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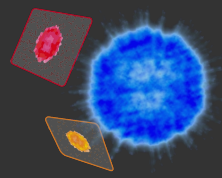


Imaging
New Modalities

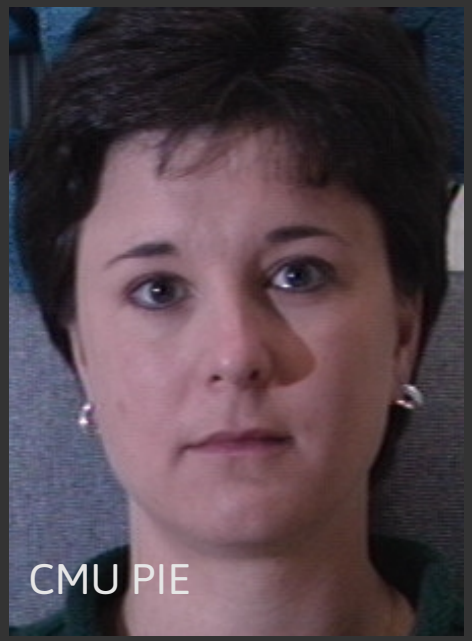
Realistic Inverse Lighting from a Single 2D Image of a Face, Taken under Unknown and Complex Lighting

Davoud Shahlaei, Volker Blanz

May 2015, Ljubljana

Inverse Rendering

input



- 3D Geometry
- Reflectance
- Lighting
- Camera
- Color Balance

3D Morphable Model (3DMM)

(Blanz & Vetter, SIGGRAPH'99)

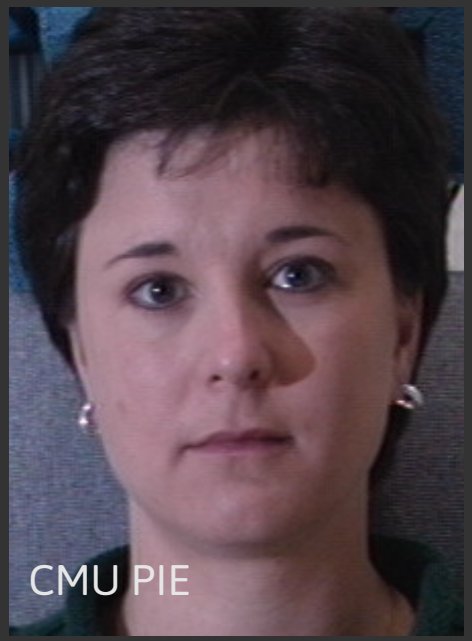
α_1  + α_2  + α_3  + α_4  + ...

β_1  + β_2  + β_3  + β_4  + ...

Shape and Texture Vectors

Inverse Rendering with 3DMM Framework

input

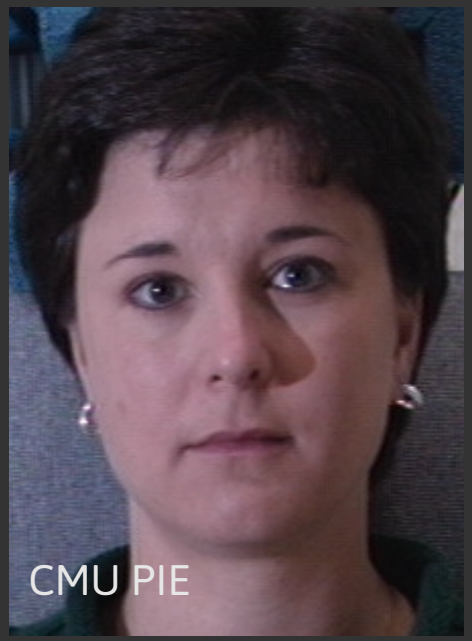


3DMM so far

- 3D Geometry
- Reflectance
- Lighting
- Camera
- Color Balance

Inverse Lighting with 3DMM Framework

input



3DMM so far

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- Reflectance
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Inverse Lighting with 3DMM Framework

input

- 3D Geometry
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- Color Balance

Inverse Lighting with 3DMM Framework

input

proposed

- 3D Geometry
- Reflectance
- Lighting
- Camera
- Color Balance

Inverse Lighting with 3DMM Framework

input

proposed

- 3D Geometry
- Reflectance
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- Camera
- Color Balance

Inverse Lighting with 3DMM Framework

input

3DMM so far

- 3D Geometry
- Reflectance
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Challenges

- Specular Highlights
- Grazing angles (Fresnel)
- Multiple lighting directions
- Colorful light
- Cast shadows
- Harsh illumination

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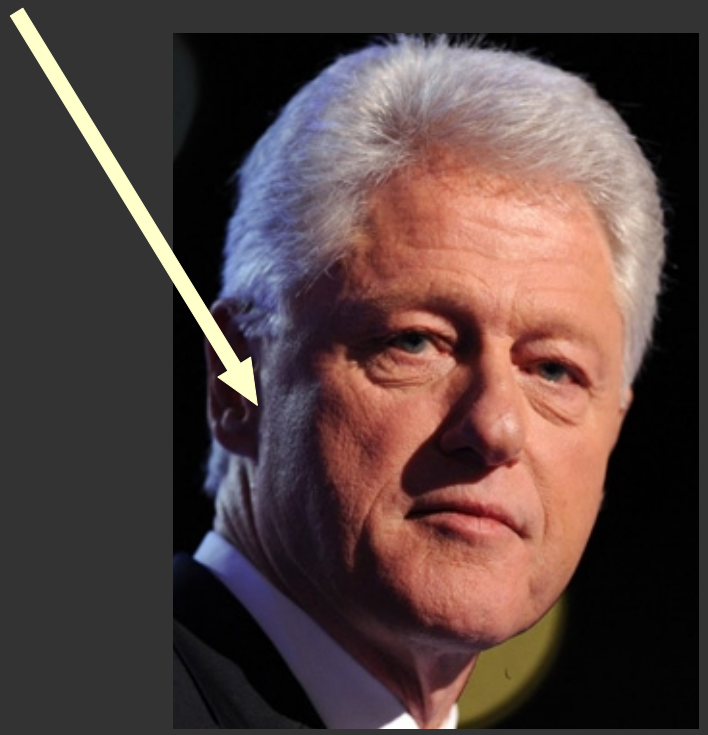

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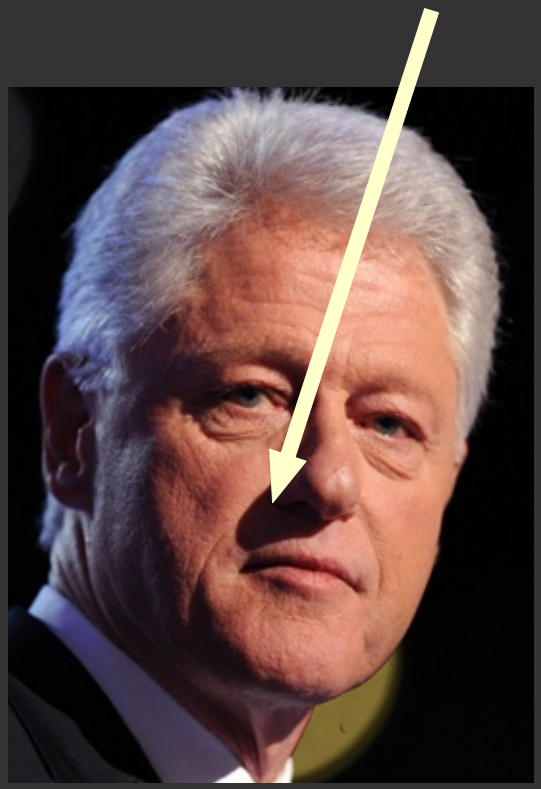
Challenges



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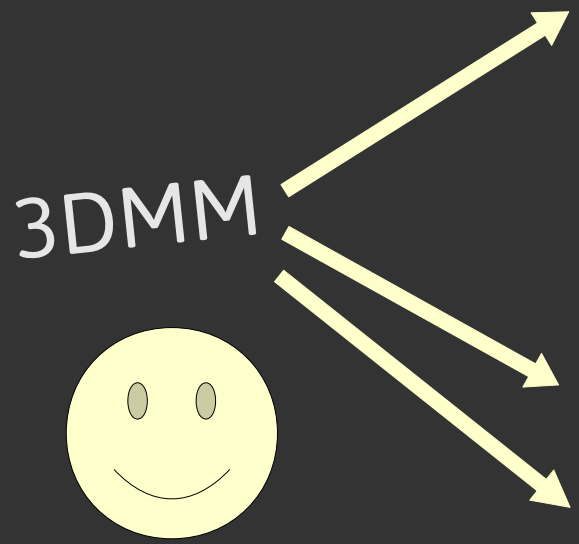
Challenges



- Specular Highlights
- Grazing angles (Fresnel)
- Multiple lighting directions
- Colorful light
- Cast shadows
- Harsh illumination

So Far 3DMM Lighting

- Ambient + one directional light
- Ad hoc Phong model and Texture

Enhanced 3DMM Lighting

- Ambient + one directional light
- Ad hoc Phong model and Texture

100 light sources
No ambient

Enhanced 3DMM Lighting

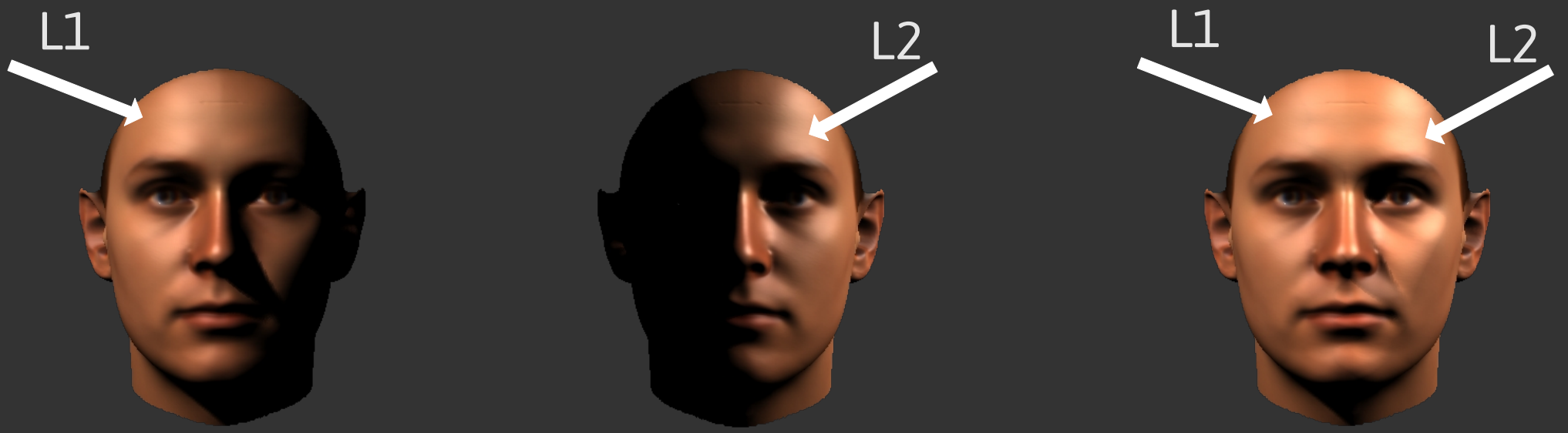
- Ambient + one directional light
- Ad hoc Phong model and Texture

100 light sources
No ambient

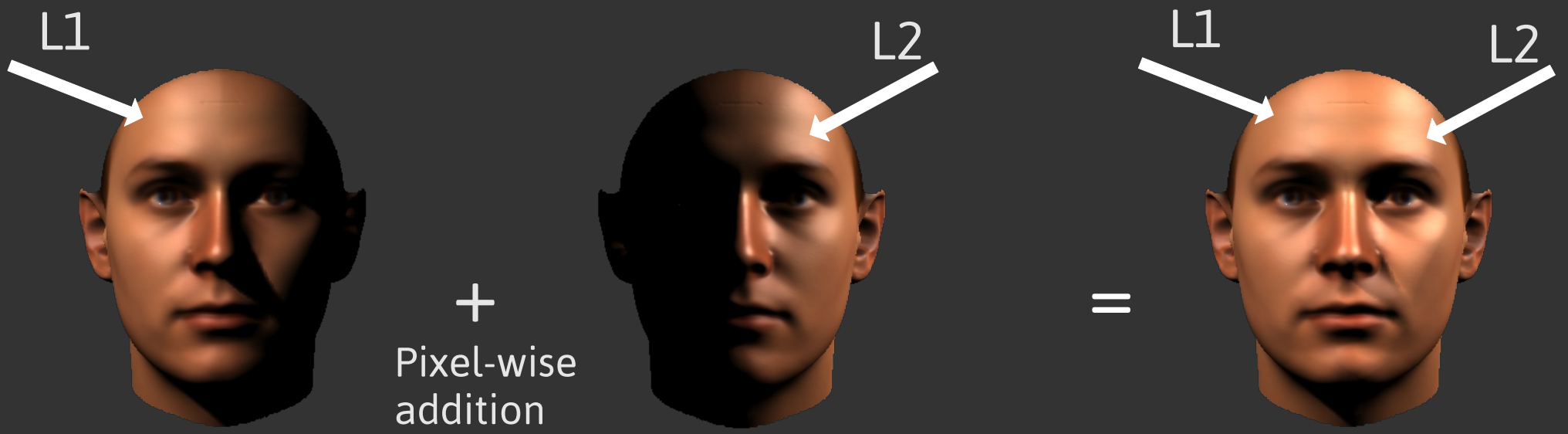
Measured BRDF of Skin
From Weyrich et al. 2006

Superposition

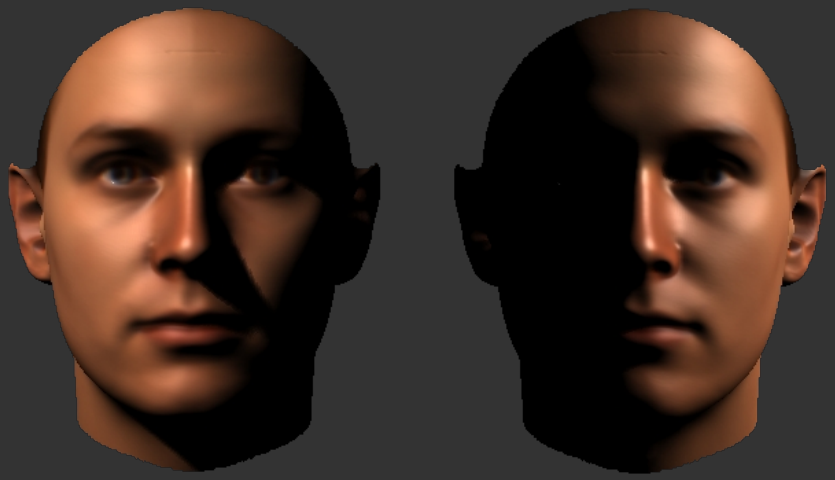
Superposition



Superposition



Illumination Cone



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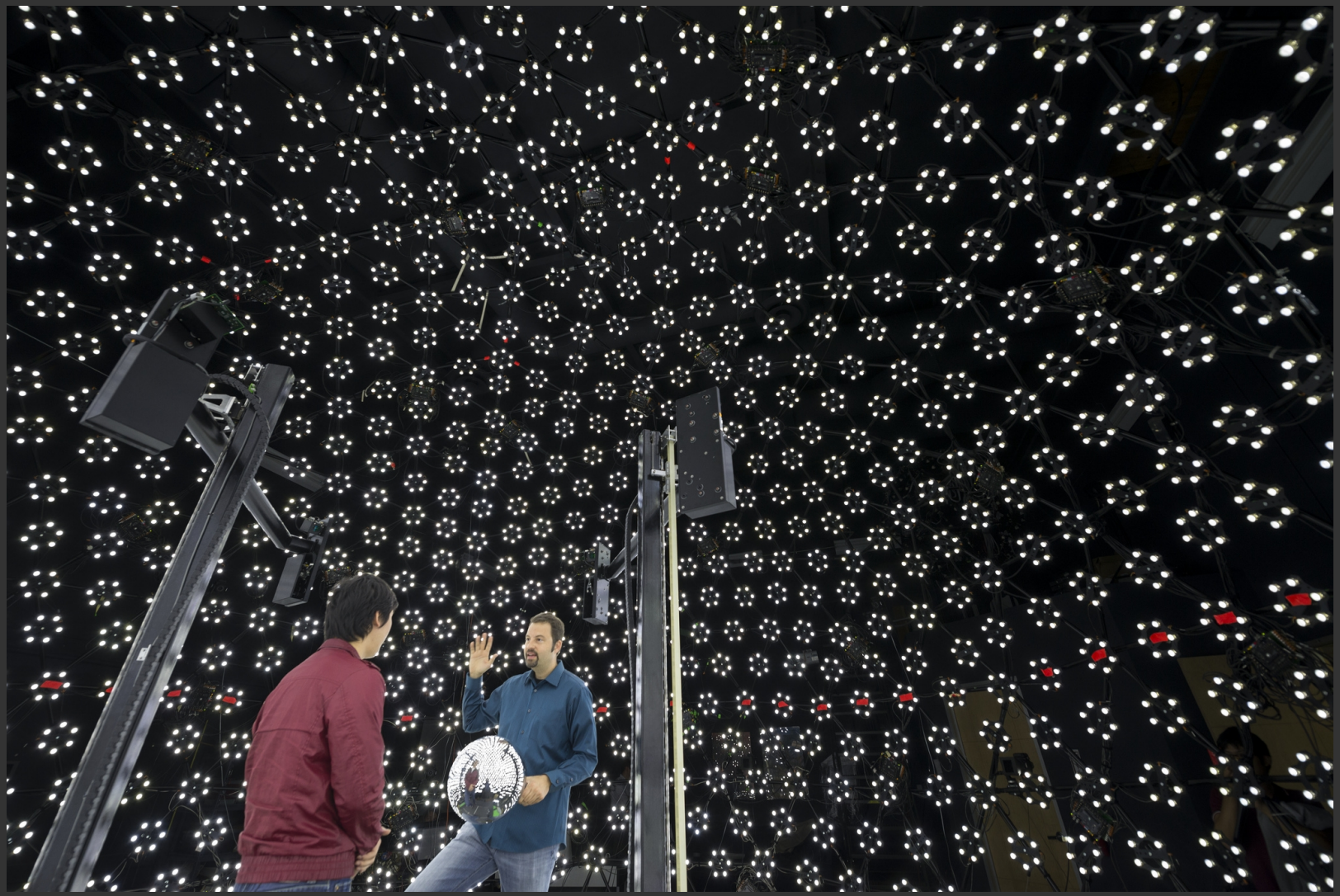
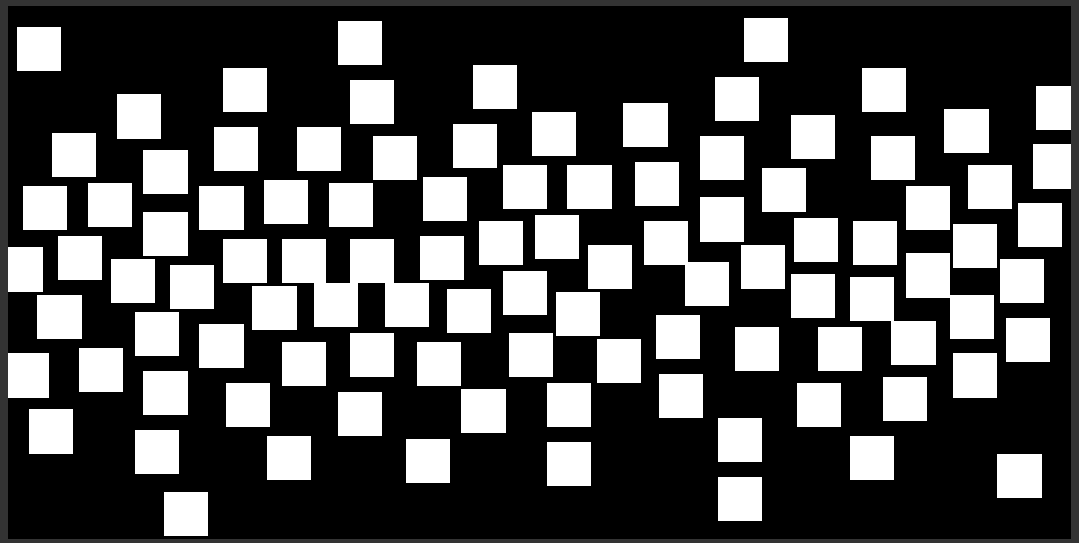
Under all the possible lighting situations

Light Stage

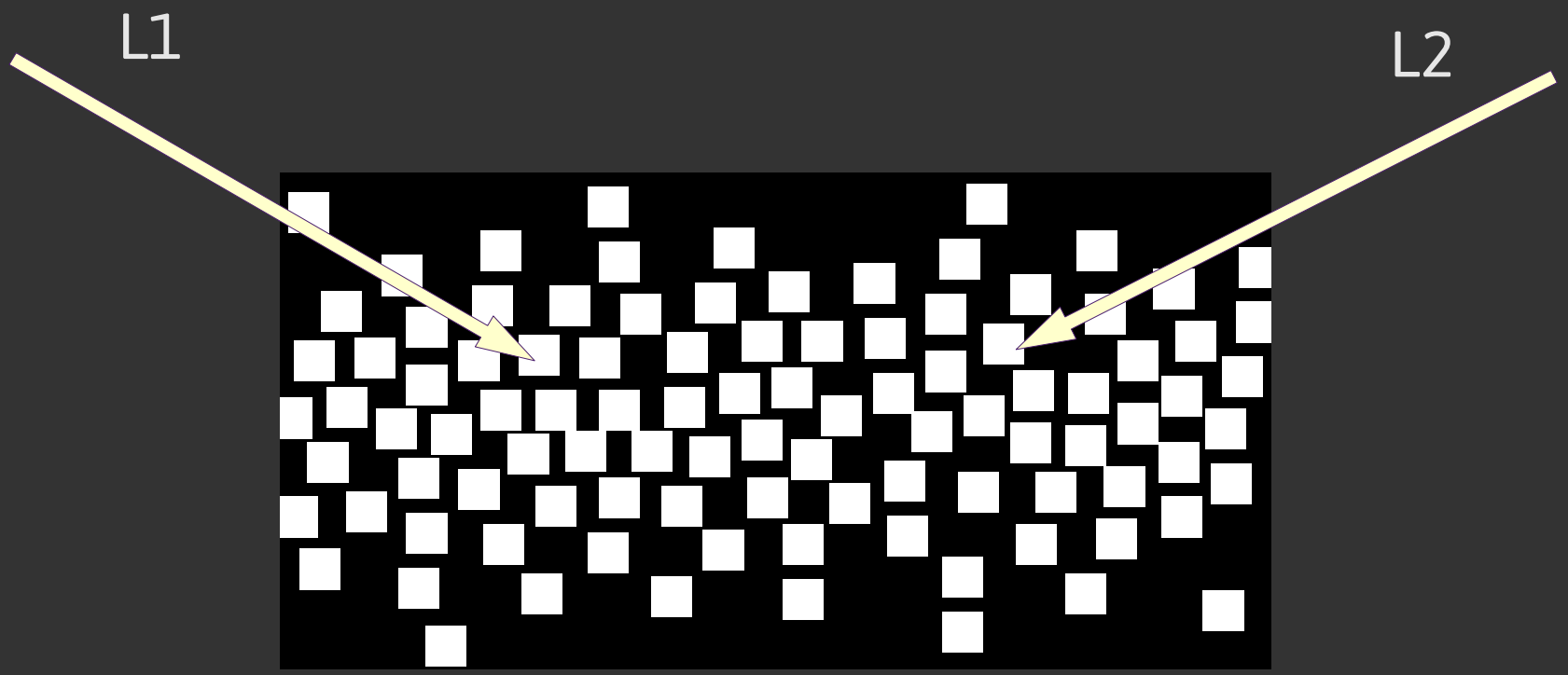


Paul Debevec, Light Stage at USC - ICT

Virtual Light Stage



Virtual Light Stage



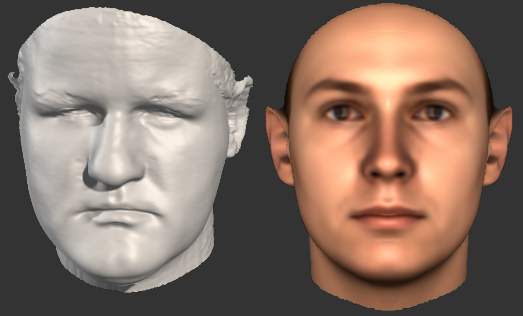
Step 0:

input

Step 1:

input

3D Morphable Model

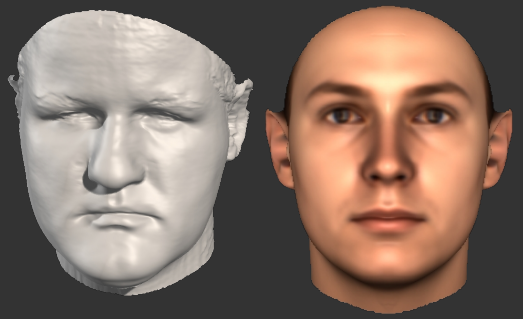


Shape Texture

Step 2:

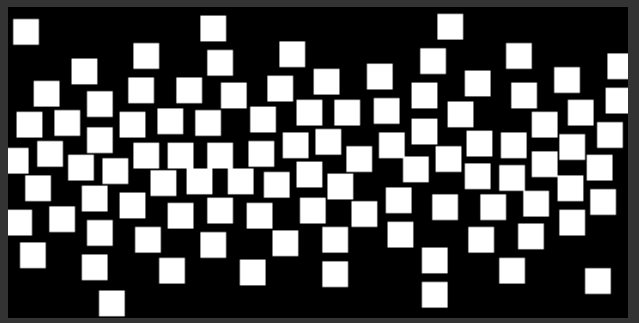
input

3D Morphable Model



Shape Texture

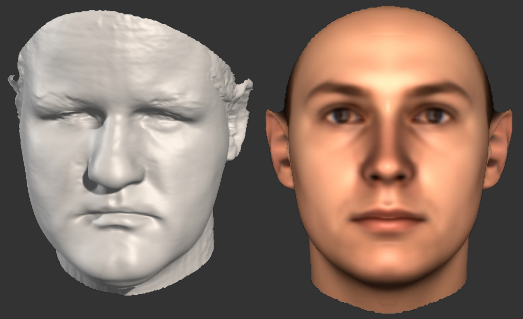
Light Sources



Step 2:

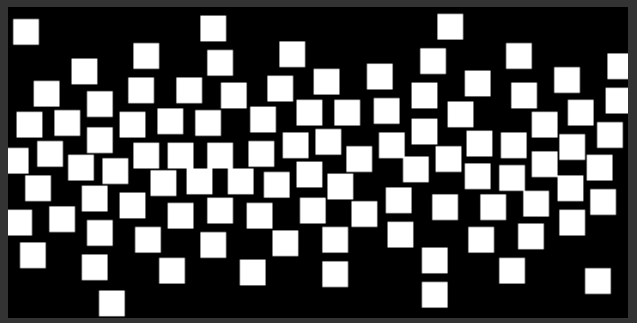
input

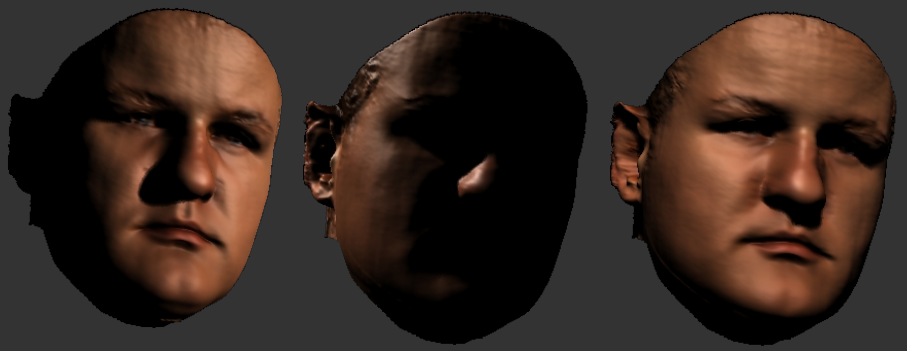
3D Morphable Model



Shape Texture

Light Sources





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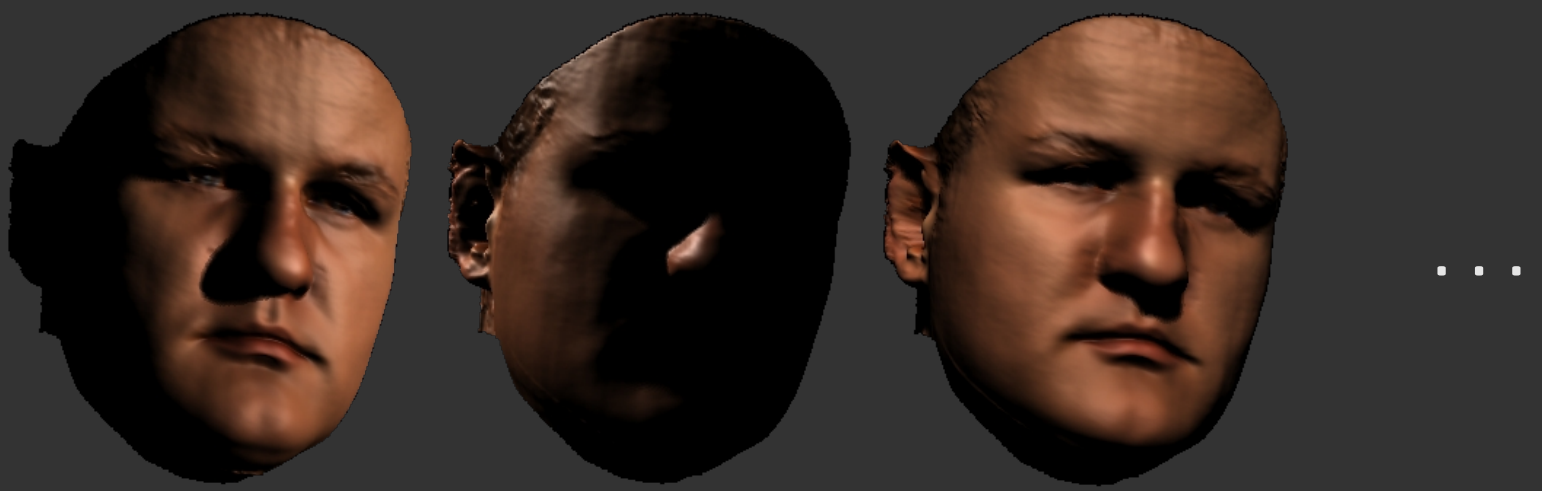
Synthetic Illumination Cone



$\vec{C}_1$ $\vec{C}_2$ $\vec{C}_3$ ...

Superposition for Synthetic Illumination Cone

$$\vec{I} \approx \boldsymbol{C}\ \vec{\alpha}$$

Input image

Coefficient vector

Synthetic cone images

$$(\vec{C}_1\ \ \vec{C}_2\ \ \vec{C}_3\ \ \ldots) = \boldsymbol{C}$$

Superposition for Synthetic Illumination Cone

$$\vec{I} \approx \boldsymbol{C}\ \vec{\alpha} \qquad \forall i\ \ \alpha_i \geq 0$$

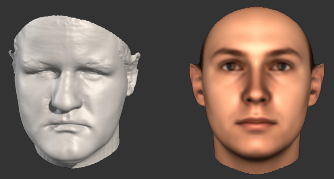
When solved:

α_i **is the intensity of the light** L_i

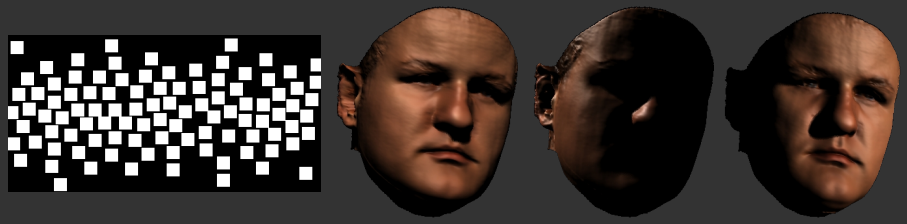
Pipeline:

Single input

3DMM fitting



Synthetic illumination cone



Superposition

$$\vec{I} \approx \boldsymbol{C}\ \vec{\alpha}$$

Regularized Non-Negative Least Squares

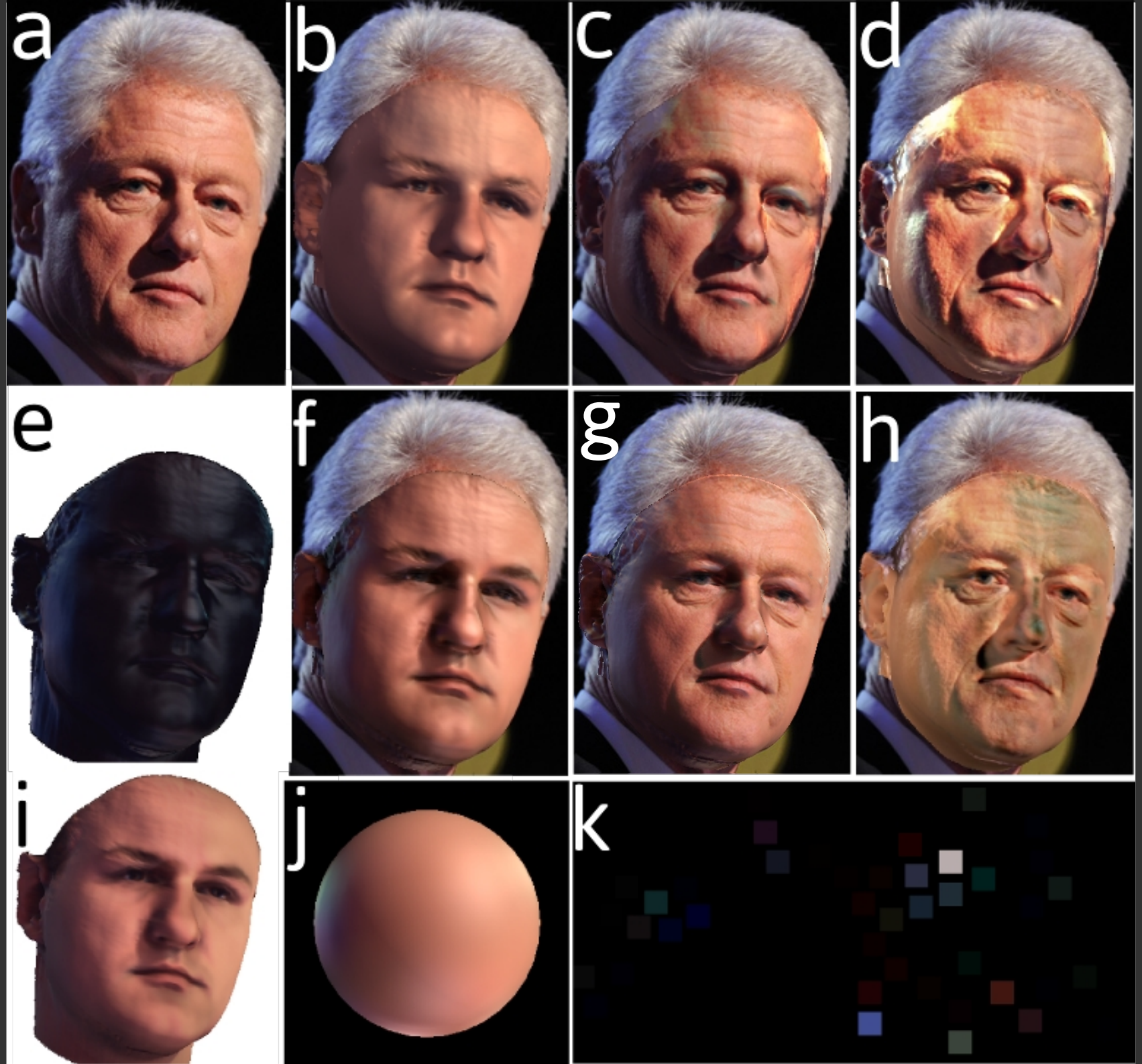
$$\vec{\alpha} \geq 0$$

Lighting estimation

Scene reconstruction

Illuminate novel objects

De-illumination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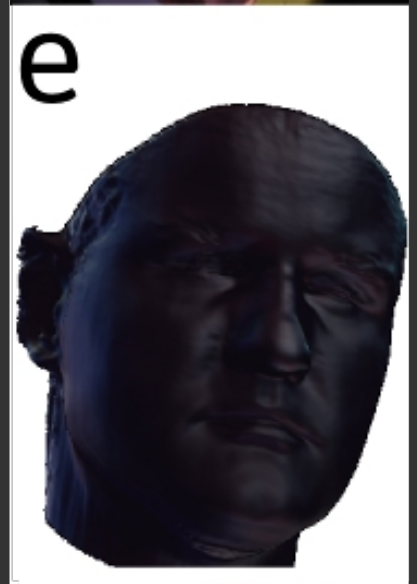
j
k

De-Illumination

De-Illumination



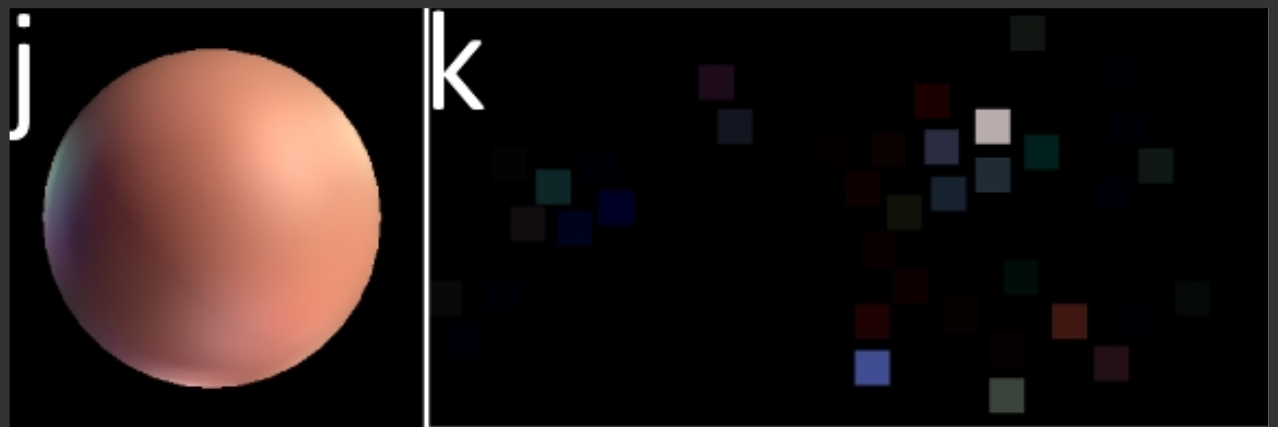
Specular reflectance

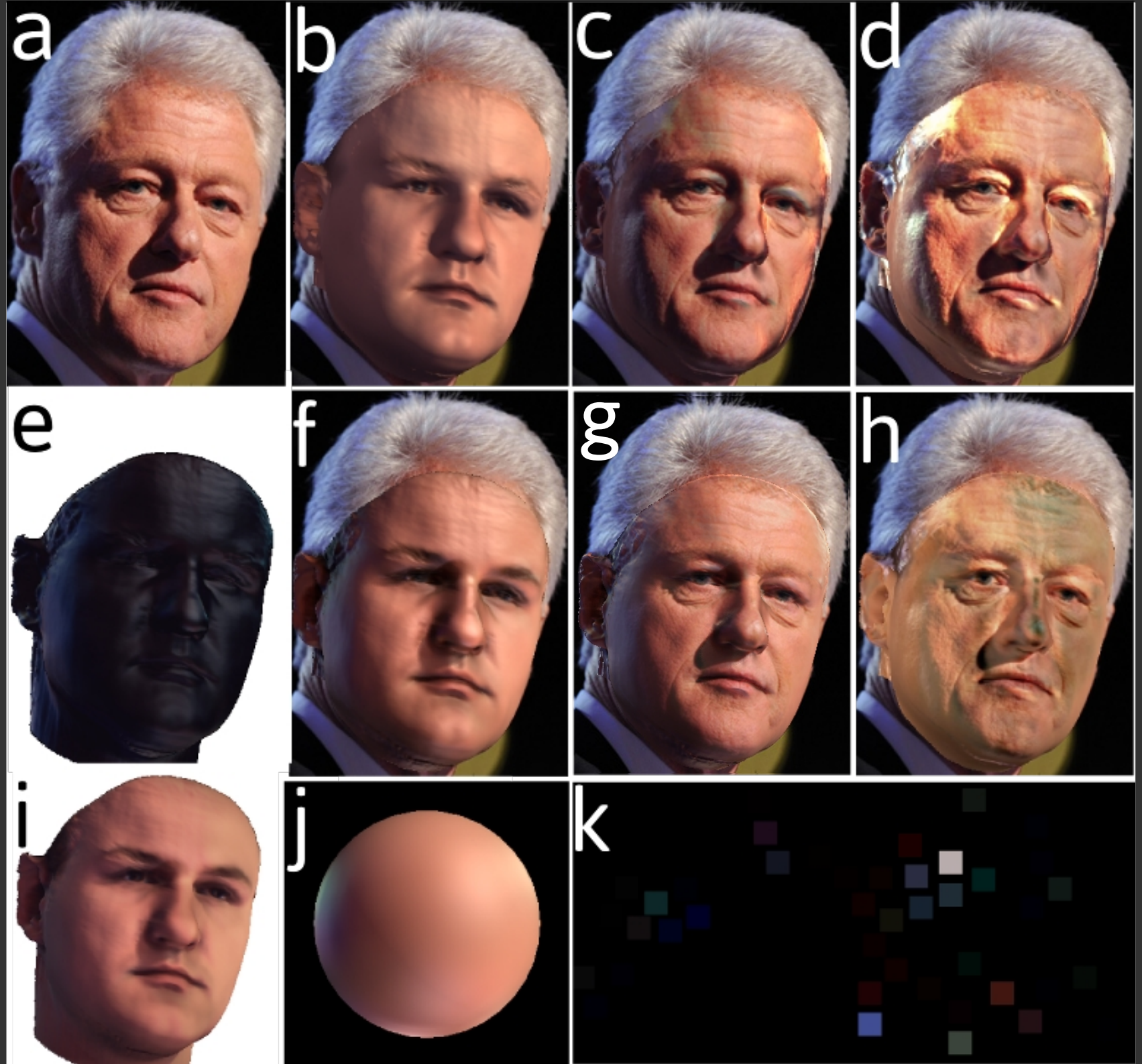
Defuse reflectance

Cast shadows

Novel Objects

Lighting Map

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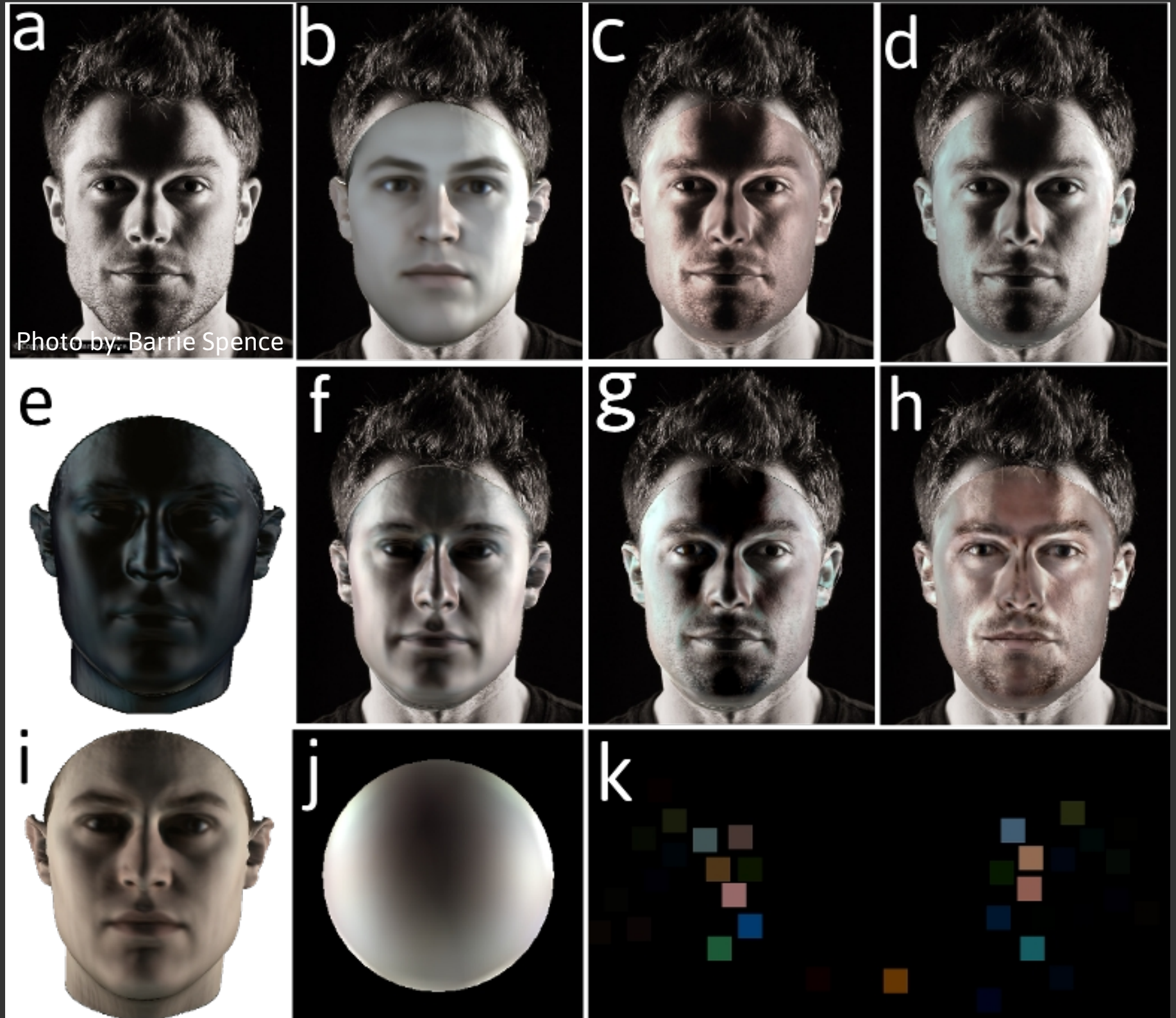
a
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Photo by: Barrie Spence
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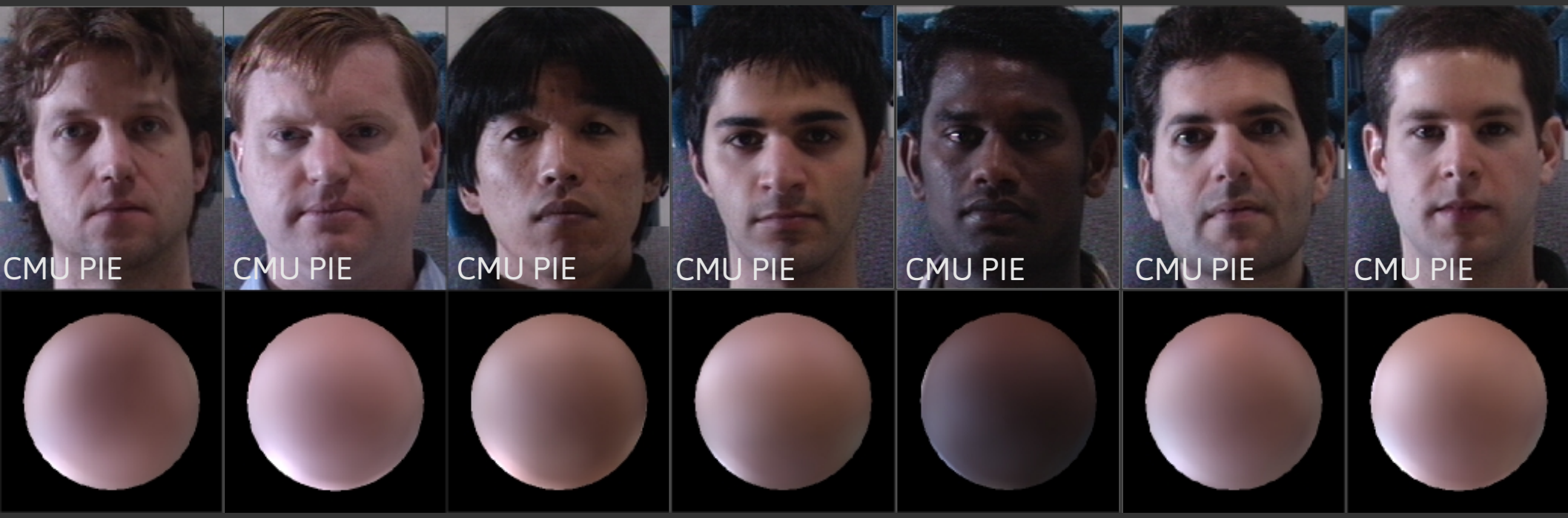
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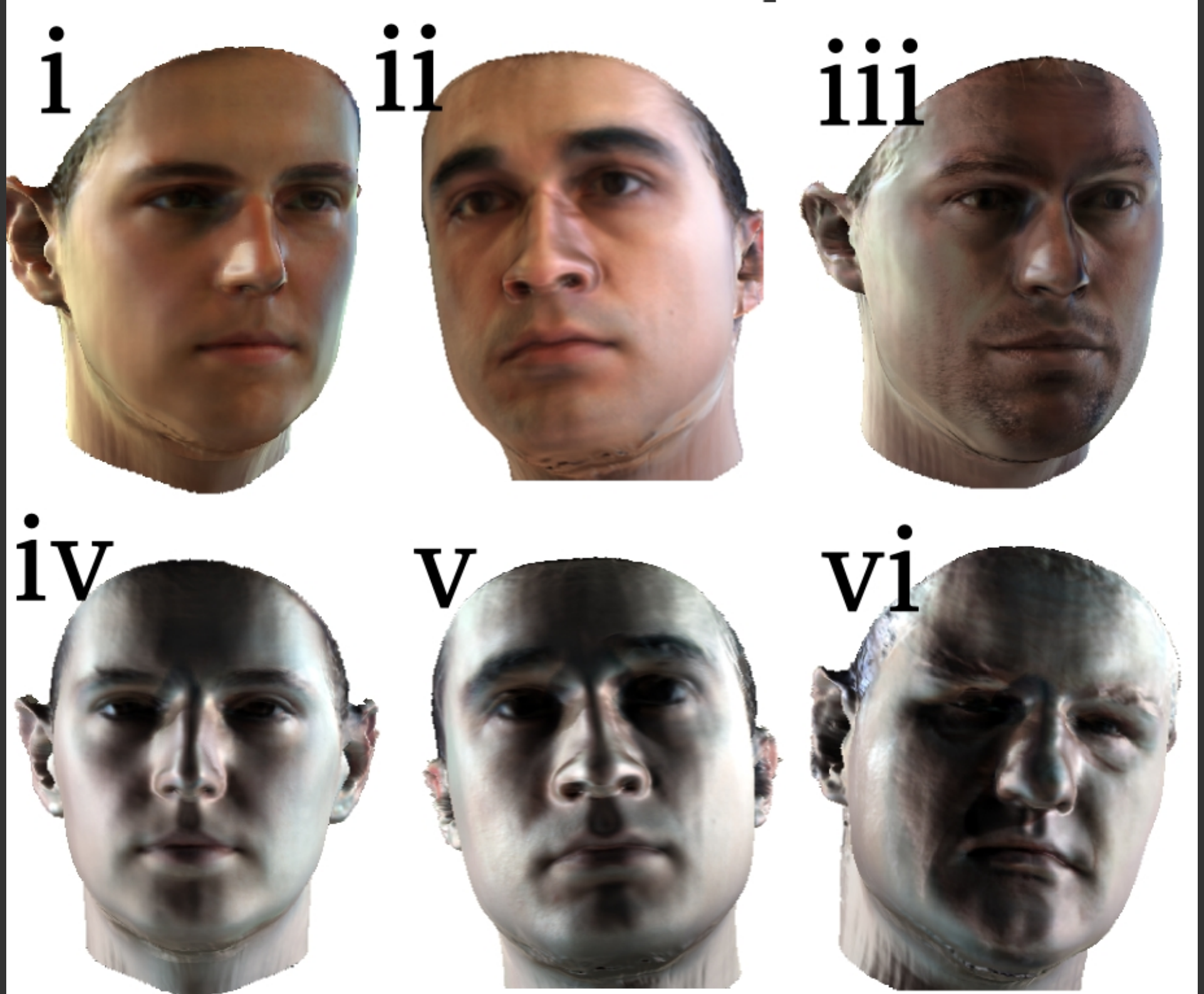
i
ii
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vi

Thank You

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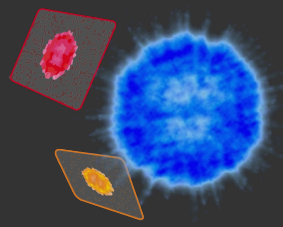

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New Modalities

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