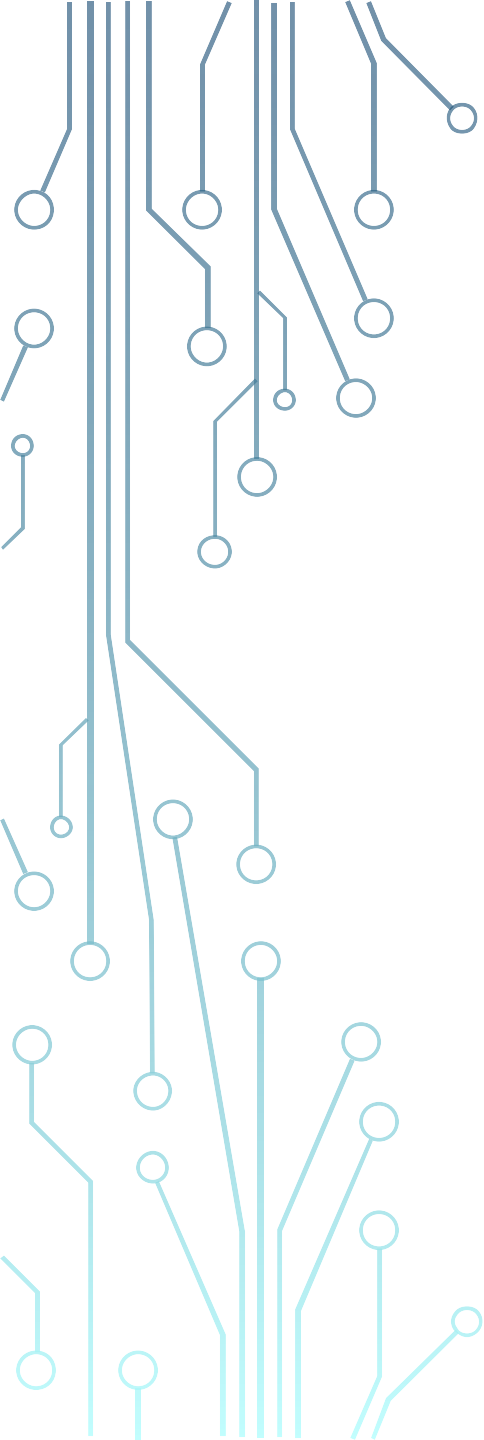
Realistic animation in real time

Minimal manual handling

Adaptability to any individuals face



bit.ly/vikt4



DEMO: bit.ly/vikt6

WHICH ACTION UNITS (AU) CORRESPOND TO…

1. … happiness?
2. … sadness?
3. … anger?
4. … fear?

DEMO: bit.ly/vikt6

Qualifying and disqualifying Action Units in four emotions (summarized from Kohler et al (2004))

Emotion	Qualifying AUs	Disqualifying AUs
Happiness	AU6, AU12	AU4, AU20
Sadness	AU17	AU25
Anger	AU9, AU16	AU1
Fear	AU2	AU7, AU10

Fig: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3402717/

SOURCES

1. DOI: 10.7763/IJCTE.2013.V5.770
2. DOI: 10.1145/1198555.1198596
3. 10.1145/3242969.3243017
4. https://dictionary.cambridge.org/dictionary/english/interpolation
5. https://en.wikipedia.org/wiki/Interpolation˙(computer˙graphics)
6. https://en.wikipedia.org/wiki/Facial˙Action˙Coding˙System

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