Persuading Visual Attention through Geometry

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Outline

- Contributions
- Background
- Overview
  - Region Selection
  - Persuasion Filters
  - Validation
  - Stylized Rendering

Contributions

- Introduce the concept of persuading visual attention through geometry modification
- Present a general class of mesh filters that can increase the saliency of a mesh over an arbitrary ROI
- Examine the effectiveness using an eye-tracking- based user study
- Show that the technique is more effective in drawing and holding the viewers' attention than in prior art (the Gaussian-based enhancement method)

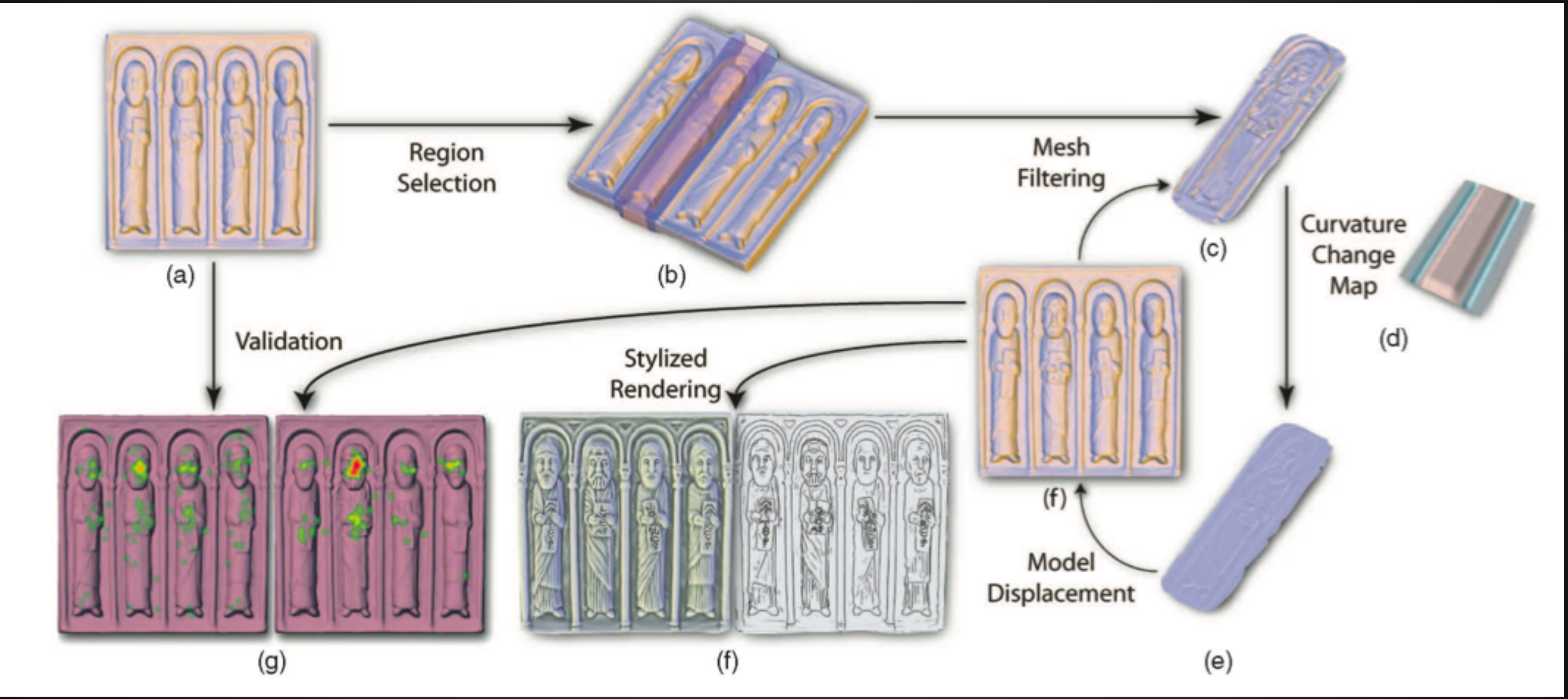
Ansel Adams, Canyon de Chelly, 1941

Mona Lisa, Leonardo da Vinci

Overview

- Region Selection
  - Specify regions in a scene by directly selecting vertices, regions or objects
- Persuasion Filters
  - Design of a general class of mesh filters
- Validation
  - Verify filter effectiveness through eye-tracking user study
- Stylized Rendering
  - Stylized rendering is used to demonstrate the effectiveness of the technique

Overview



Region Selection
Mesh Filtering
Curvature Change Map
Validation
Stylized Rendering
Model Displacement
(a)
(b)
(c)
(d)
(e)
(f)
(f)
(g)

Region Selection

- WYSIWYG type interface
- Screen-space brush projection onto surface
- Variable brush size, shape, and resolution
- Circular, rectangular, and spherical brushes allow for better testing

Persuasion Filters

The basis of persuasion filters are in smoothing and sharpening the geometry. However, this technique is not trivial in 3D applications.

Solution

1. Identify which 3D mesh property to modify by smoothing and sharpening operators.
2. Develop a framework that can structure the modification of the geometry in a controlled manner.

Persuasion Filters

What is needed?

- Laplacian-operator-based isotropic mesh smoothing and anisotropic filtering
- Bilateral filtering for meshes
- Control over the mean curvature values of a mesh using methods for displacing vertices and smoothing

Persuasion Filters

How do they change the mean curvature values in a controlled manner?

$$\mathbf{d_i} = \mathbf{v_i} - \frac{\sum_{\{i,j\}\in E} w_{ij}\mathbf{v_j}}{\sum_{\{i,j\}\in E} w_{ij}}. \qquad (1)$$

The equation for laplacian based vertex displacement offers a direct way to change the mean curvature values in the selected region of interest.

Persuasion Filters

$$B(\mathbf{v}) = \mathbf{v} + d \cdot \mathbf{n}, \tag{2}$$

$$d = \frac{\sum_{\mathbf{p} \in N(\mathbf{v}, 2\sigma_c)} W_c(\|\mathbf{v}-\mathbf{p}\|) W_f(<\mathbf{n}, \mathbf{v}-\mathbf{p}>) <\mathbf{n}, \mathbf{v}-\mathbf{p}>}{\sum_{\mathbf{p} \in N(\mathbf{v}, 2\sigma_c)} W_c(\|\mathbf{v}-\mathbf{p}\|) W_f(<\mathbf{n}, \mathbf{v}-\mathbf{p}>)}.$$

W_c is the closeness smoothing function

σ_c gives a greater weight to the vertices closer to **v**

W_f is the feature weight function

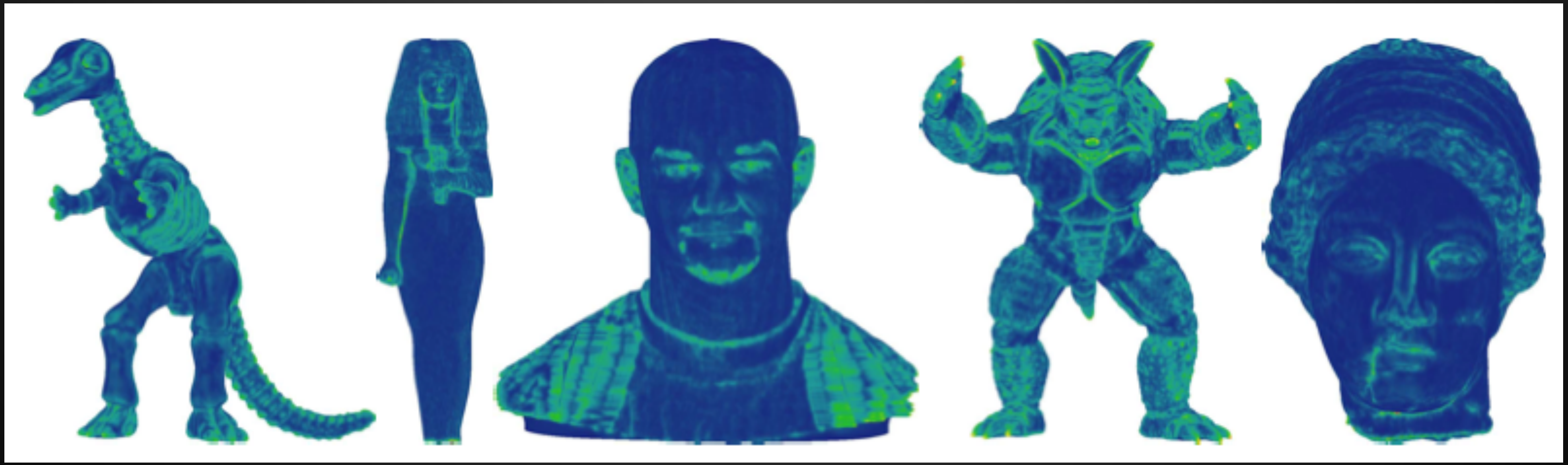
σ_f that limits height from the local tangent plane

N is the neighborhood of **v** containing all vertices p

Persuasion Filters

Saliency-Guided Attention Persuasion

The ability to change mean curvature values at vertices around the user-specified ROI resulting in user-desired saliency changes *(ΔS)*.



Persuasion Filters

$$\Delta \mathcal{S}(\mathbf{v}) = w_1 G(\Delta \mathcal{C}, \mathbf{v}, \sigma) - w_2 G(\Delta \mathcal{C}, \mathbf{v}, 2\sigma),$$

$\Delta S(\mathbf{v})$ is the mesh saliency change map at vertex **v**
ΔC is defined as the curvature change map
$G(\Delta C, \mathbf{v}, \sigma)$ is the Gaussian-weighted average
w_1, w_2 are the weights of the Gaussian-weighted averages

Given a user-specified saliency change map ΔS, we can compute the curvature change map (ΔC) around a vertex **v** by solving a system of linear equations.

Persuasion Filters

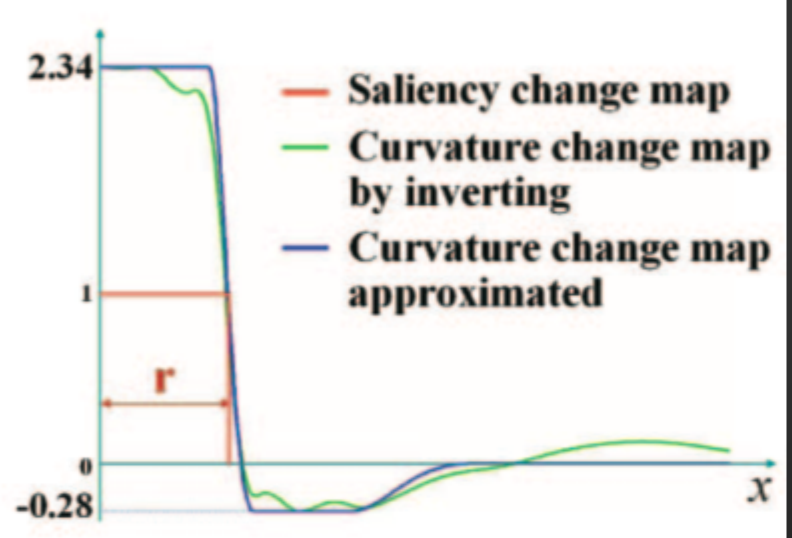
$$\begin{bmatrix} c_{1,1} & c_{1,2} & \cdots & c_{1,n} \\ c_{2,1} & c_{2,2} & \cdots & c_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ c_{n,1} & c_{n,2} & \cdots & c_{n,n} \end{bmatrix} \begin{bmatrix} \Delta\mathcal{C}(v_1) \\ \Delta\mathcal{C}(v_2) \\ \vdots \\ \Delta\mathcal{C}(v_n) \end{bmatrix} = \begin{bmatrix} \Delta\mathcal{S}(v_1) \\ \Delta\mathcal{S}(v_2) \\ \vdots \\ \Delta\mathcal{S}(v_n) \end{bmatrix},$$

The coeffs $c_{i,j}$ represent the difference between two Gaussian weights at scale σ and 2σ for vertex v_j in the neighborhood v_i.

This system of linear equations is solved for multiple scales σ_i to get the curvature change map (ΔC_i) at each scale σ_i. The overall curvature change map is computed as the multiscale summation of ΔC_i.

Persuasion Filters

Assuming a spherical region of interest, the resulting curvature change map (ΔC_i) has the shape of the green curve.



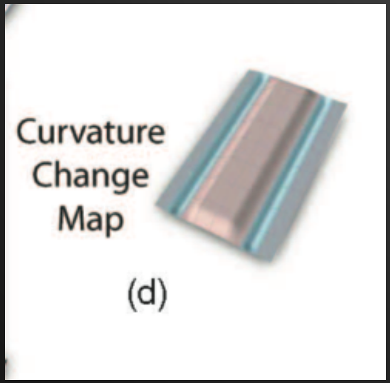
(a)

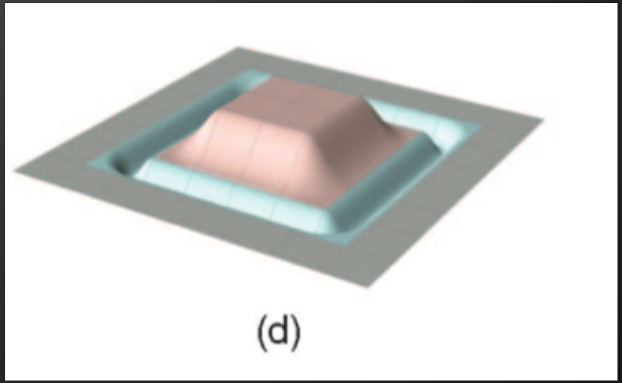
Persuasion Filters

Generalization of ROI using computed distance fields

$d_b(\mathbf{v})$ is the distance from the boundary of ROI to the vertex $\mathbf{v}$

$$dist(\mathbf{v}) \begin{cases} r + d_b(\mathbf{v}) & \text{for vertex } \mathbf{v} \text{ (outside of ROI)} \\ r - d_b(\mathbf{v}) & \text{for vertex } \mathbf{v} \text{ (inside of ROI)} \end{cases}$$





Persuasion Filters

Finally, the mean curvature values of the vertices in a mesh are changed by using the bilateral displacements.

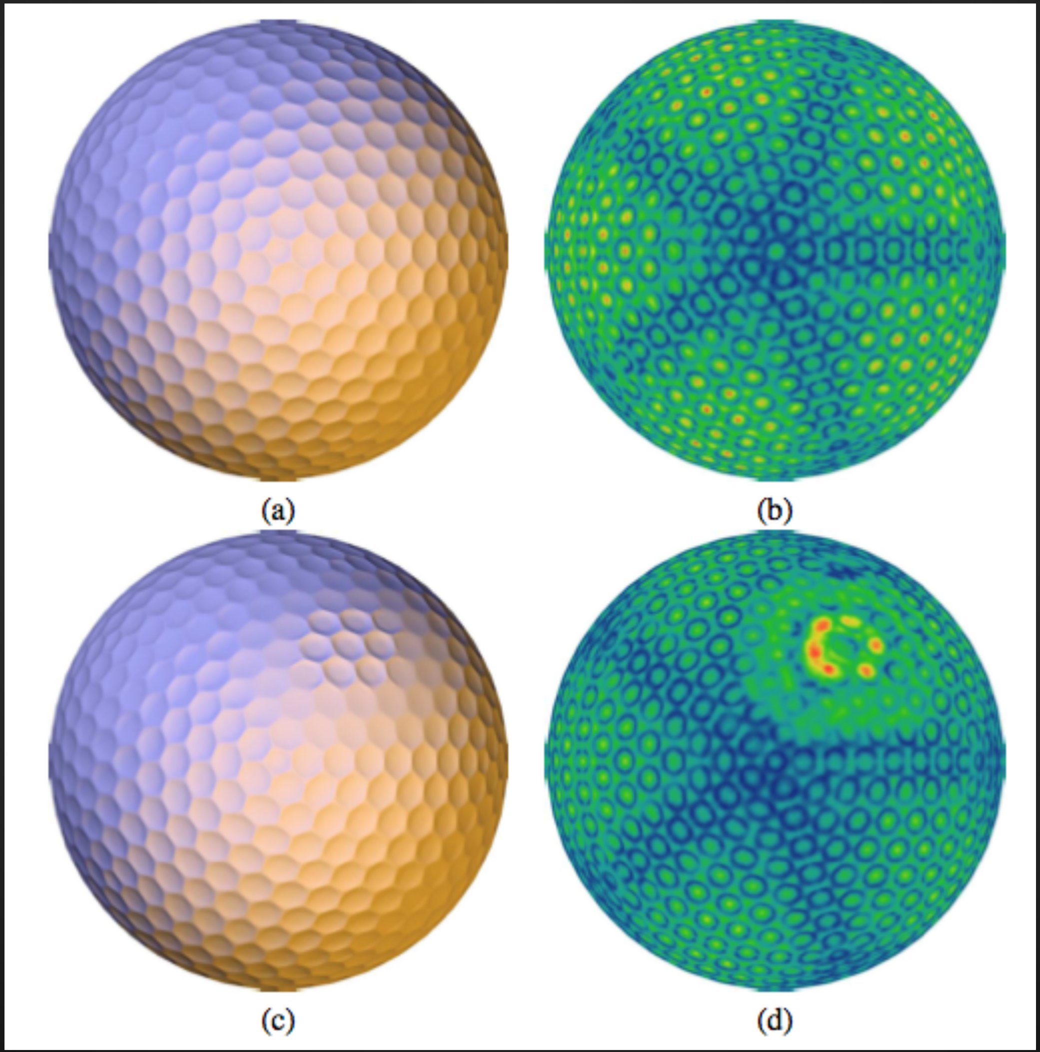
d is the displacement from the bilateral mesh filter in (eq 2)
ΔC(x) is the curvature change map

We refer to this as the persuasion filter *P.*

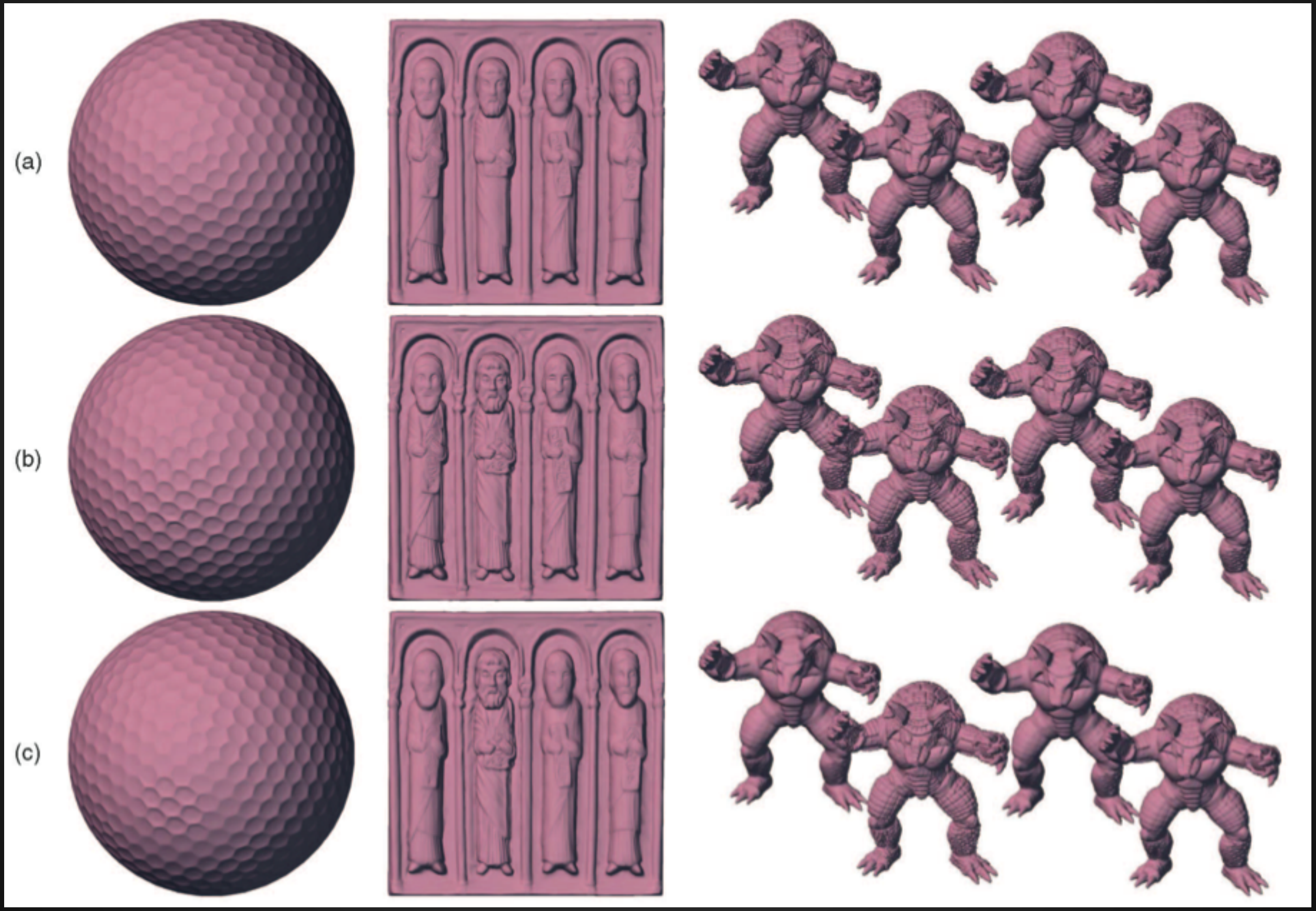
$$\mathcal{P}(\mathbf{v}) = \mathbf{v} - \Delta\mathcal{C}(dist(\mathbf{v})) \cdot d \cdot \mathbf{n}, \tag{3}$$

In practice, they approximate the computed curvature change map by piecewise C^2-continuous degree-4 polynomial radial functions. Simply, they used a series of if-else statements to calculate the curvature change map (aka persuasion filter). In all the examples, the persuasion filter is run 5 times.

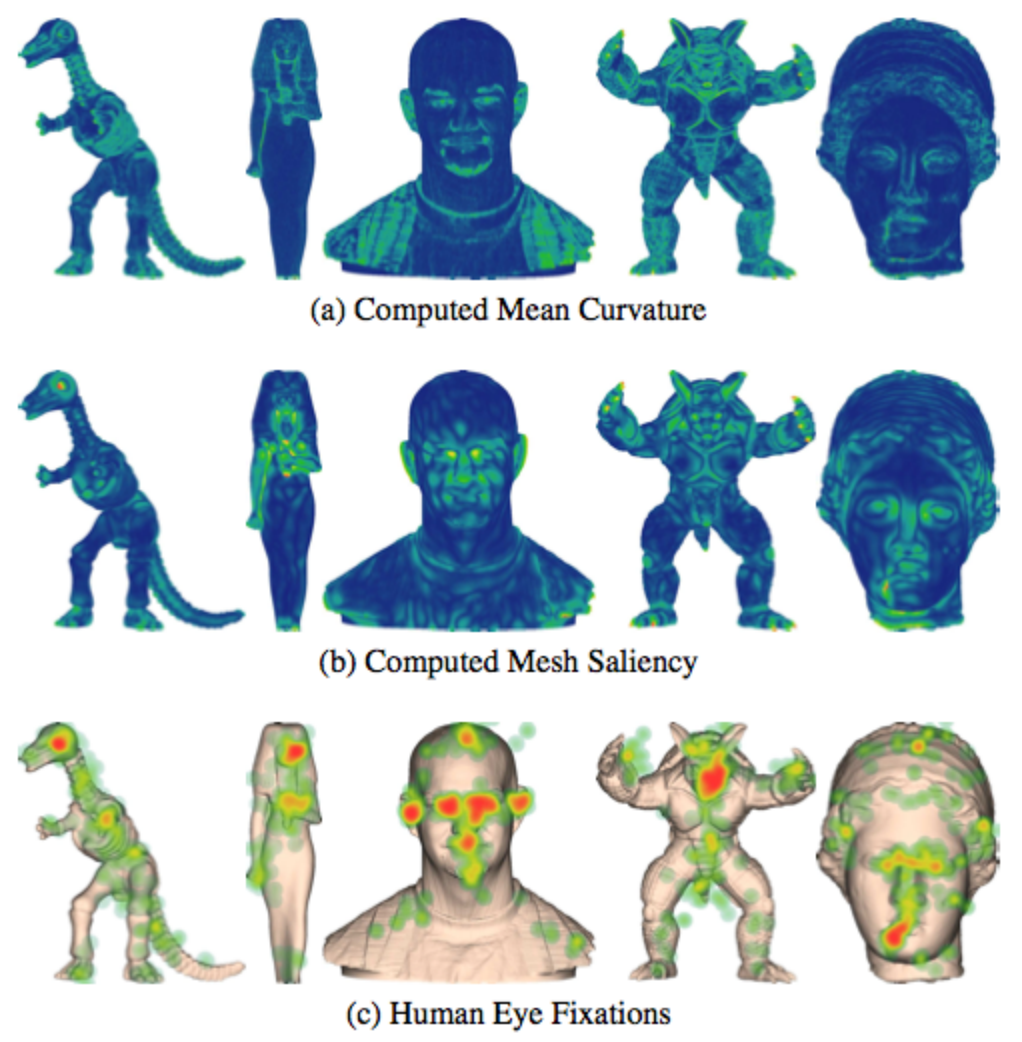
Persuasion Filters



Persuasion Filters



Persuasion Filters



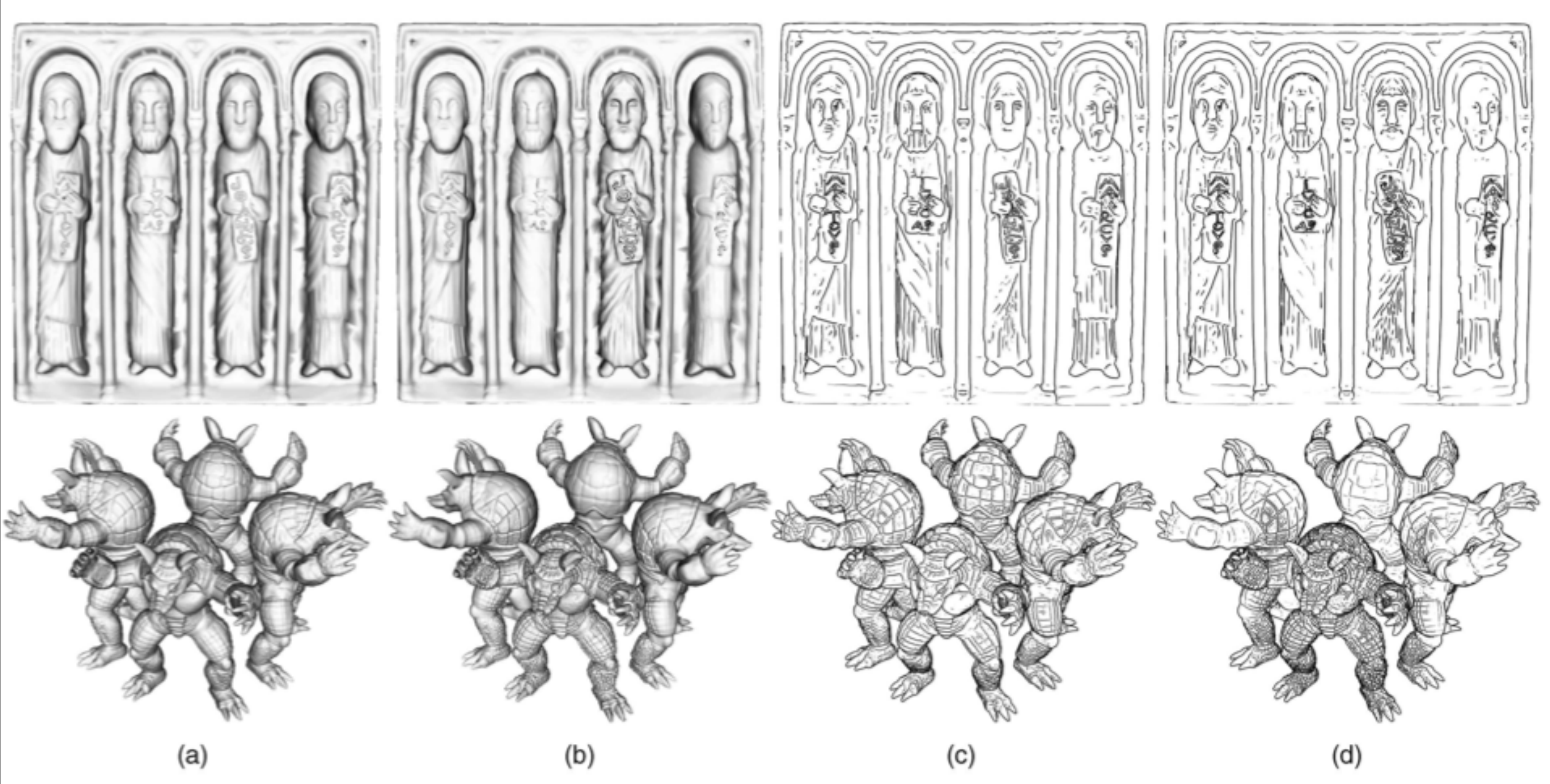
Validation

How do we really know if the geometry-based model of visual attention persuasion results in an increase in mesh saliency over a user-specified region?

Gather evidence!

1. Setup an eye-tracking-based user study
2. Analyze results of study
   - percentage of fixation points on the ROI (attract gaze)
   - average duration of consecutive fixation points on ROI (hold gaze)

Stylized Rendering



Stylized Rendering

They tested the models with a variety of illumination and rendering styles.

- Standard OpenGL lighting model
- Suggestive contours

Since persuasion filters are applied to the geometry before the graphics pipeline, this process is view independent.

The results suggest that persuasion filters may also be able to elicit attention across a wide class of illumination and stylized rendering techniques such as luminance contrast, color contrast, and texture contrast.

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Ansel Adams, Canyon de Chelly, 1941

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Mona Lisa

http://en.wikipedia.org/wiki/Mona_Lisa