

CGI 2013



Mona Lisa alive

Create self-moving objects using hollow-face illusion

Jing Tong

Happy Dragon Boat Festival !

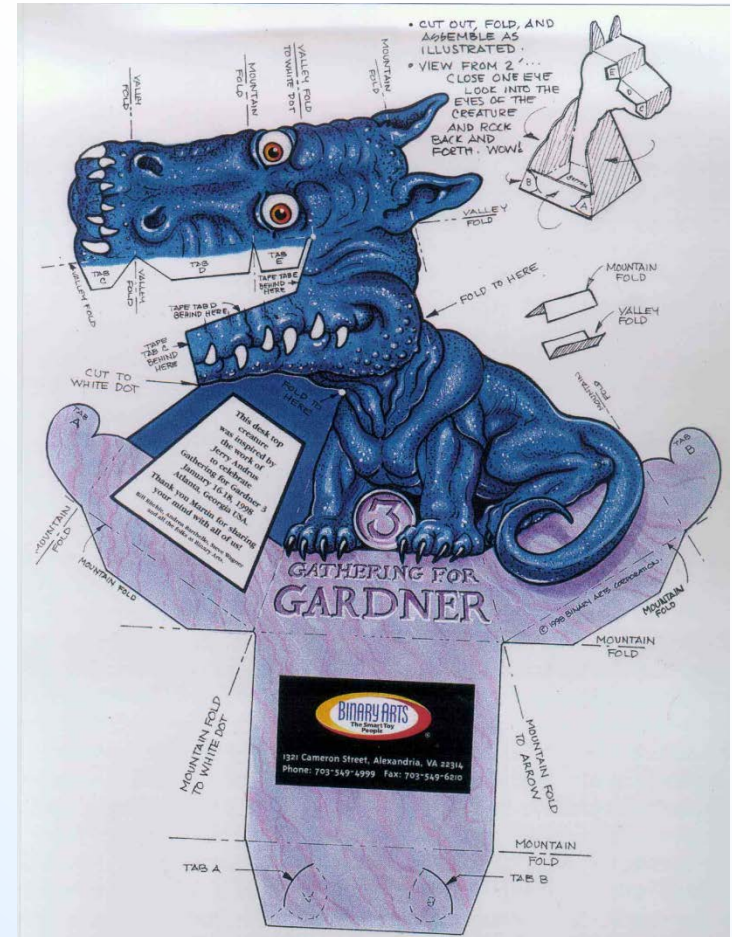


race dragon boats

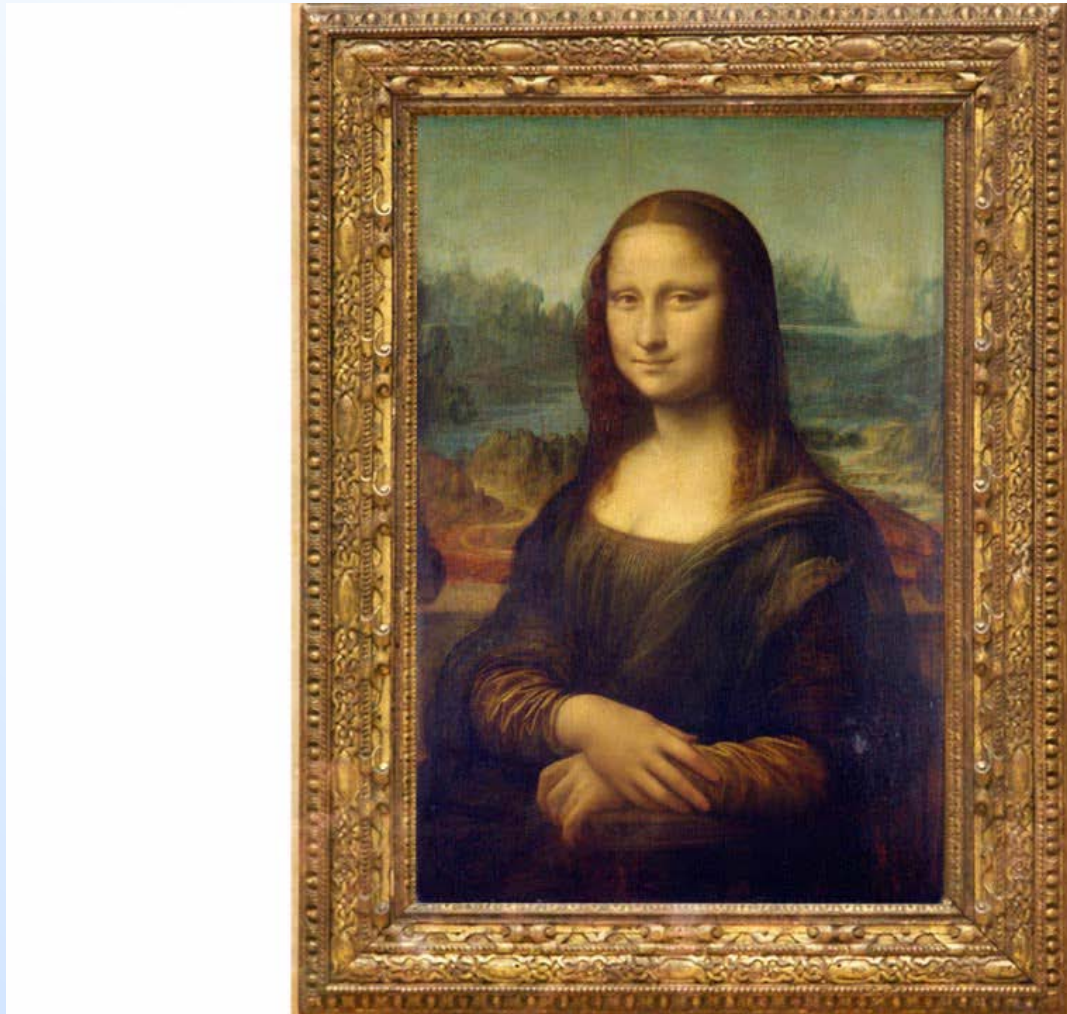
The magic paper dragon



<http://www.grand-illusions.com/>



Mona Lisa's mysterious smile



Hollow-face illusion

concave



Hollow-face illusion

convex



concave



0°

15°

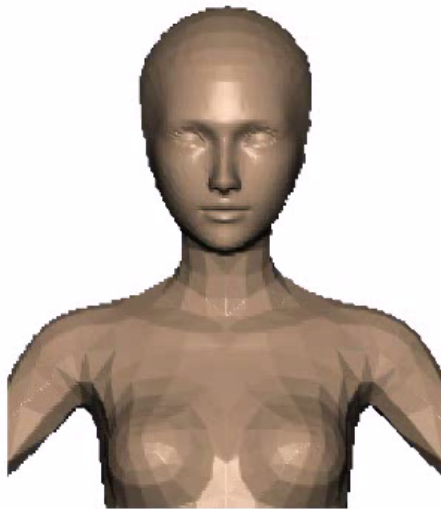
30°

45°

Goal

input animation

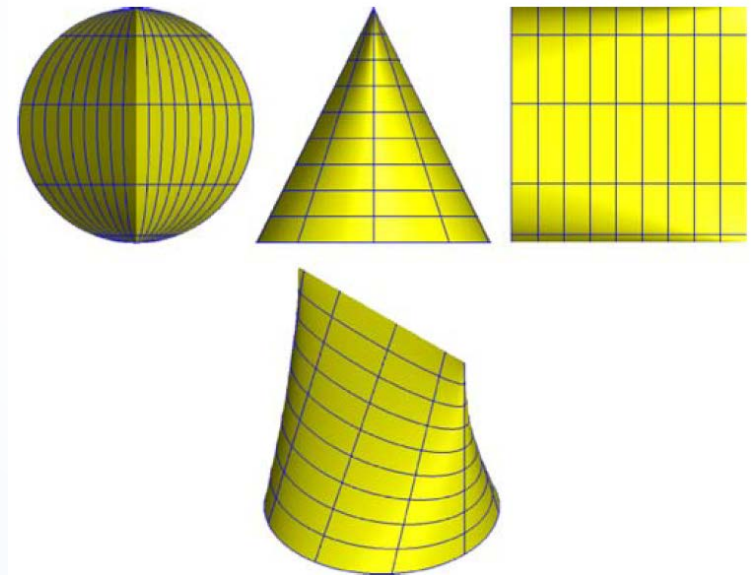
output static mesh



observe the static mesh from different views



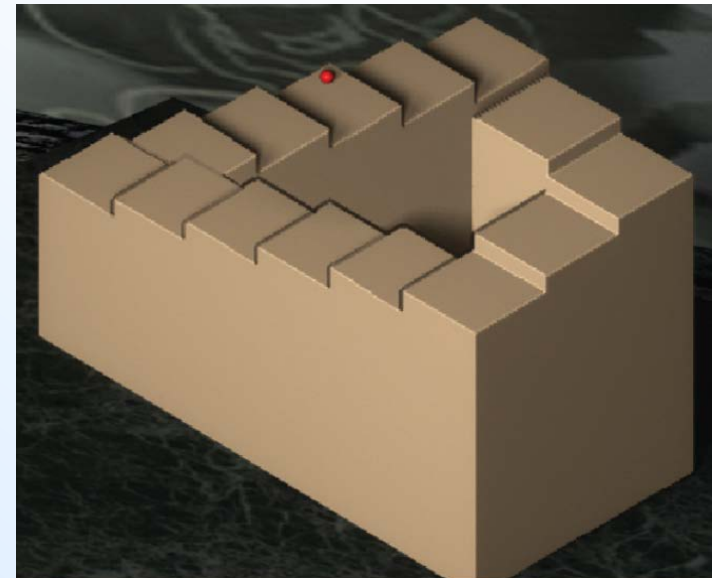
Hybrid images. SIGGRAPH 2006



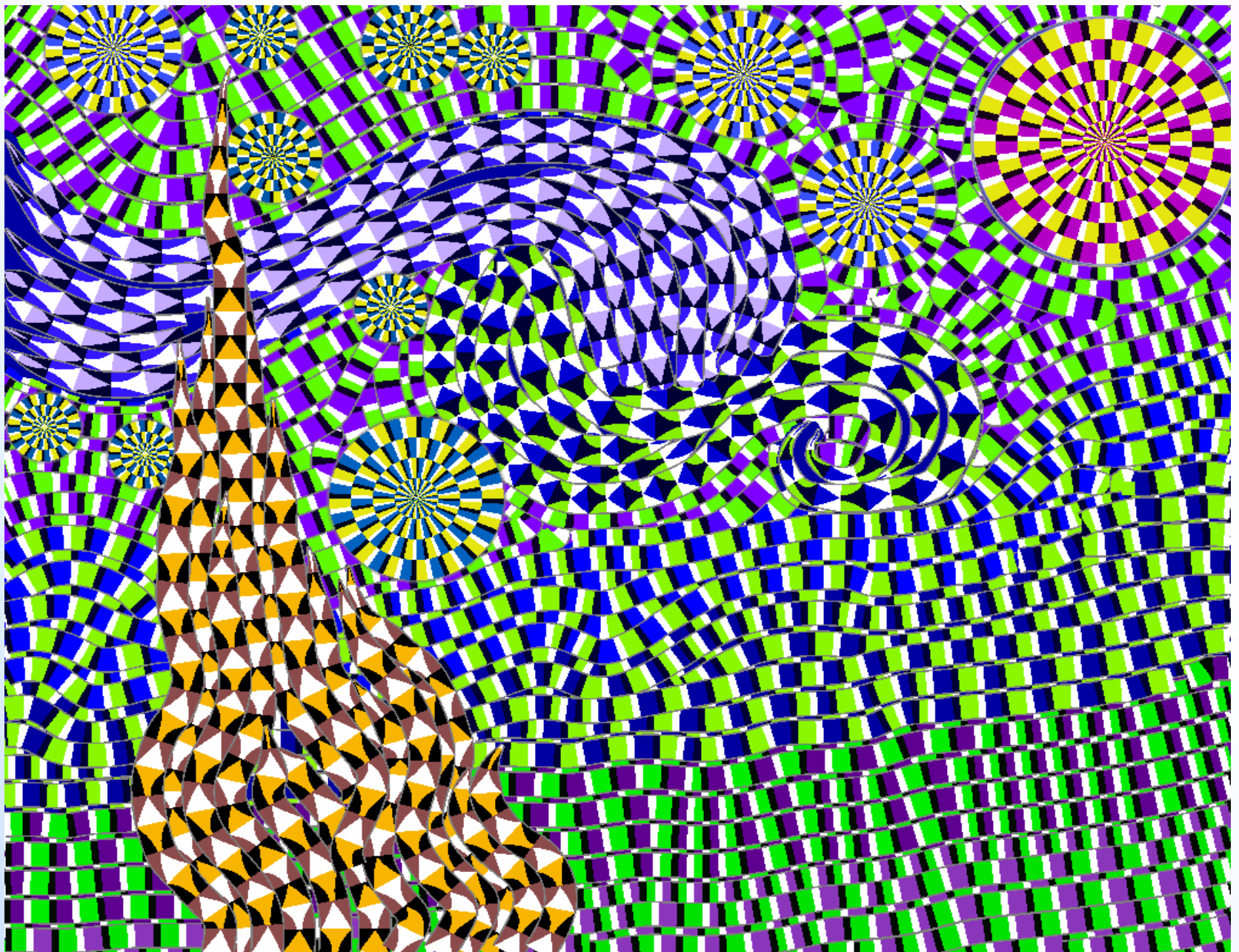
Generation of view dependent models using free form deformation. Visual Compute 2007



Shadow Art. SIGGRAPH Asia 2009

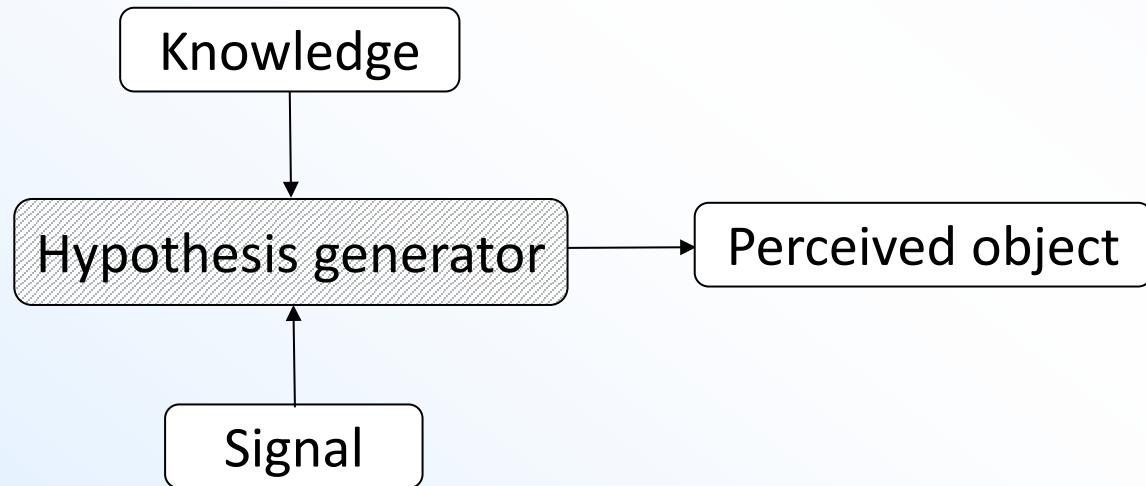


Modeling and Rendering of Impossible Figures.
TOG 2010



Self-Animating Images. SIGGRAPH 2008

Why can we perceive the hollow-face illusion ?



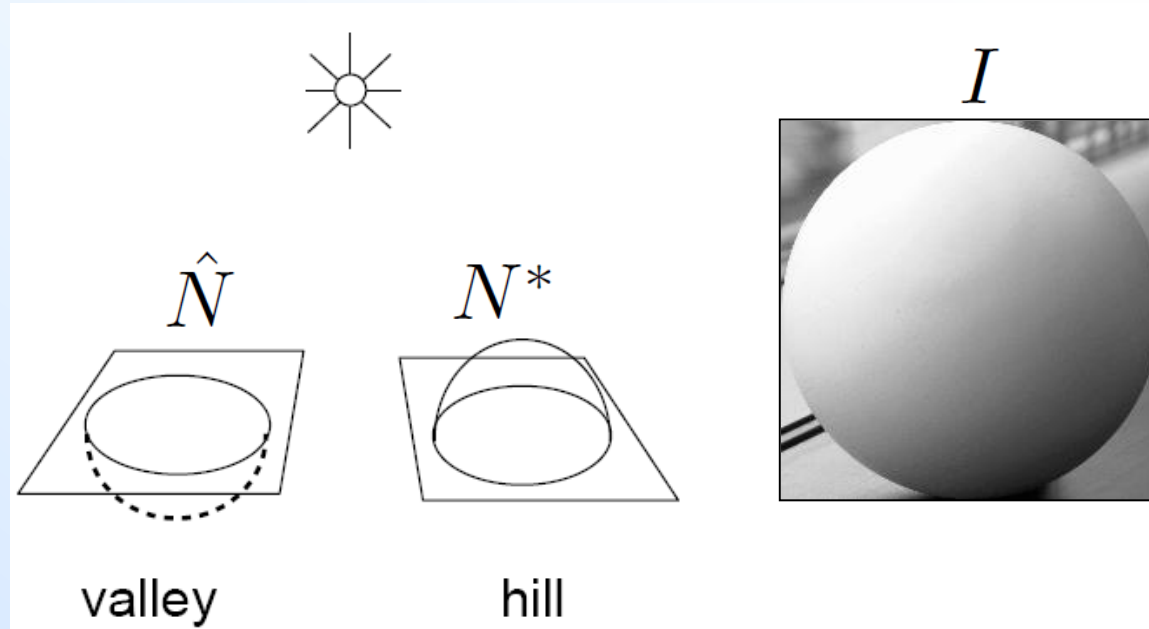
Knowledge in perception and illusion. Biological sciences 1997

Why can we perceive the hollow-face illusion?



► Visual signal

- Can we determine 3D shape from this image?
- Ambiguity to determine 3D shape from a single image



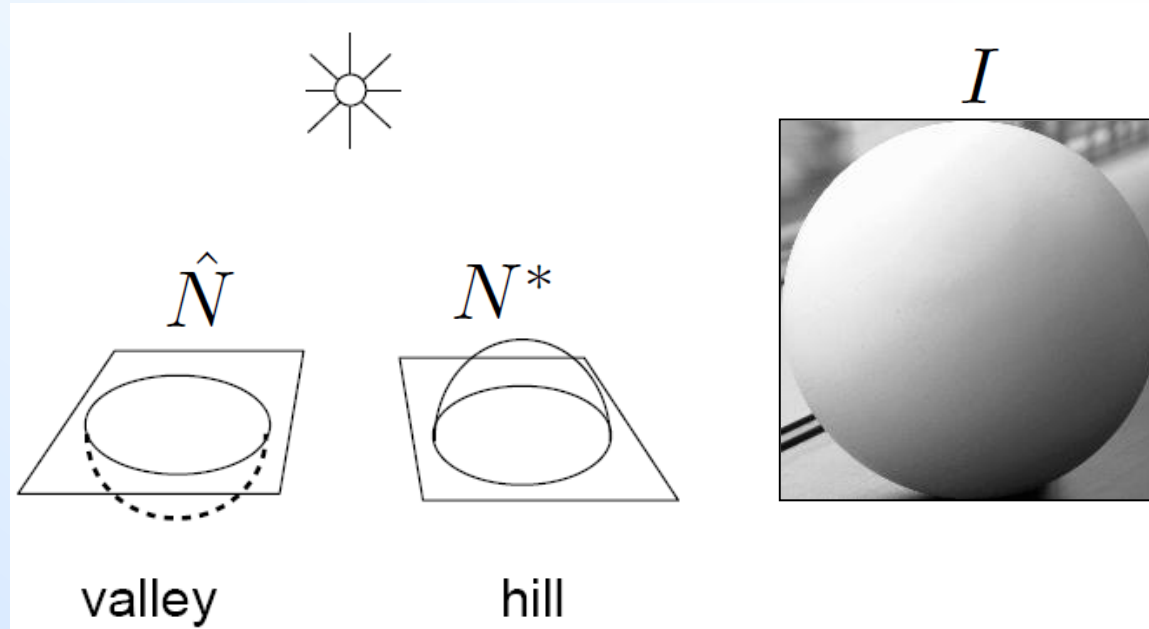
$$I = \hat{N} \hat{L} = (\hat{N} A) (A^{-1} \hat{L}) = N^* L^*$$

Why can we perceive the hollow-face illusion ?



► Prior knowledge

- Why we recognize the object as a convex sphere
- Because convex objects are more common in nature



$$I = \hat{N} \hat{L} = (\hat{N} A) (A^{-1} \hat{L}) = N^* L^*$$

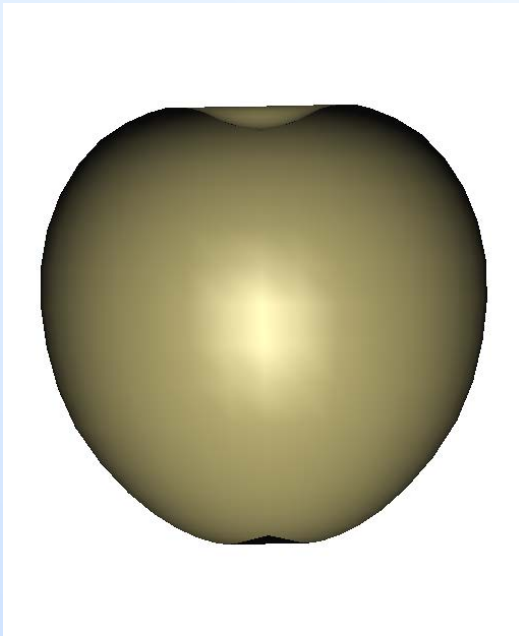
Why can we perceive the hollow-face illusion?



► Prior knowledge

- Perception of convex shapes for hollow face is much stronger
- Because faces have a special status in social communication

hollow apple



hollow face

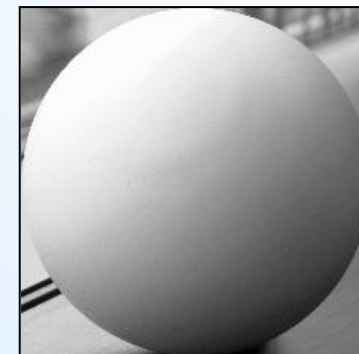
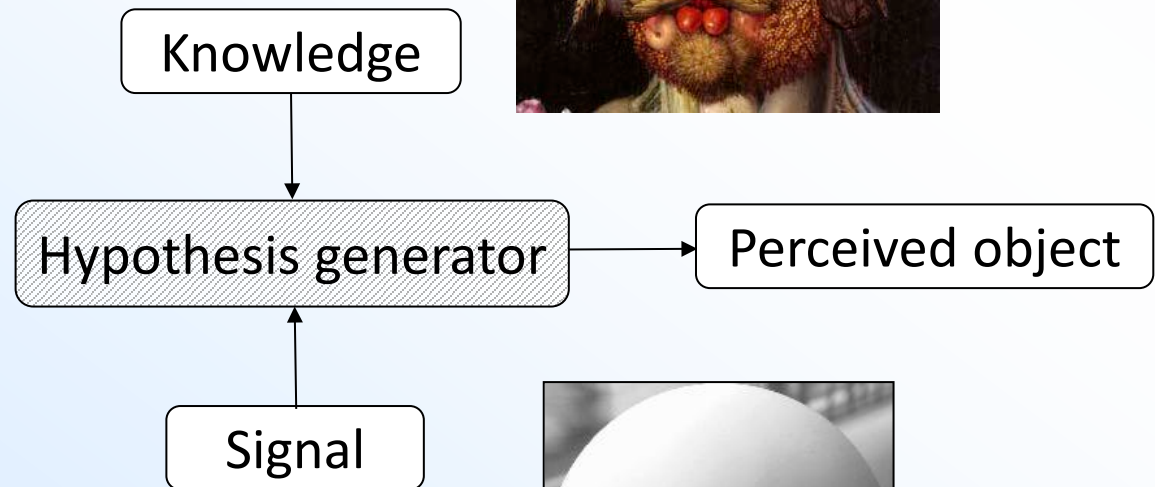


Vertumnus 1591

Why can we perceive the hollow-face illusion ?



Be-face



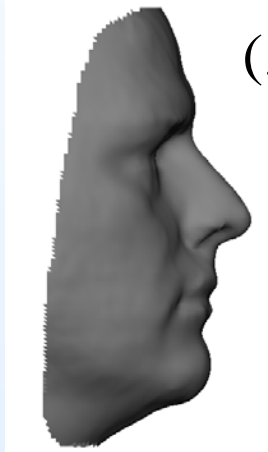
Shading

Quantitative analysis of hollow-face illusion



M

(x, y, z)



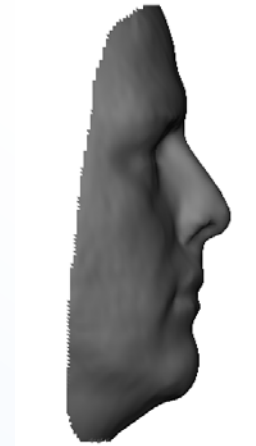
Side view:

bas-relief
transformation

$f_{BR}(M)$

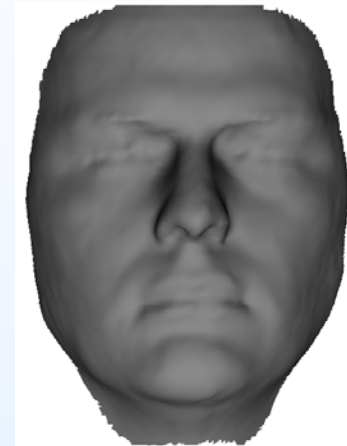
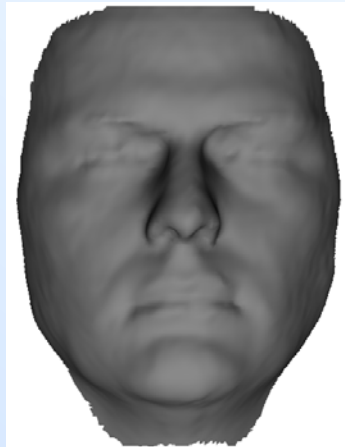
$(x, y, \lambda z)$

$0 < \lambda < 1$

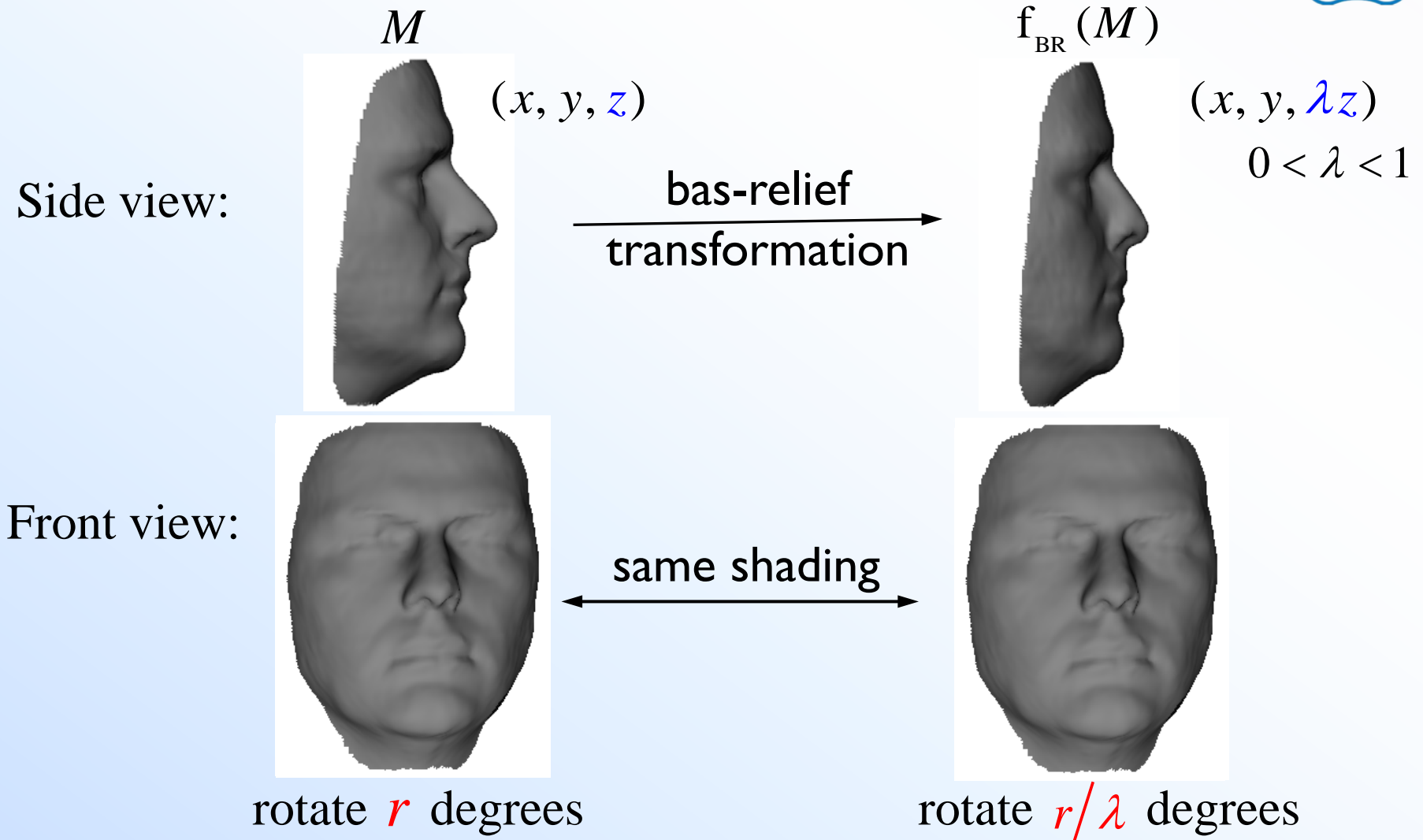


Front view:

same shading



Quantitative analysis of hollow-face illusion

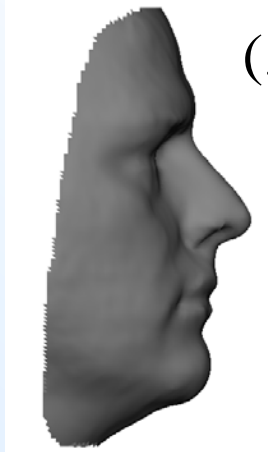


Quantitative analysis of hollow-face illusion



M

(x, y, z)



Side view:

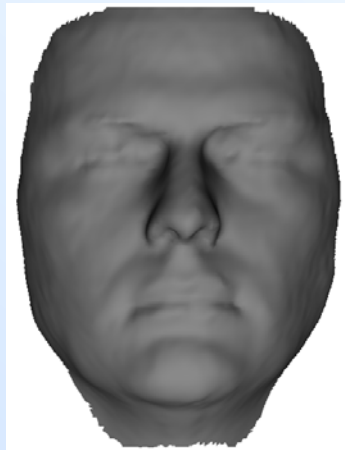
$f_{BR}(M)$

$(x, y, \lambda z)$

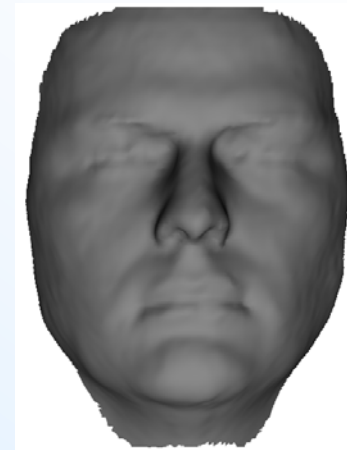
$\lambda = -1$



Front view:

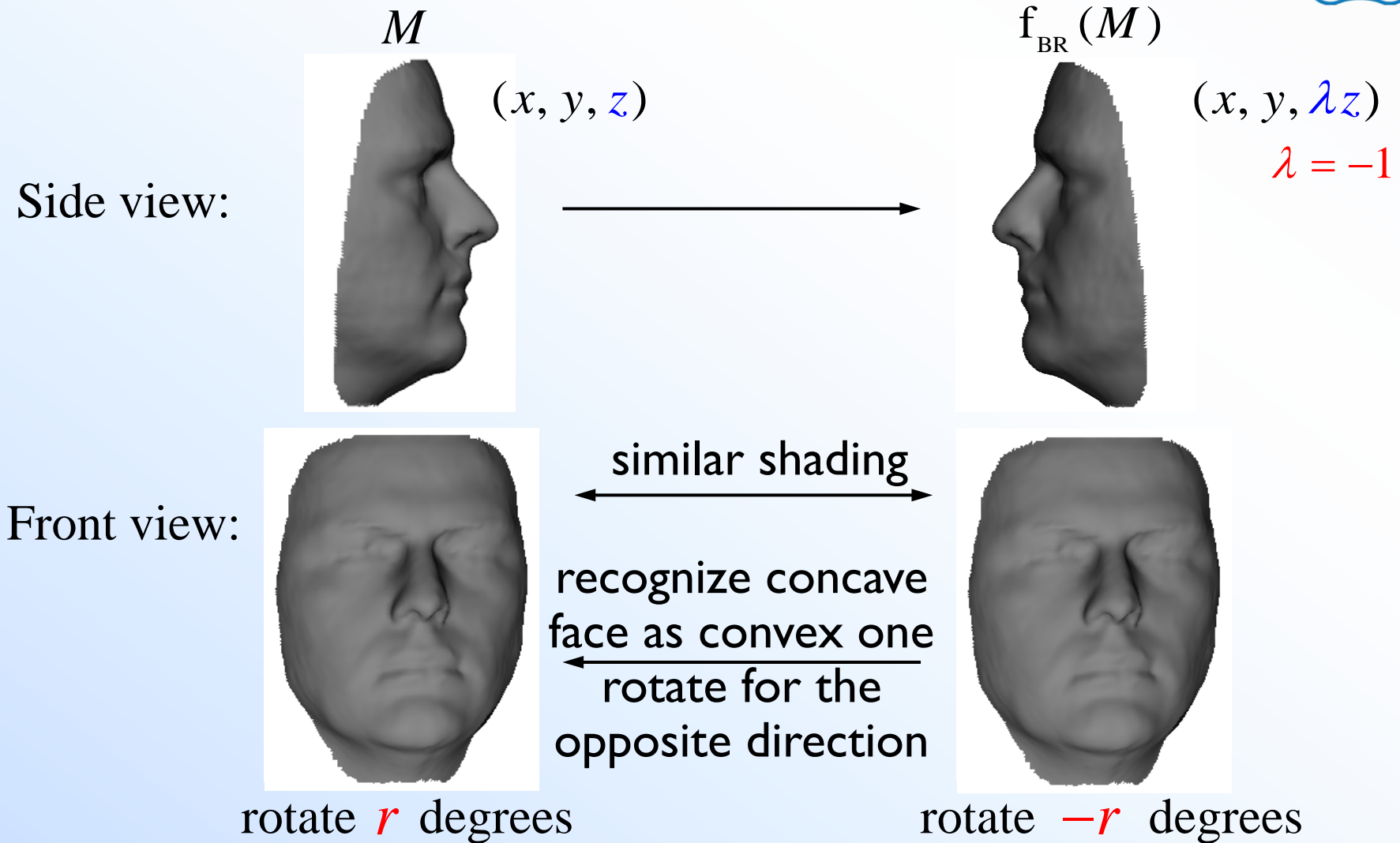


similar shading

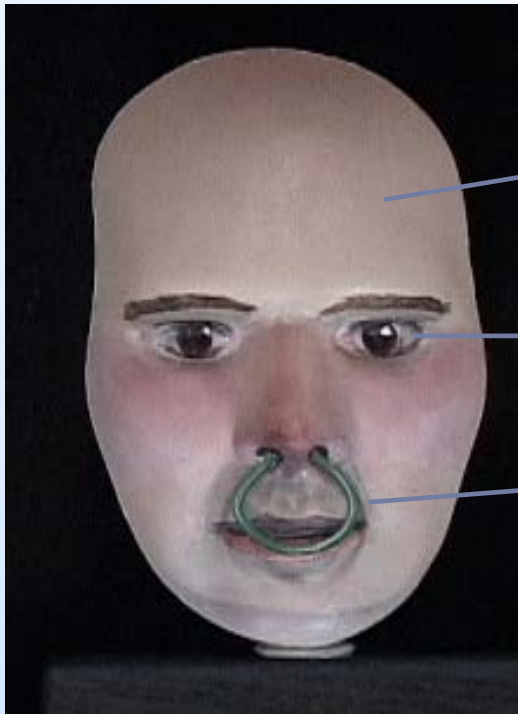


recognize concave
face as convex

Quantitative analysis of hollow-face illusion



Relative rigid motion illusion



hollow face mask

convex eyeballs

convex nose ring

Rolling eyes on a hollow mask (2008)

Relative rigid motion illusion



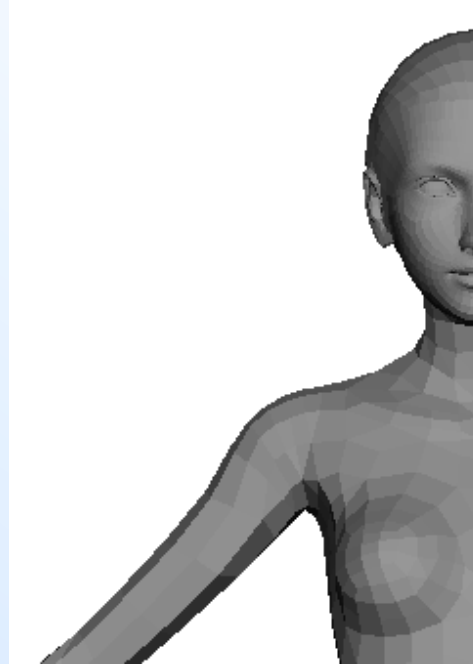
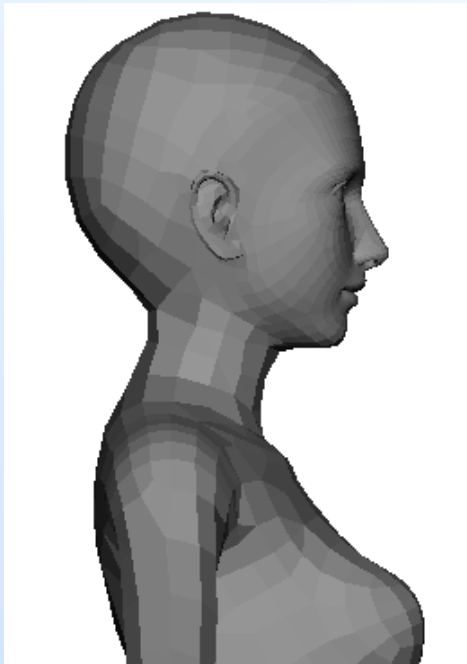
hollow face mask
convex eyeballs
convex nose ring



- ▶ Cannot generate the complex illusion of non-rigid deformation on an object

Idea

- ▶ How to create the head-turn illusion
- ▶ Different influence on different areas



$$(x_i, y_i, z_i) \rightarrow (x_i, y_i, \lambda \cdot z_i)$$

→ head: λ

→ body: 1

$$(x_j, y_j, z_j) \rightarrow (x_j, y_j, 1 \cdot z_j)$$

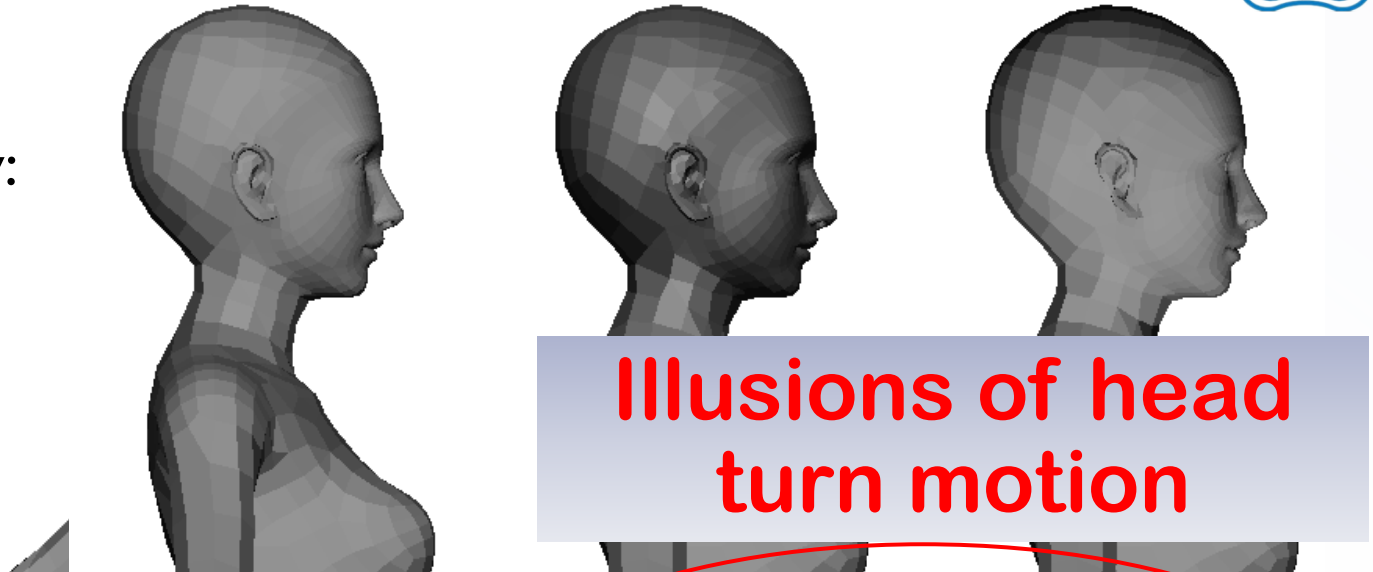
Test

original

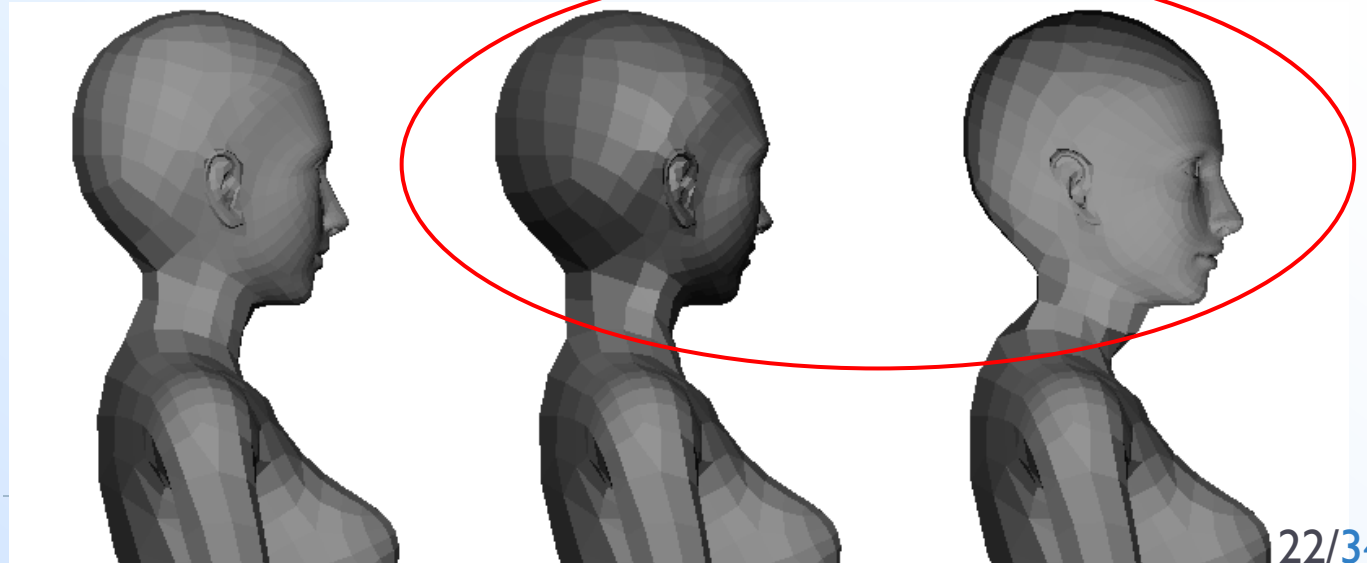
$\lambda = 2$

$\lambda = -1$

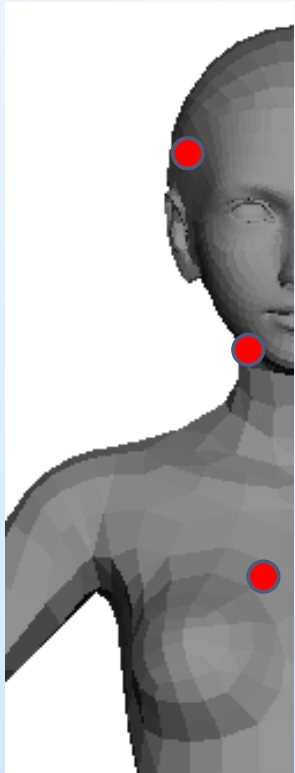
- viewing perpendicularly:



- Rotate by the same angle:



Idea



$$(x_i, y_i, z_i) \rightarrow (x_i, y_i, \lambda_i \cdot z_i)$$

$$(x_j, y_j, z_j) \rightarrow (x_j, y_j, \lambda_j \cdot z_j)$$

$$(x_k, y_k, z_k) \rightarrow (x_k, y_k, \lambda_k \cdot z_k)$$

Manipulate the gradients:

$$g'(x, y) = \lambda(x, y) \cdot g(x, y)$$

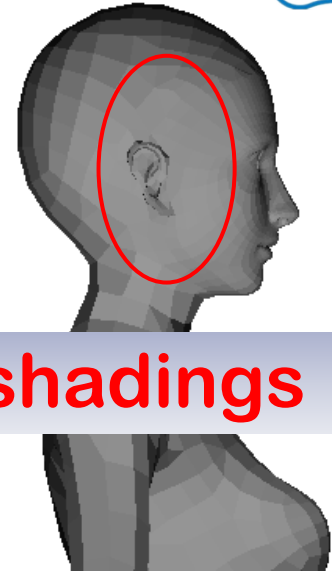
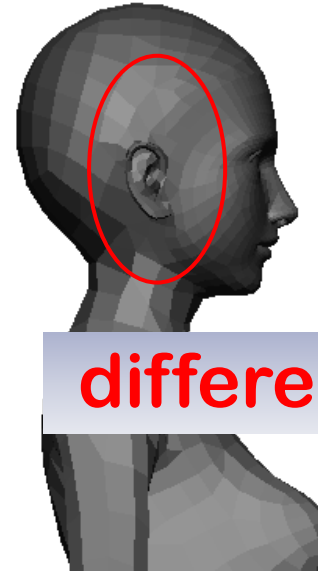
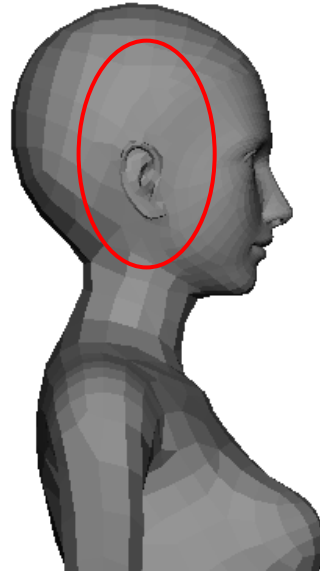
Problems

original

$\lambda = 2$

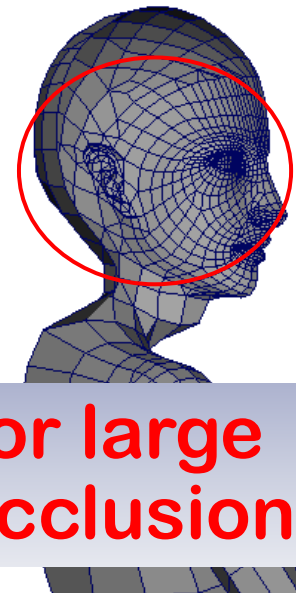
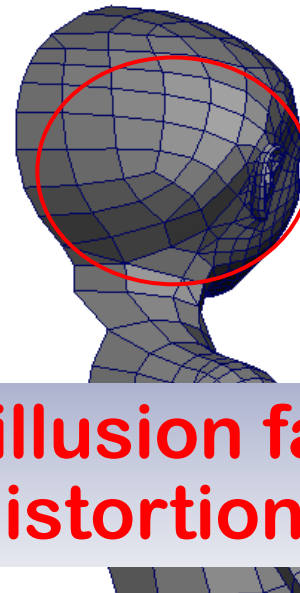
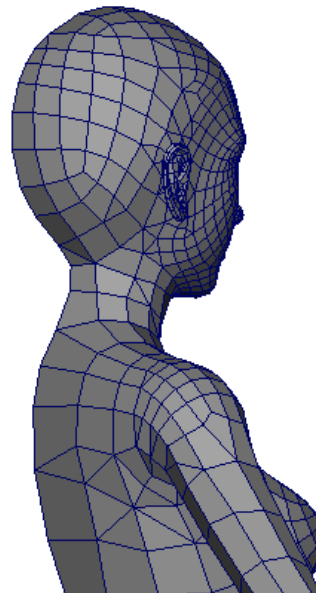
$\lambda = -1$

- viewing perpendicularly:



different shadings

- Rotate by the same large angle:

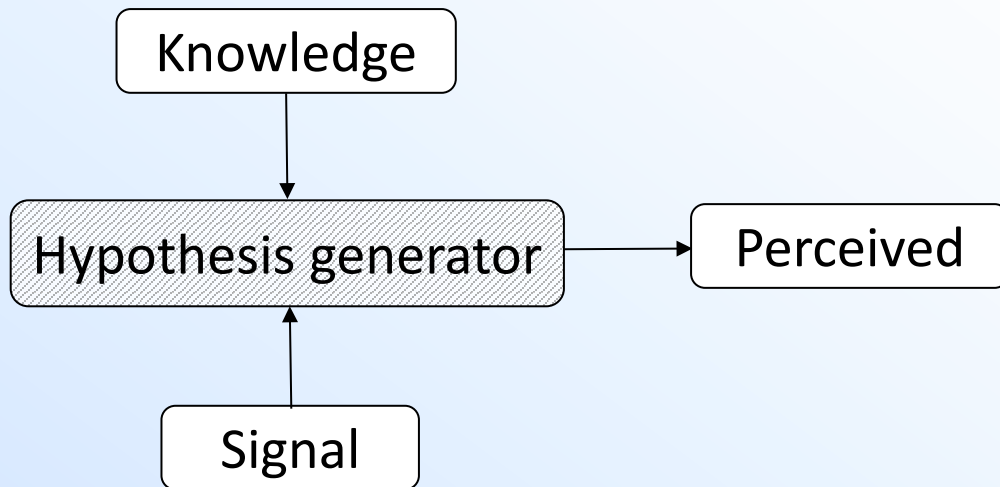


illusion fails for large distortion or occlusion

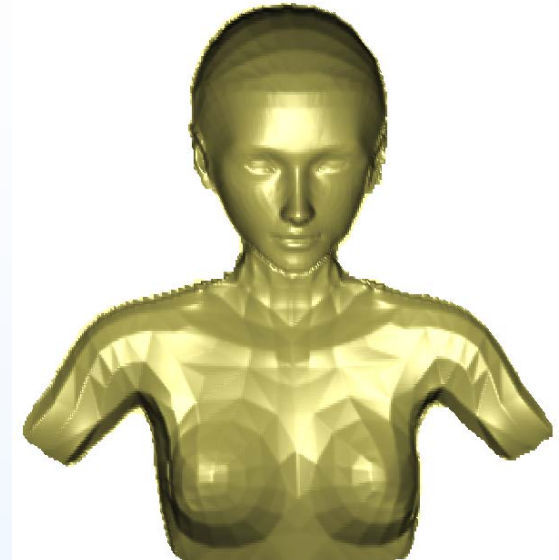
Solution

$$E_{\text{knowledge}} = |S' - \text{beFace}(S')|$$

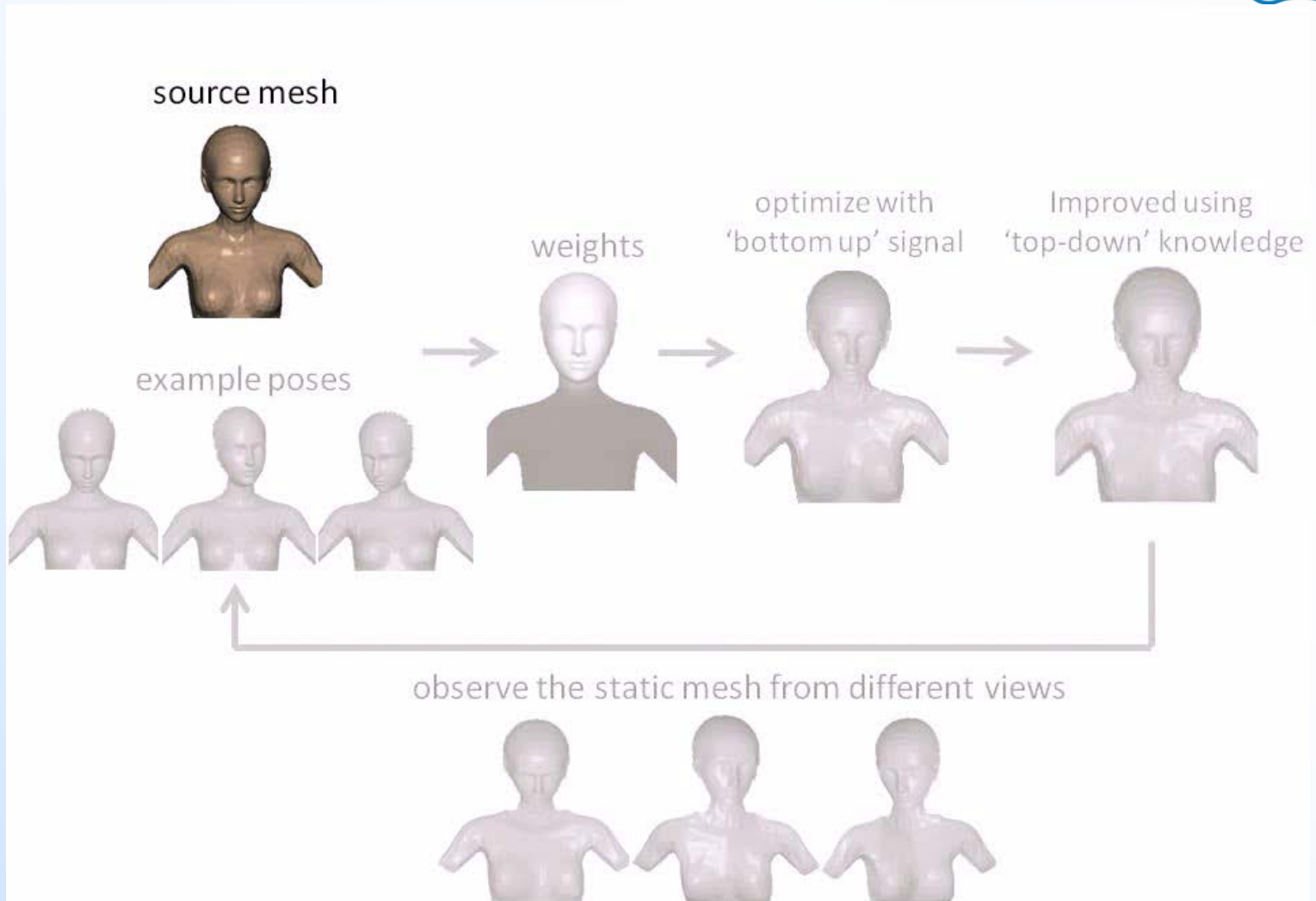
More like human face while
keeping geometric details



$$E_{\text{signal}} = \int \int \|\nabla S' - g'\| dx dy$$



Algorithm pipeline

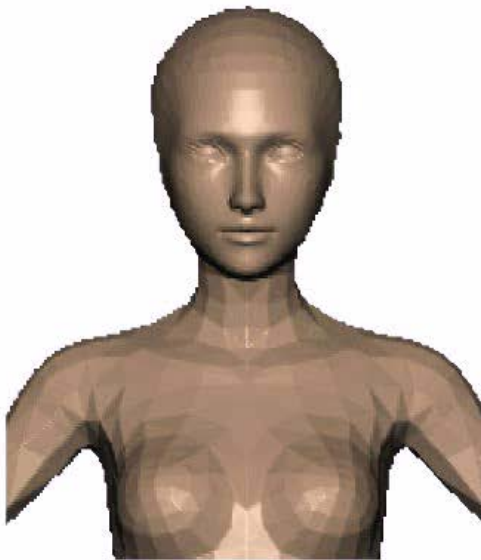


observe the static mesh from different views

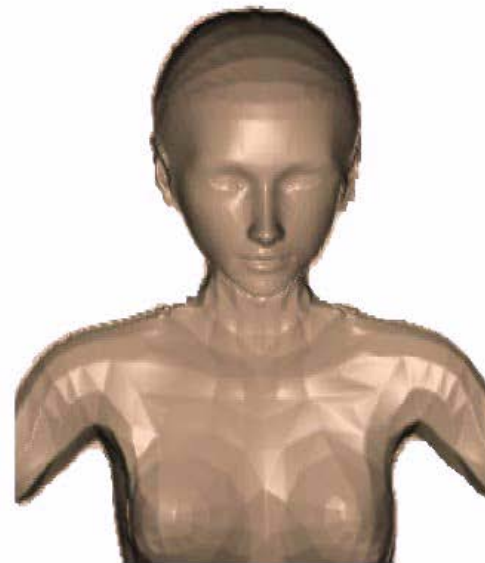


Result

input animation

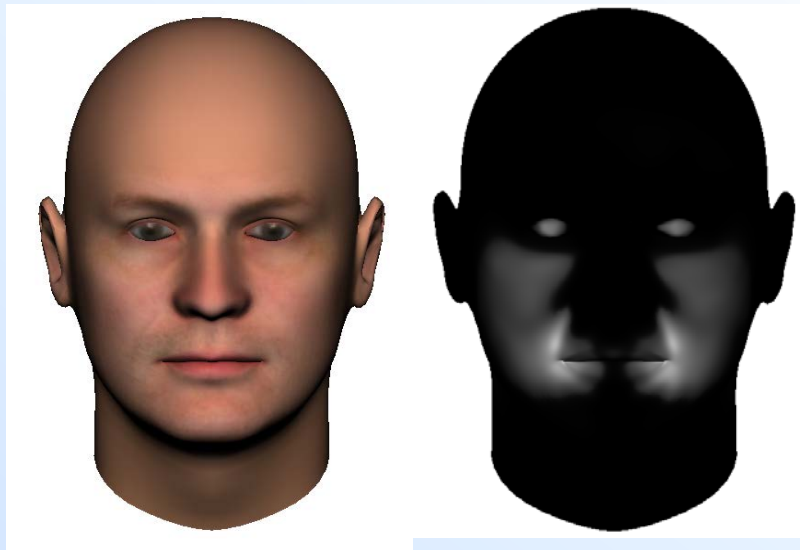


static mesh observing
from different views



Expression changing illusion

source mesh & weights



optimize



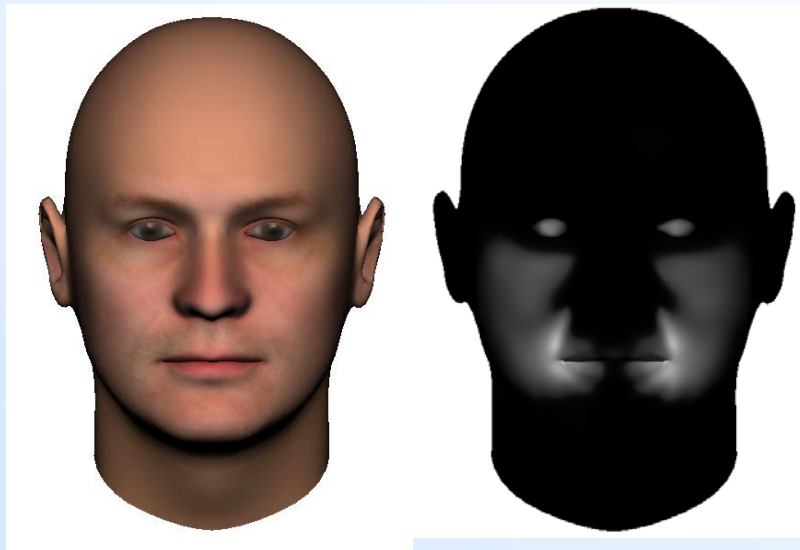
resulting static mesh



Expression changing illusion on an oil painting



source mesh & weights

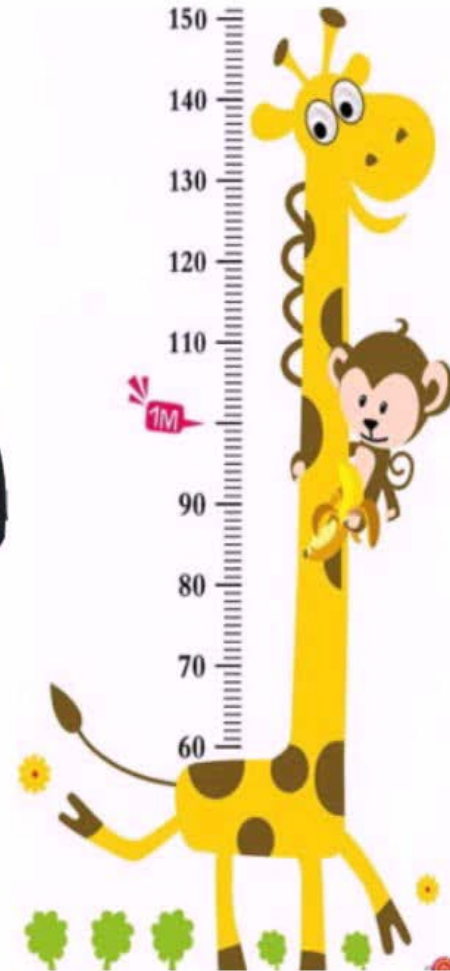


optimize with
thickness
compression

resulting static thin mesh



Applications



3D print models

3D print using photosensitive resin



Conclusions

- ▶ Quantitative analysis and guidance are first introduced to design complex hollow-face illusion
- ▶ An optimization framework to consider both visual signal and prior knowledge





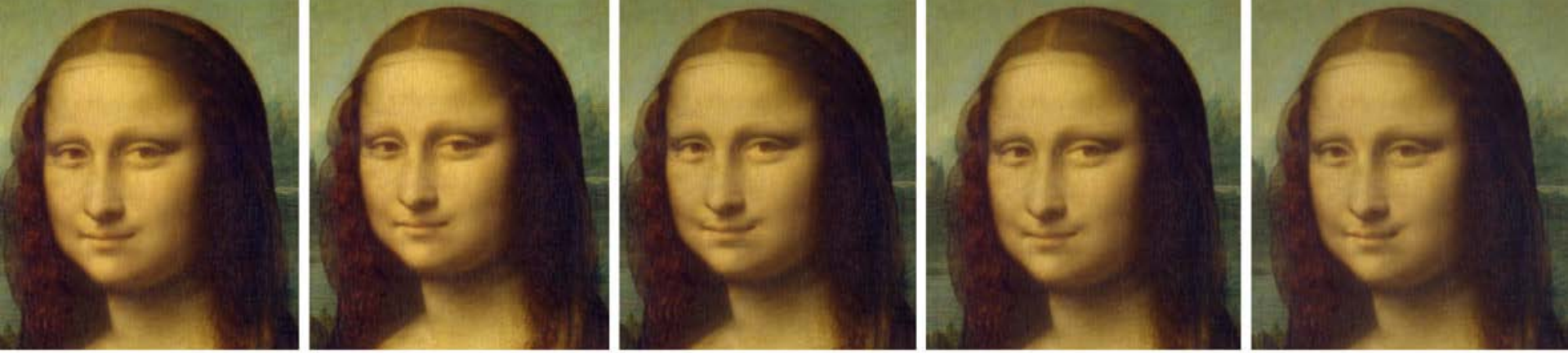
Acknowledgements

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► Also thanks to

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Questions?

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