SHAPE DEFINED PANORAMAS

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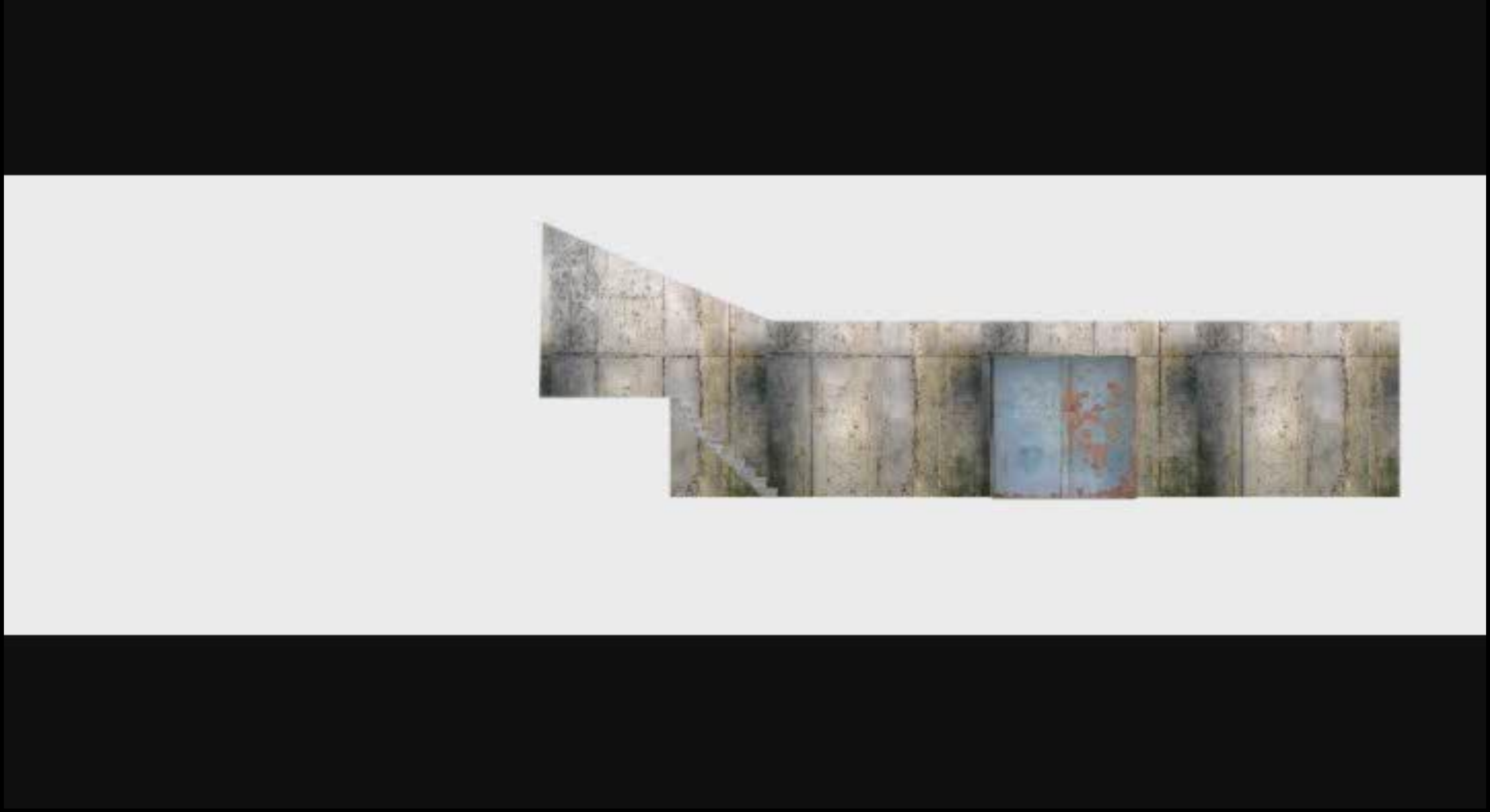
Shape Modeling International – June 2010

Outline

1. Scenario/Motivation
2. Goals
3. Related Work
4. Observations
5. Projection Surface Formulation
6. Rendering
7. Applications



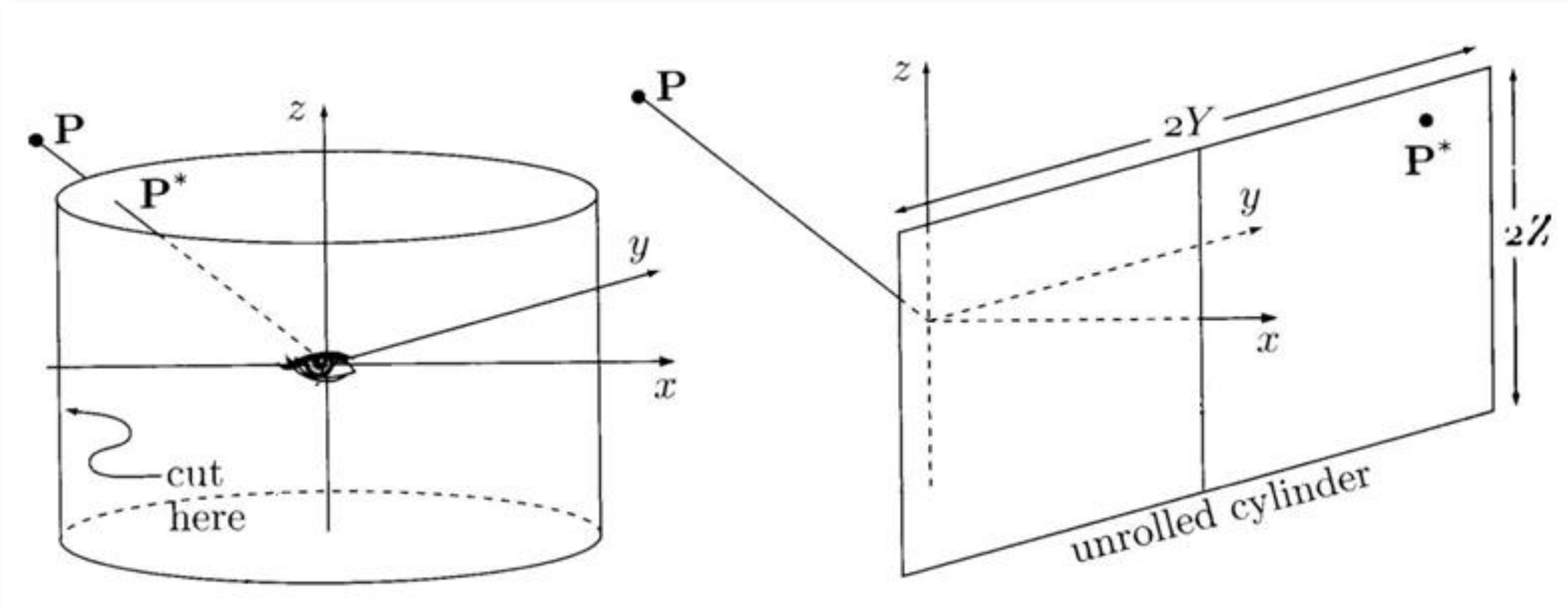
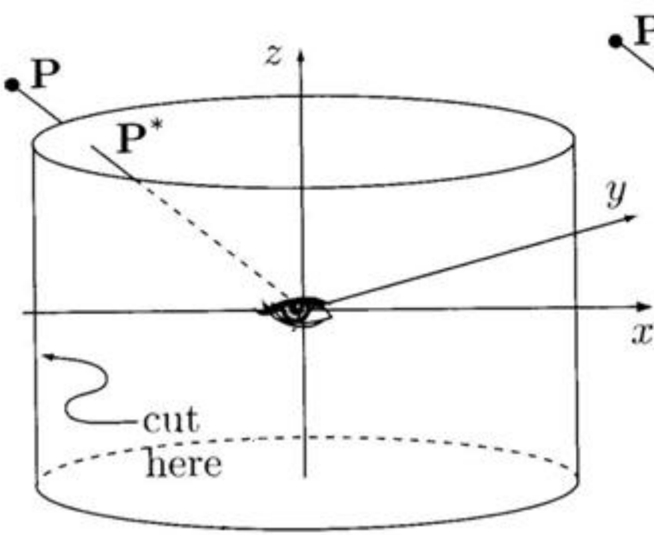
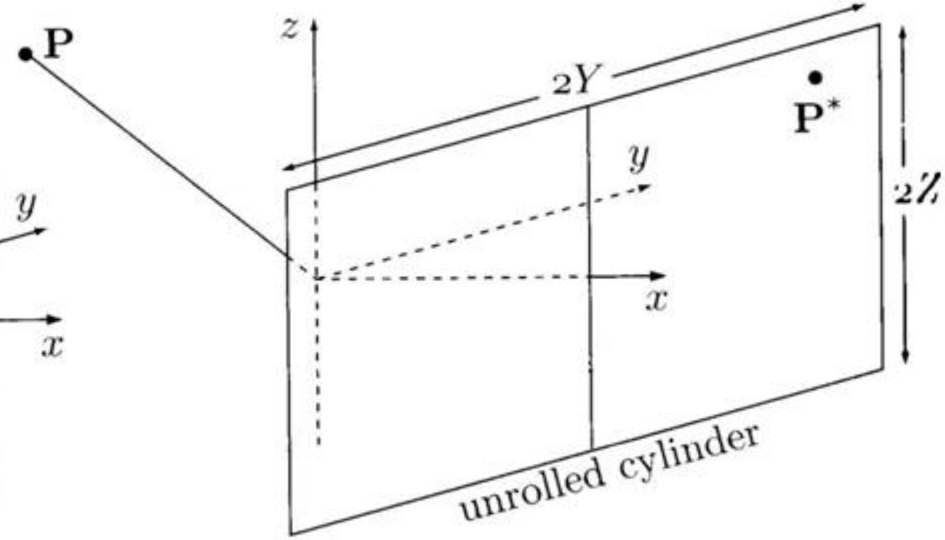
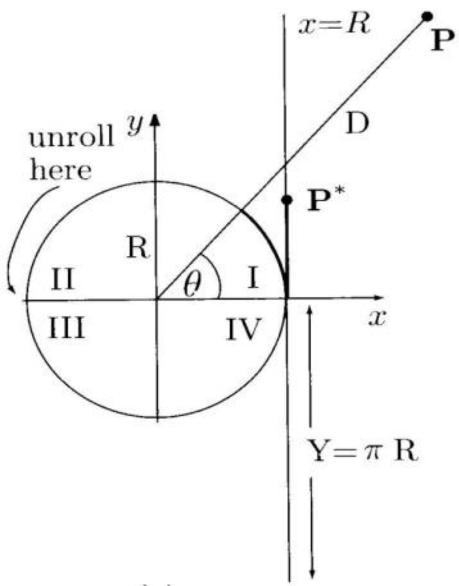


Figure from *Transformations & Projection in Computer Graphics*, Salomon, Springer, 2006



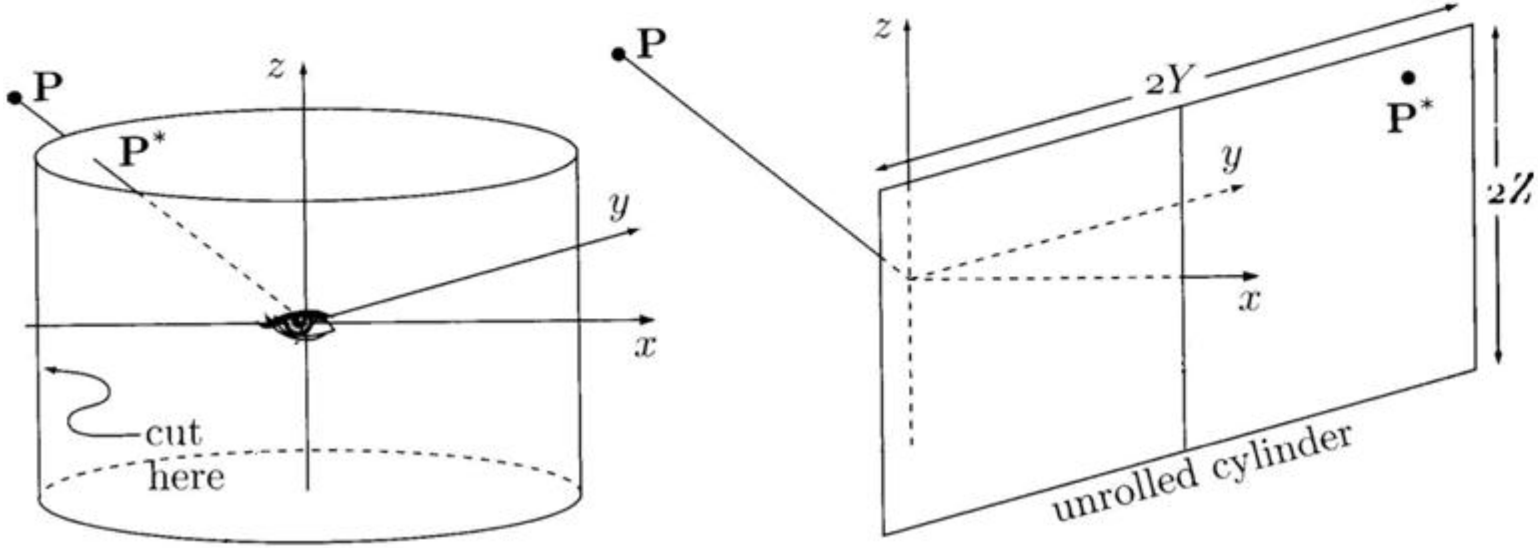


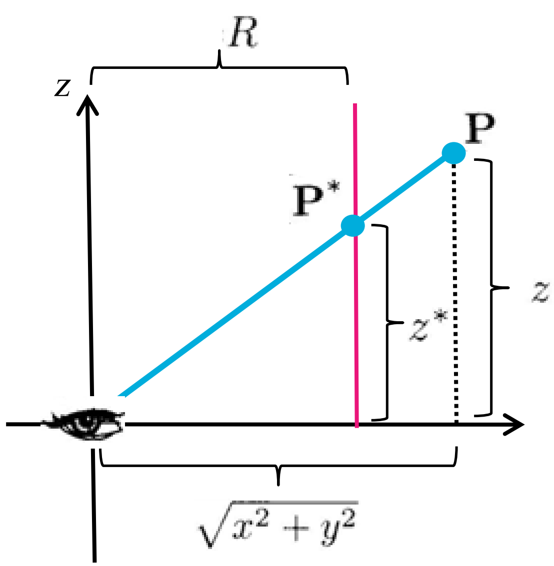


$$\theta = \arcsin \frac{y}{\sqrt{x^2+y^2}} = \arccos \frac{x}{\sqrt{x^2+y^2}} = \arctan\left(\frac{y}{x}\right)$$

$$i = \pm R\,\theta$$

Figure from *Transformations & Projection in Computer Graphics*, Salomon, Springer, 2006





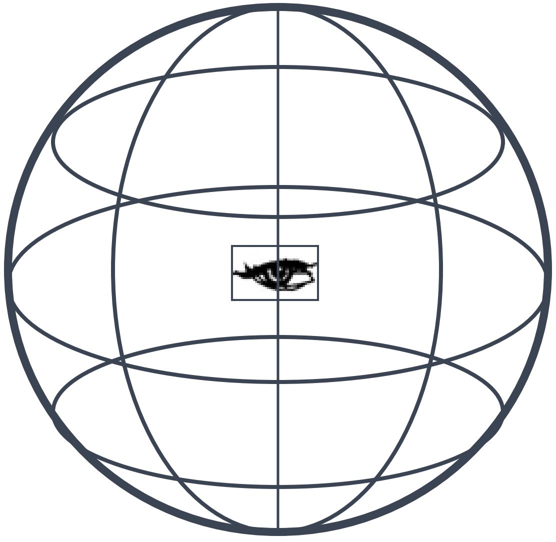
$$\frac{z}{\sqrt{x^2+y^2}} = \frac{z^*}{R} \longrightarrow z^* = \frac{zR}{\sqrt{x^2+y^2}}$$

$$j = \frac{z^*}{Z} + Z$$

$$(i, j) = \left(\theta, \frac{z^*}{Z}, Z\right)$$

Figure from *Transformations & Projection in Computer Graphics*, Salomon, Springer, 2006

Spherical Projection Equation



$$\theta = \arctan\left(\frac{y}{x}\right)$$

$$\phi = \arctan\left(\frac{z}{\sqrt{x^2 + y^2}}\right)$$

$$(i, j) = \left(\pm R\theta, \pm R\phi\right)$$

Goals

Create panoramas that:

1. Allow for exploration & customization
2. Are defined by modeling
3. Build on existing intuition
4. Allow for visual understanding

- Single Viewpoint: no “slit cameras”.

Related Work

Panoramas from Perspective Images

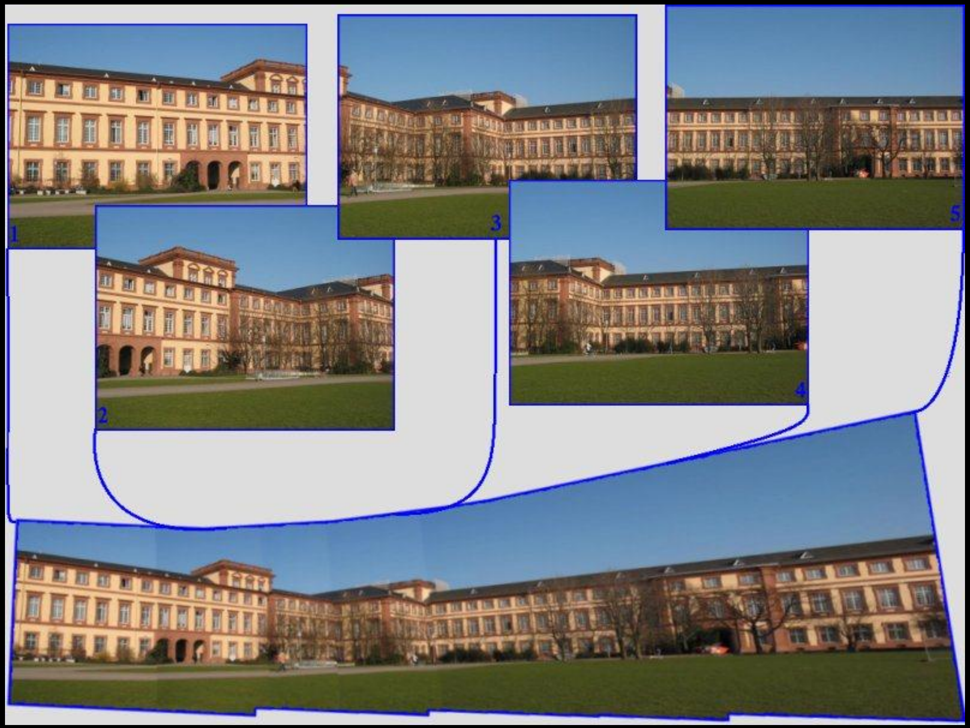


Image from http://www.cirq.de/mosaicing.html

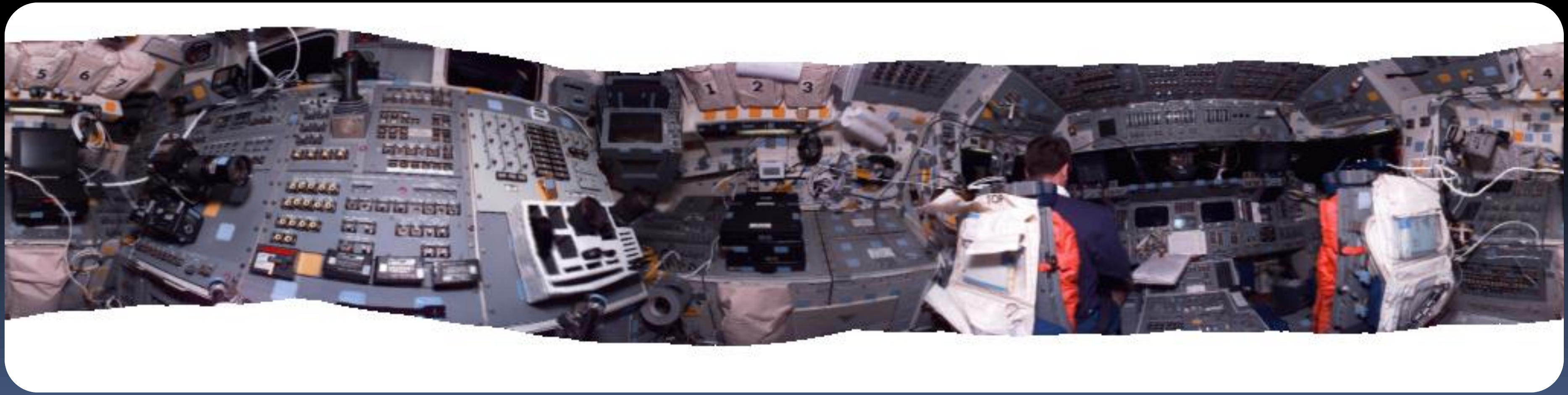


Image from Szeliski & Shum, Creating full view panoramic image mosaics and environment maps, Siggraph 1997

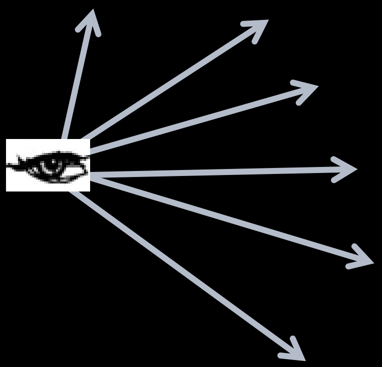
Related Work

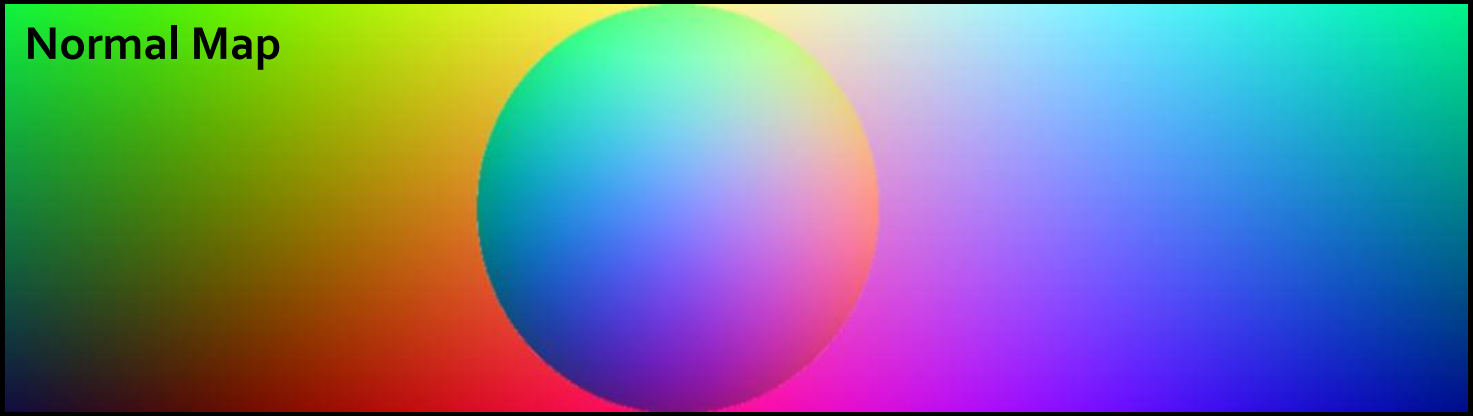
Correcting Distortion

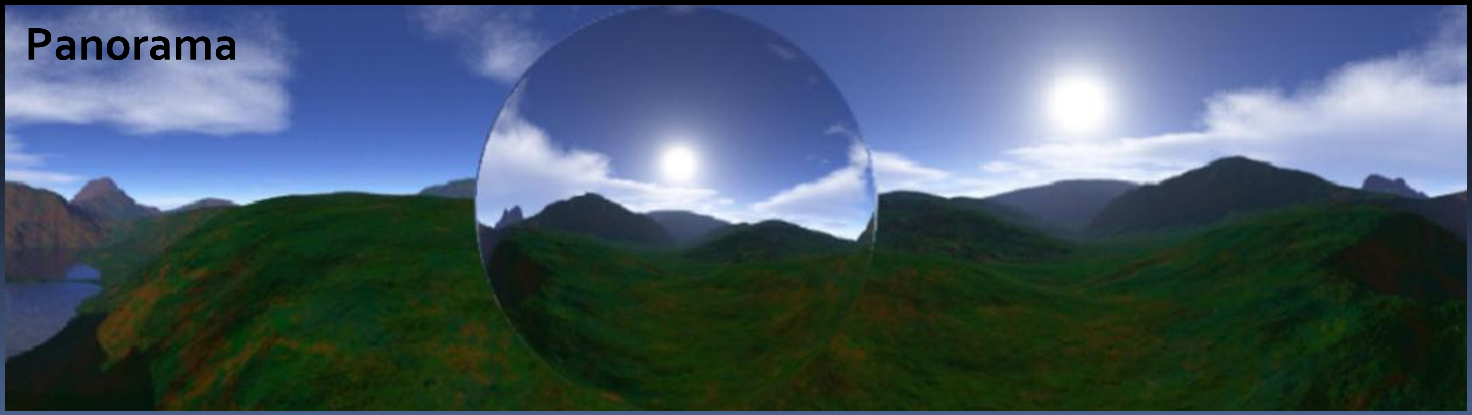
Images from Carrol, Agrawala & Agarwala, Optimizing Content-Preserving Projections for Wide-Angled Images, Siggraph 2009

Related Work

Single-Center Projections

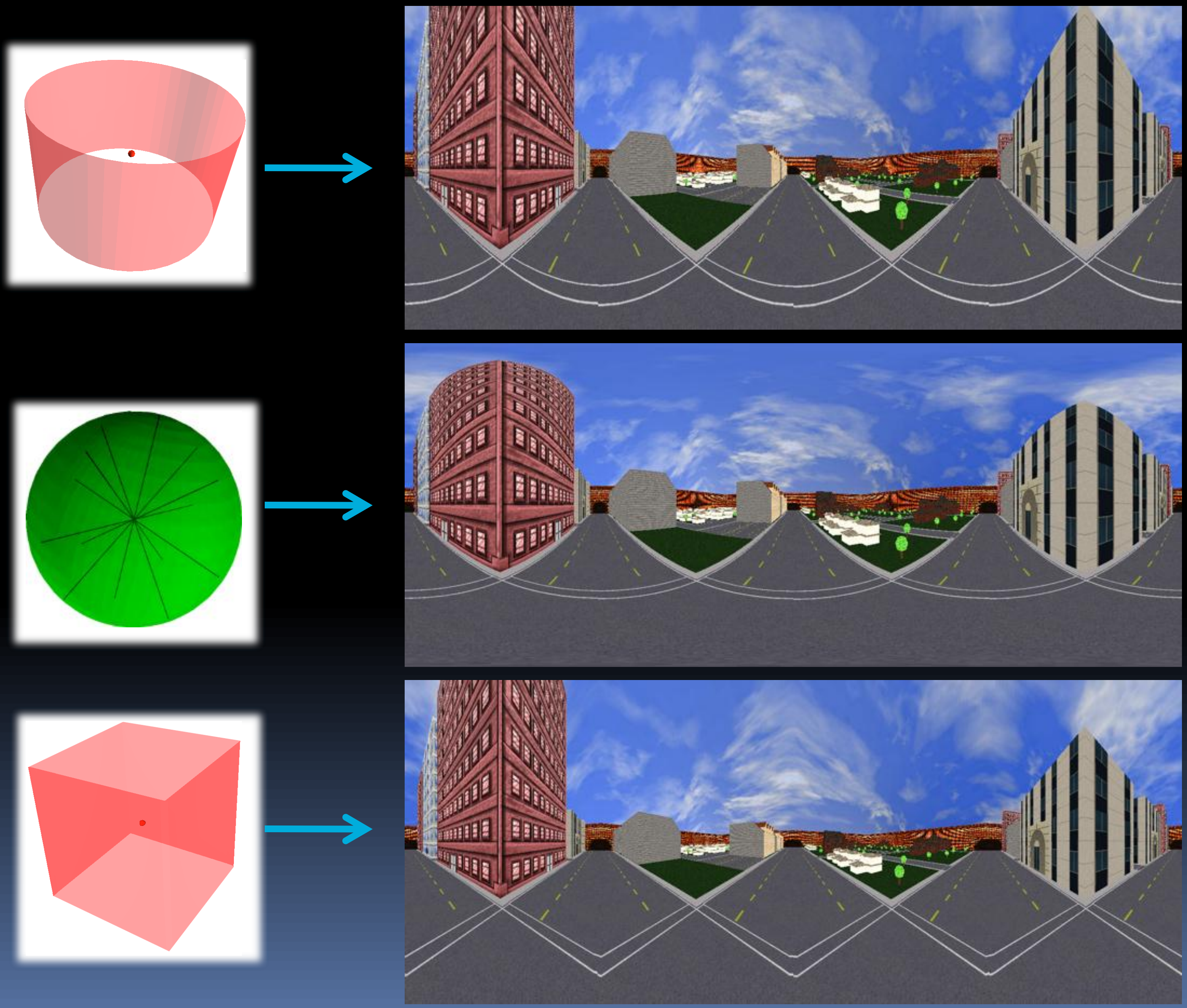






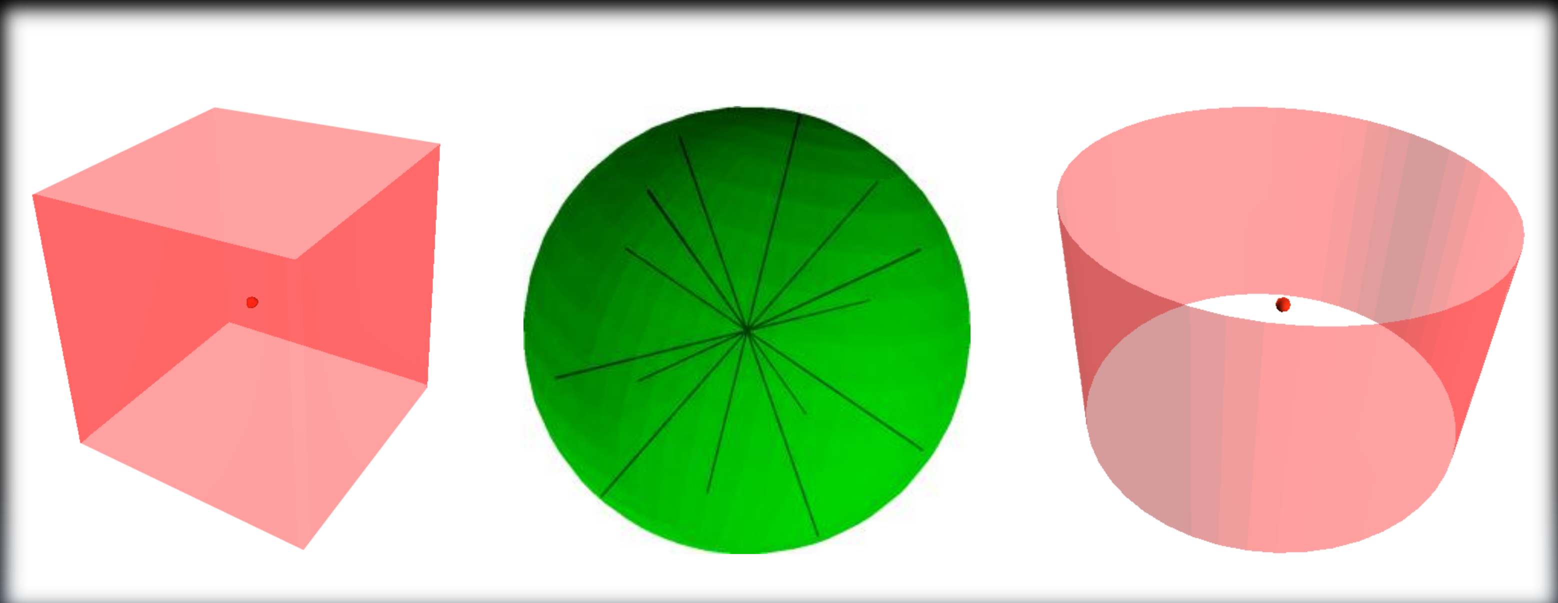
Images from Trapp & Döllner, Generalization of Single-Center Projections Using Projection Tile Screens, VISIGRAPP, 2008

Common Panoramas



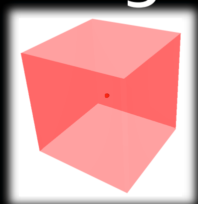
Observations

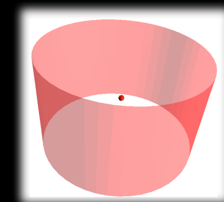
1. Shapes are associated with panoramas

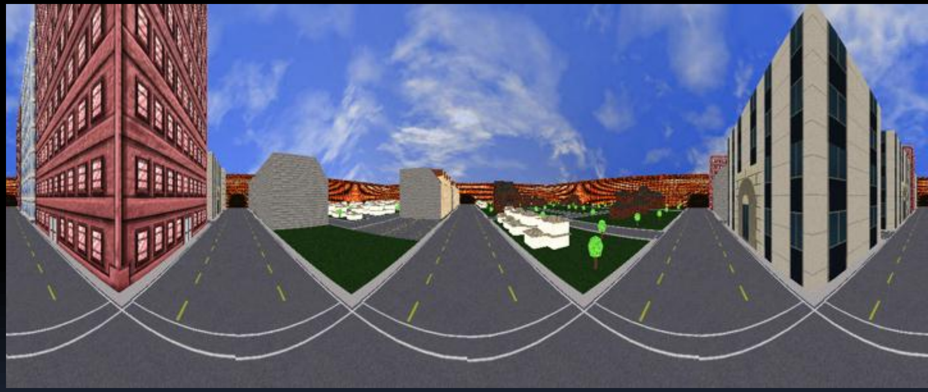


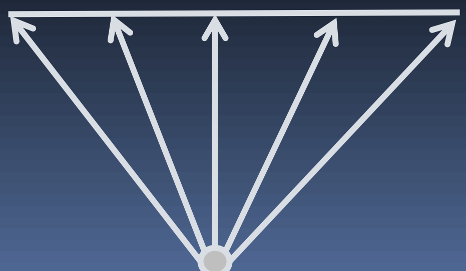
Observations

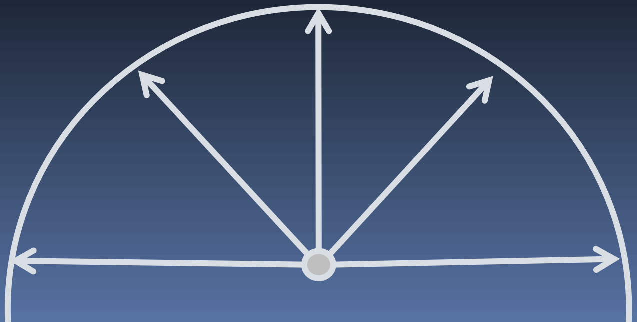
1. Shapes are associated with panoramas
2. Angular change





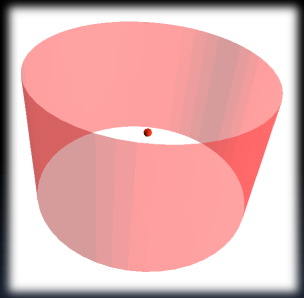


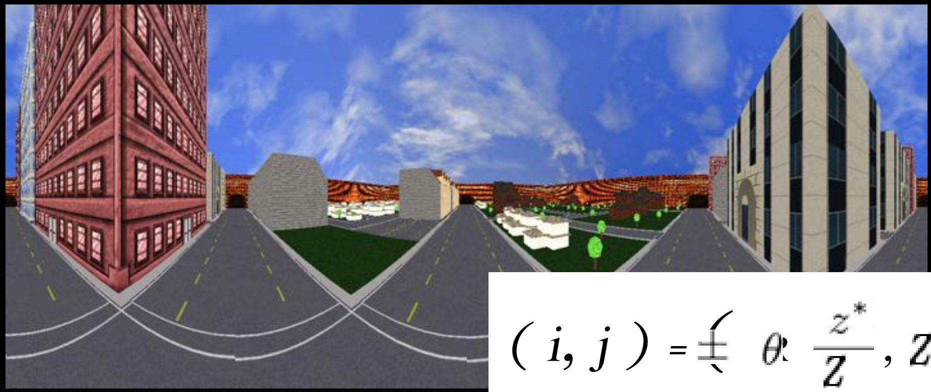




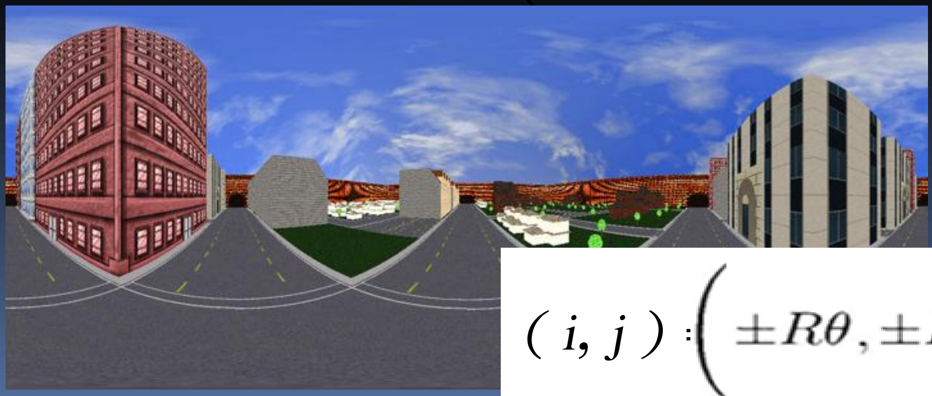
Observations

1. Shapes are associated with panoramas
2. Angular Change
3. Parameterization is important





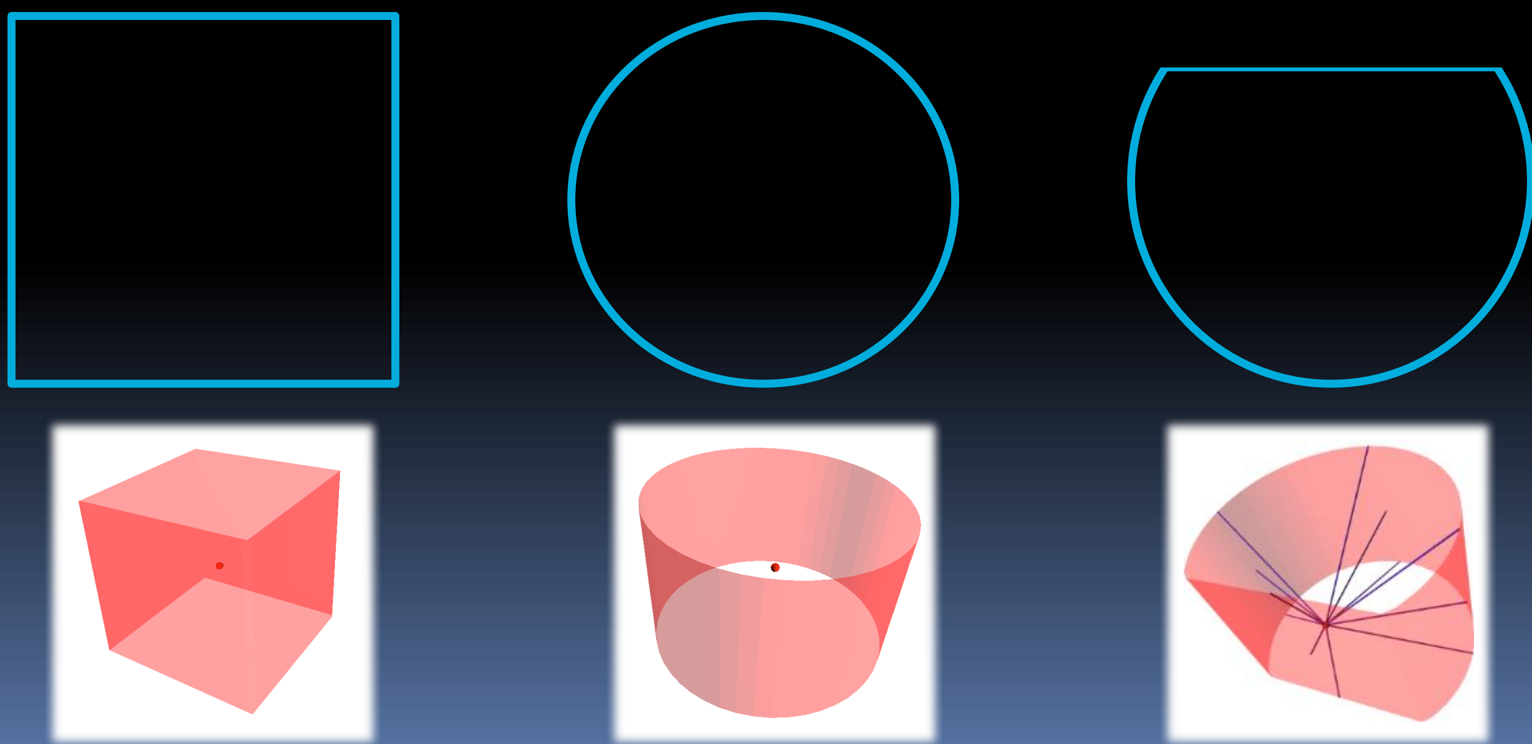
$$(i, j) = \left(\pm \theta, \frac{z^*}{Z}, Z\right)$$



$$(i, j) = \left(\pm R\theta, \pm R\phi\right)$$

Shape Defined Panoramas

- Defined by two curves
  1. **Outline:** closed, controls horizontal sampling

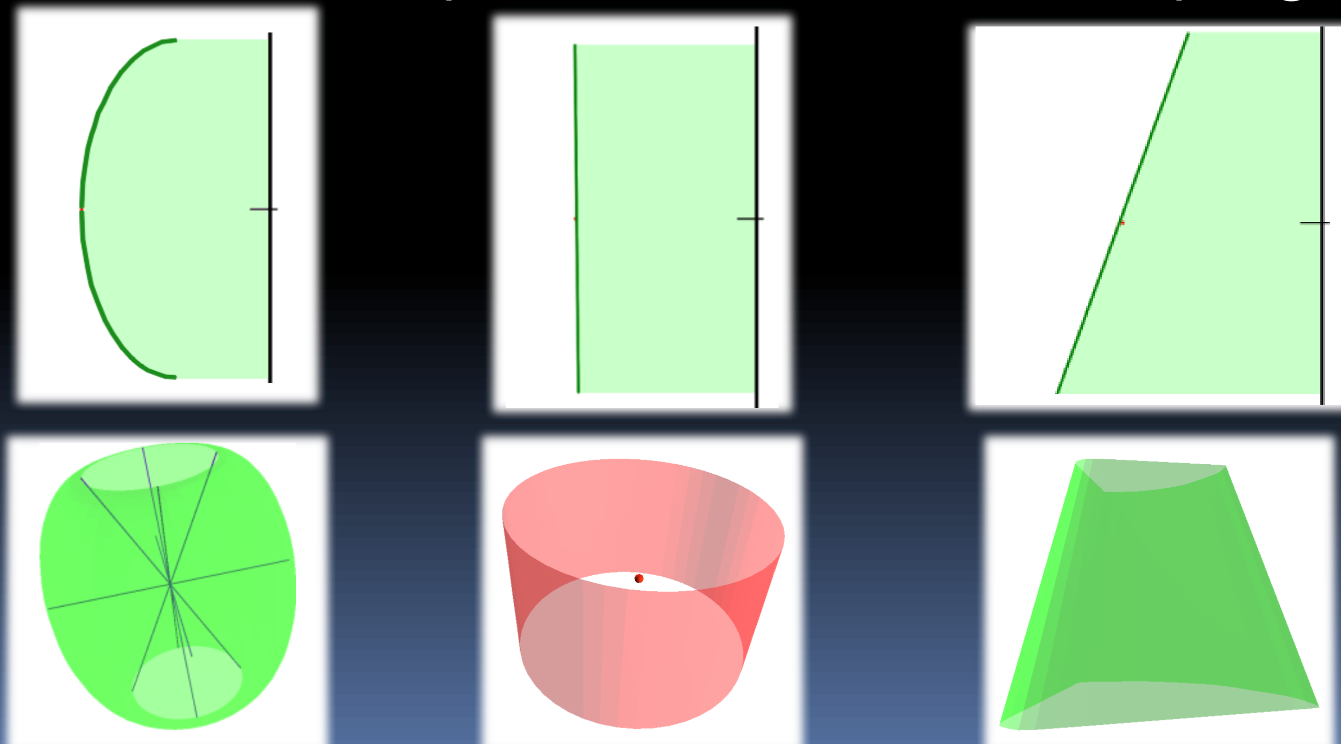


Shape Defined Panoramas

- Defined by two curves
  1. **Outline:** closed, controls horizontal sampling

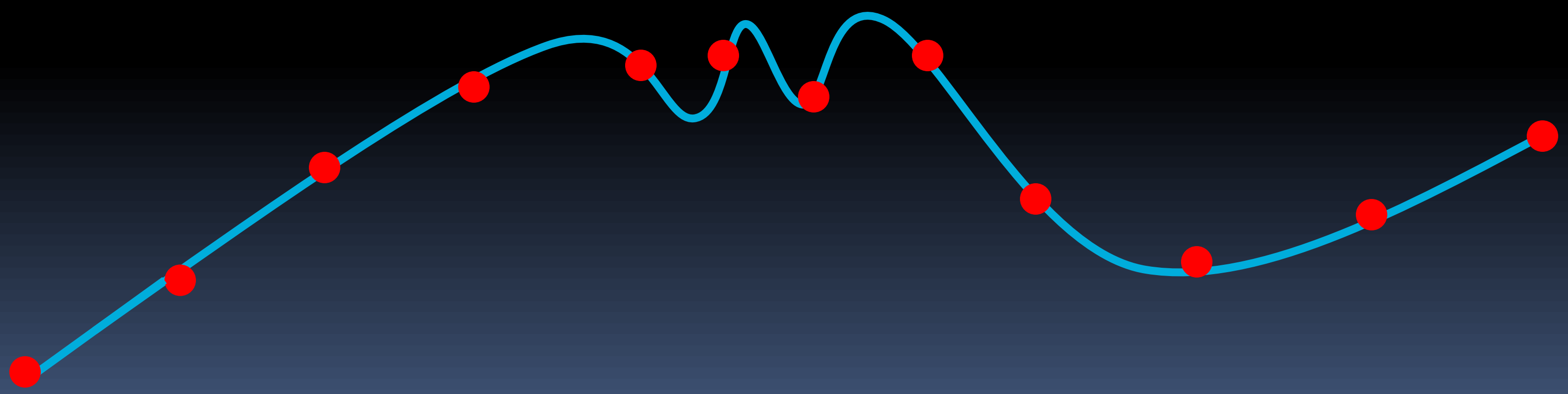
Shape Defined Panoramas

- Defined by two curves
  1. **Outline:** closed, controls horizontal sampling
  2. **Profile:** open, controls vertical sampling



Shape Defined Panoramas

- Defined by two curves
  1. Outline: closed, controls horizontal sampling
  2. Profile: Open, controls vertical sampling
- Curves parameterized by arc-length



Shape Defined Panoramas

- Mix between surface of revolution and surface extrusion

Outline

Profile

Extrusion Surface

Shape Defined Panoramas

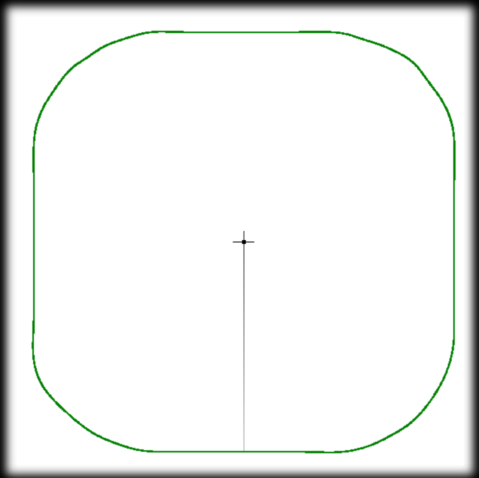
- Mix between surface of revolution and surface extrusion

Outline

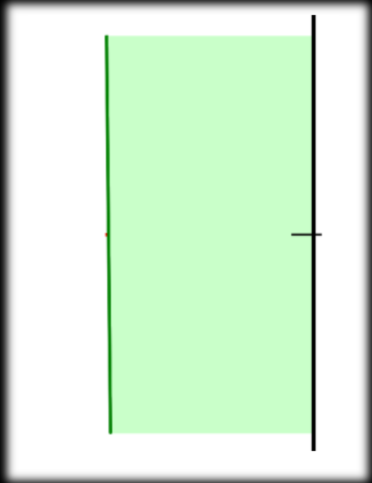
Profile

Panorama Surface

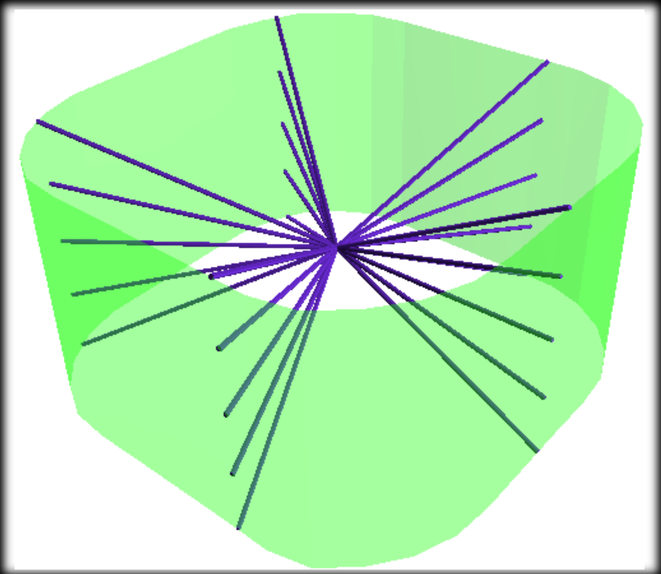
Example 1



Outline

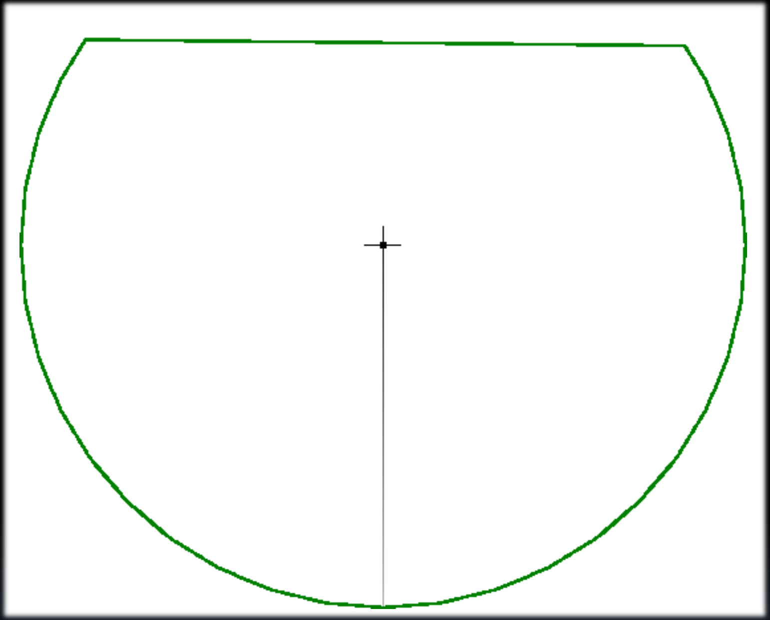


Profile

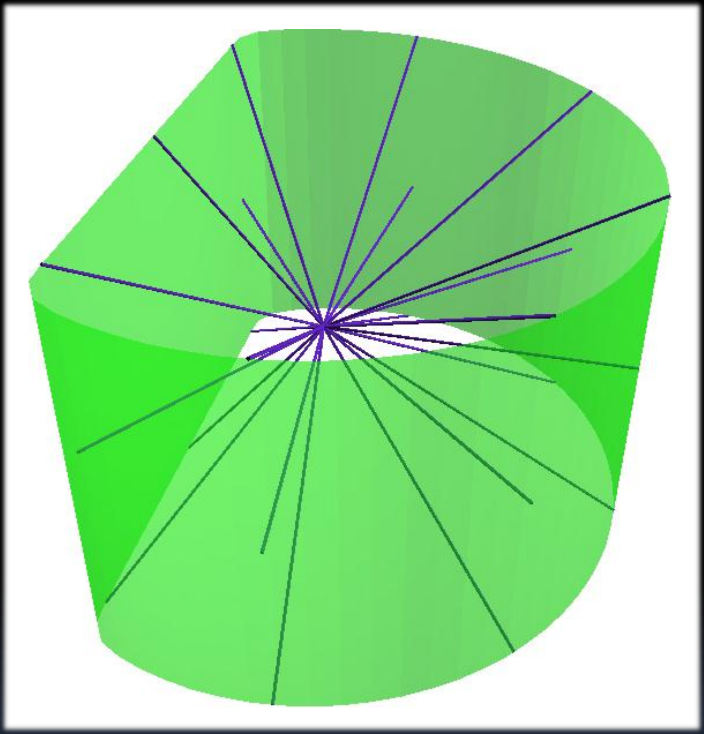


Example 2

Example 2



Outline

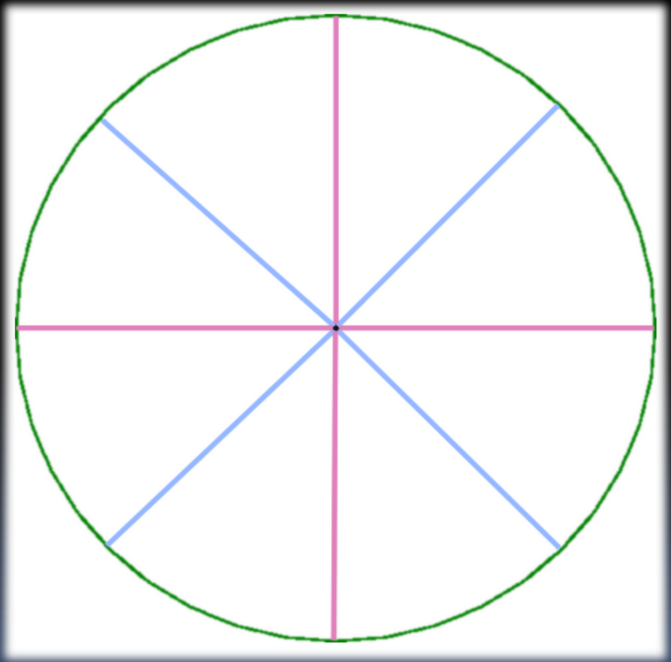


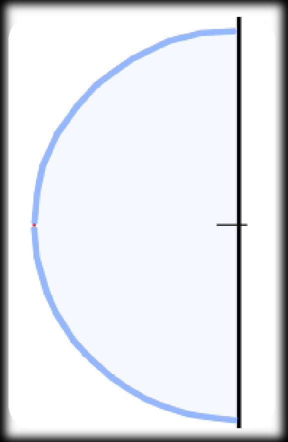
Before

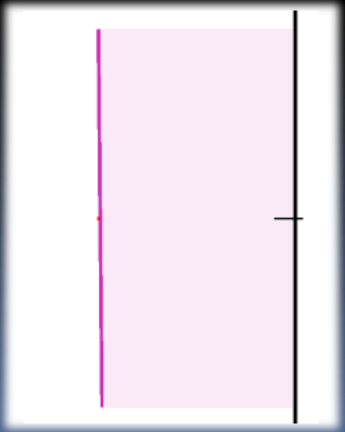
After

Shape Defined Panoramas

- Multiple Profiles

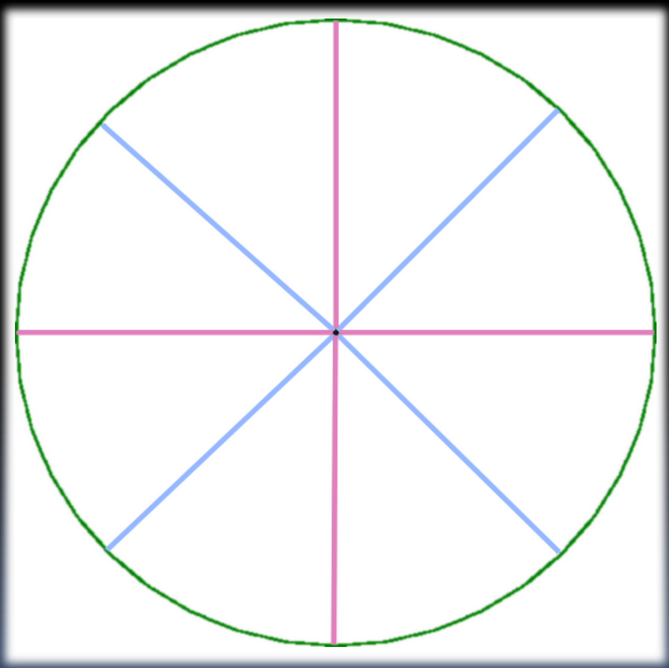


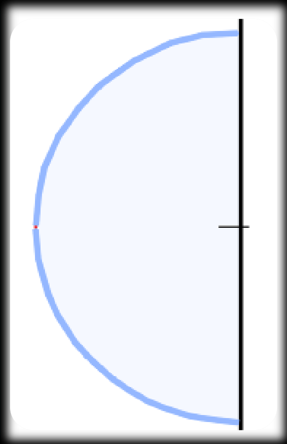


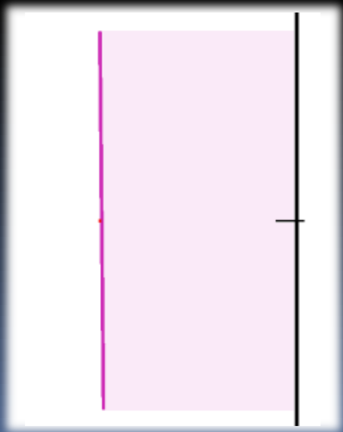


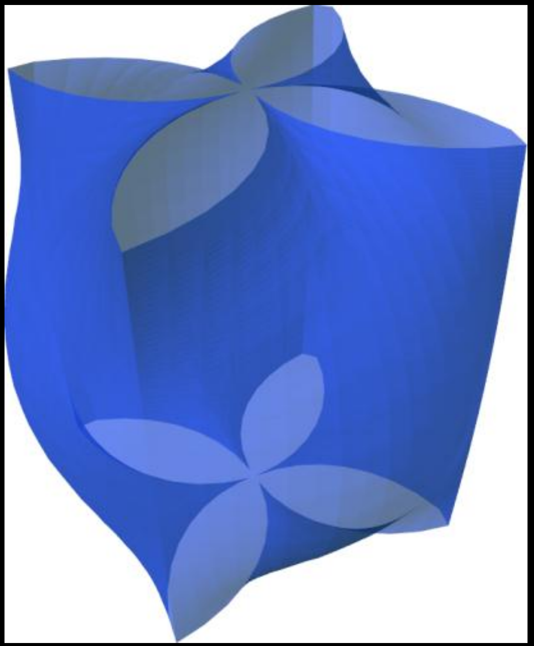
Shape Defined Panoramas

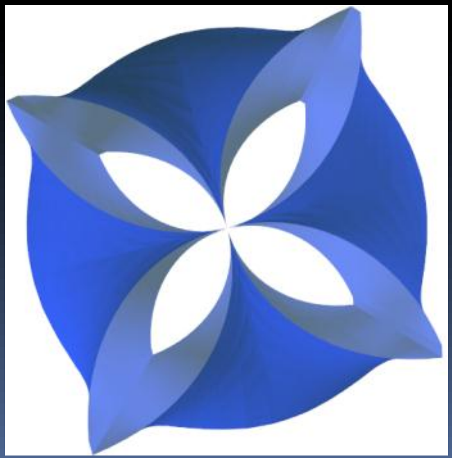
- Multiple Profiles

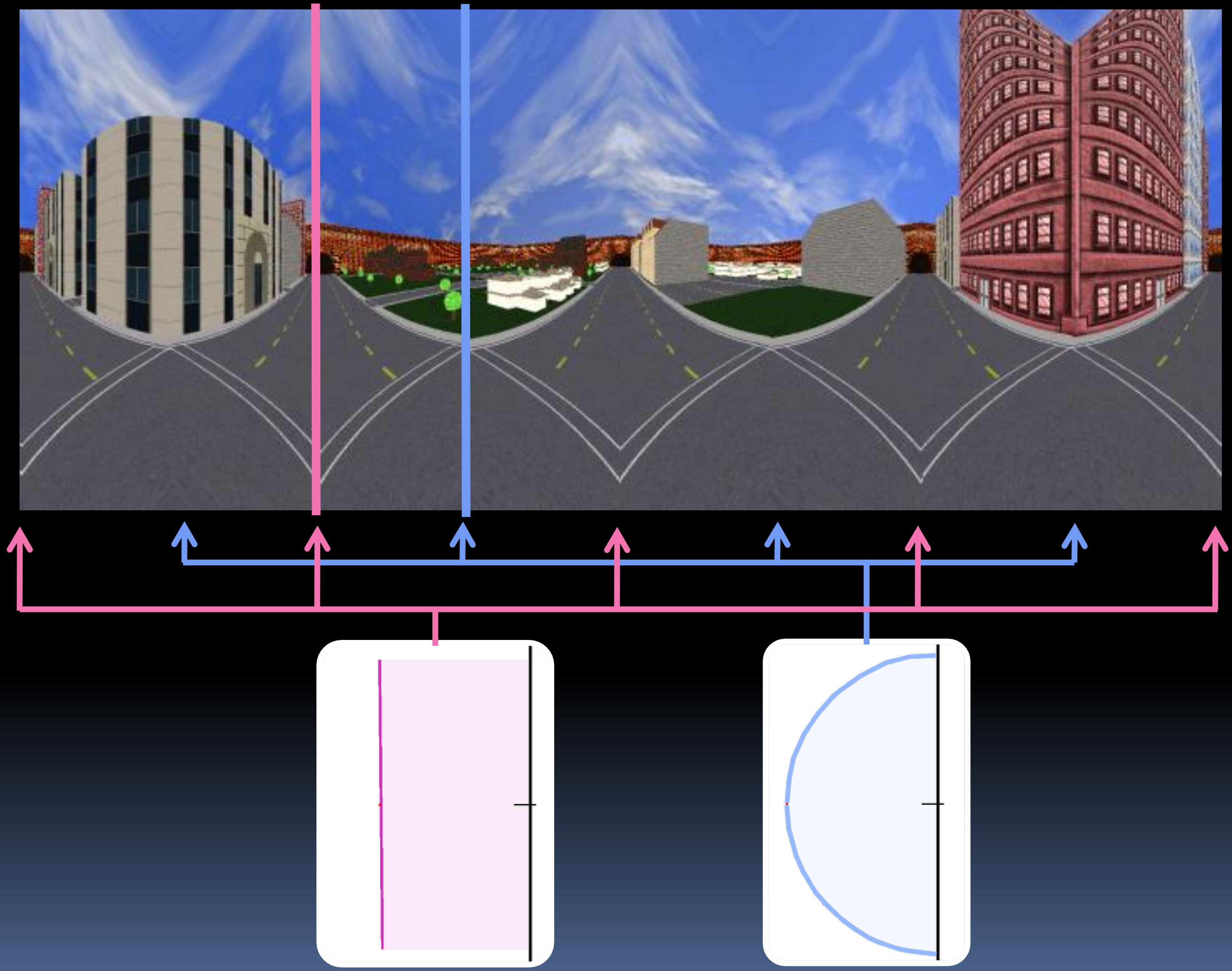










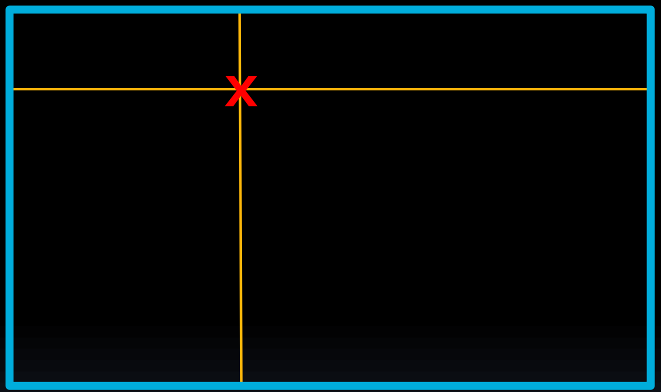


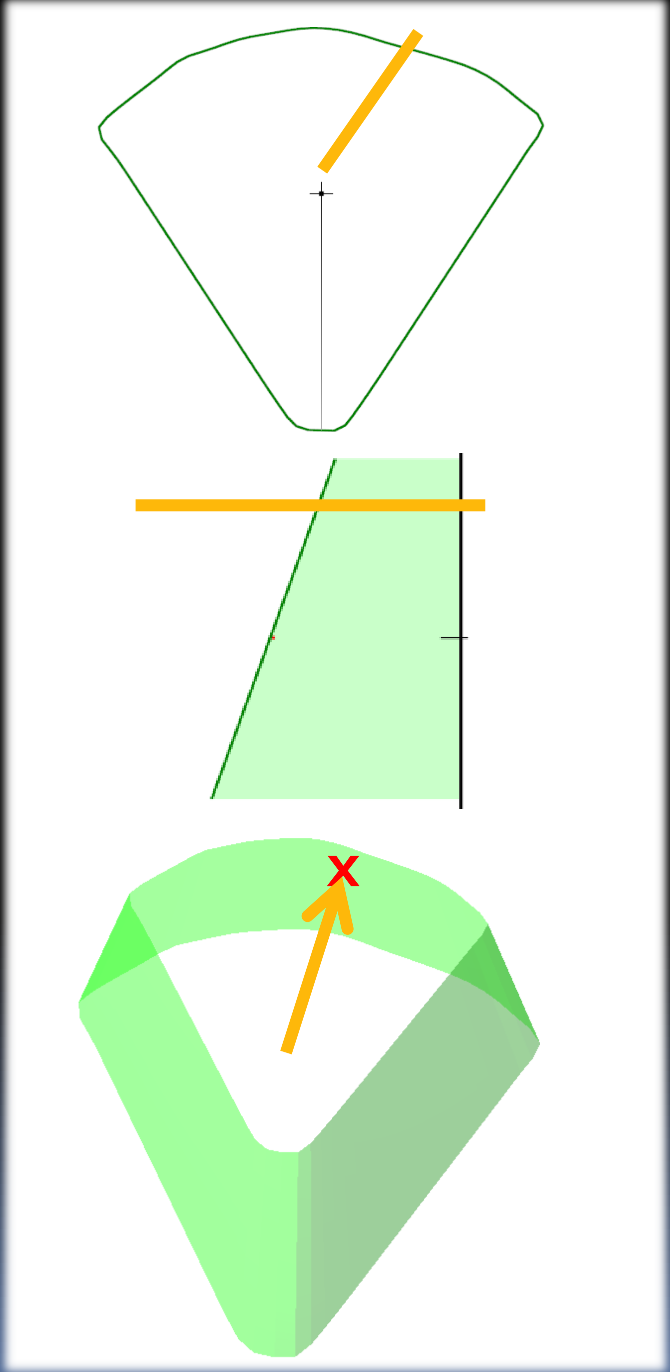
Rendering

- Ray-tracing
- Image Re-sampling
- Nonlinear Projection on GPU

Rendering

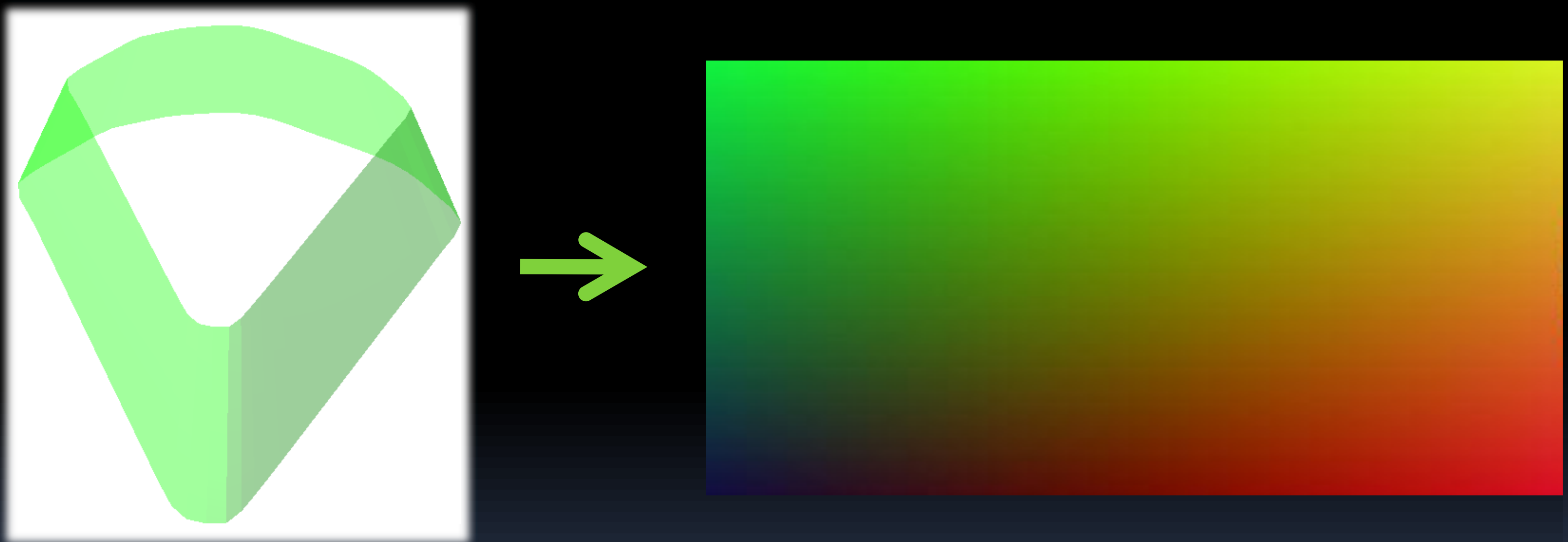
- Ray-tracing





Rendering

- Image Re-sampling



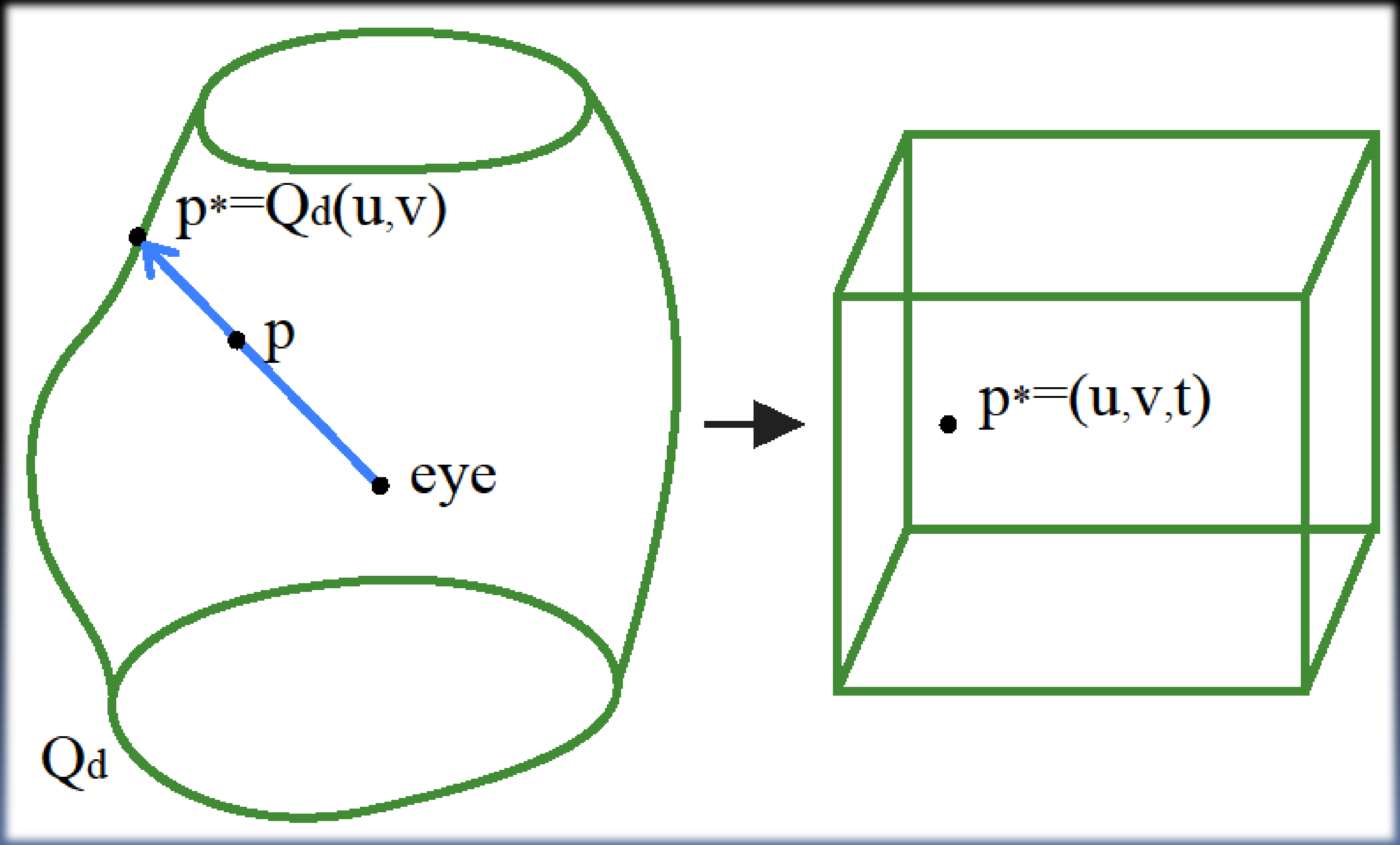
Rendering

- Nonlinear Projection on GPU

1. Find projection equation
2. Project vertices with equation on GPU
3. Be careful with seams

Find Projection Equation

World Coordinates → Normalized Device Coordinates



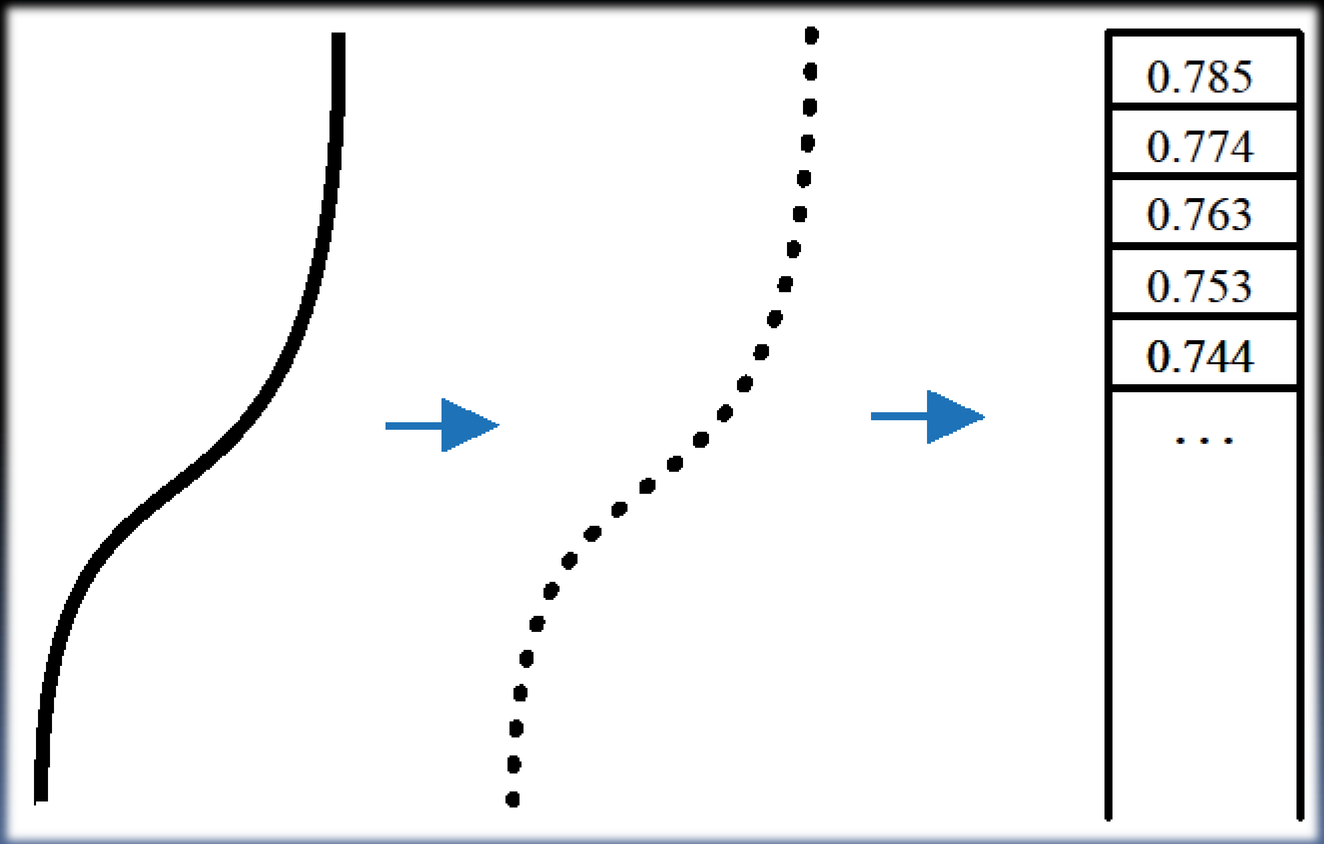
Find Projection Equation

- Only surfaces that map onto spherical coordinates.
- Projection Surface: $Q(u,v) = (x,y,z)$
- Projection Volume: $t\,(0,0,0) + (1-t)\,Q(u,v)$

1. Find spherical coordinates of $p = (x,y,z)$
2. Search for u,v s.t. $Q(u,v)$ with same spherical coords.
3. $$t = \frac{\| p \|}{\| Q(u,v) \|}$$

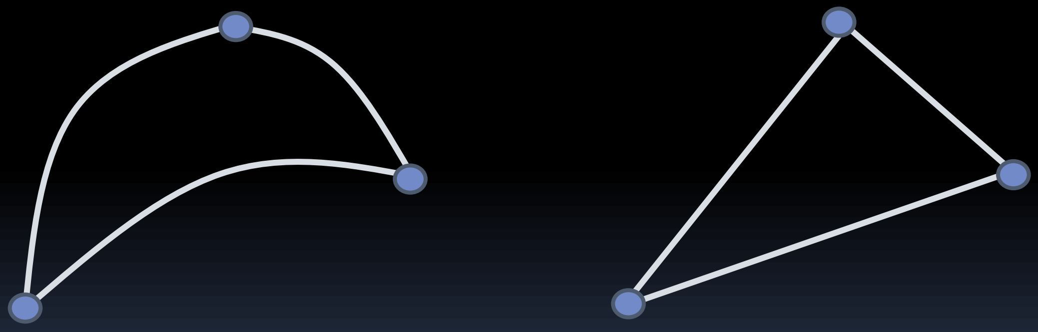
Find Projection Equation

- Search for *u,v* s.t. *Q(u,v)* with same spherical coords.



Project Vertices with GPU

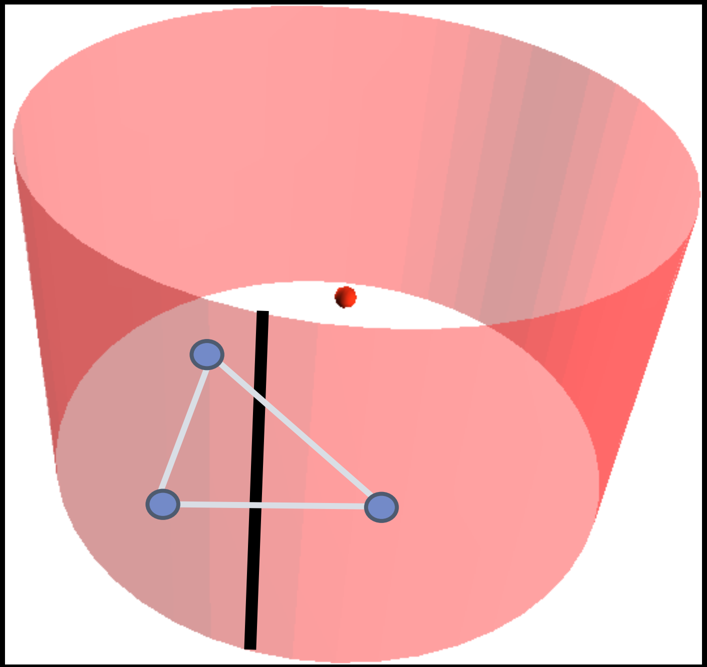
- Override projection matrix with nonlinear projection equation.
- This only moves vertices! Triangles are filled as if linearly projected.

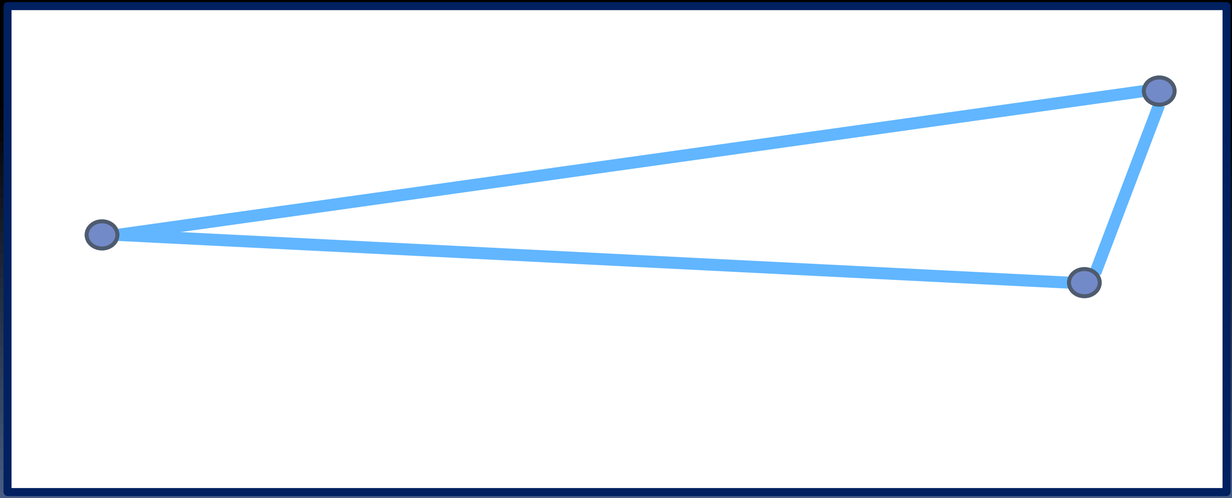


Nonlinearly Projected Triangle

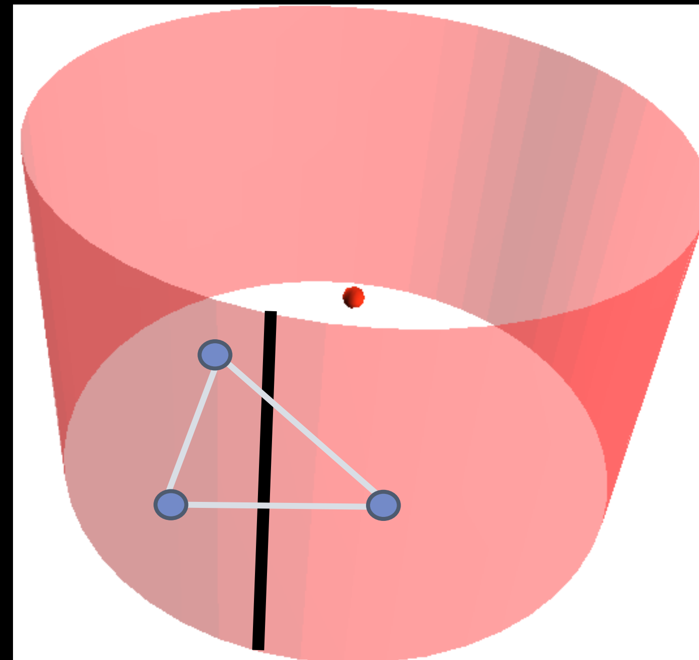
Triangle w/ Linear Fill Algorithm

Seams





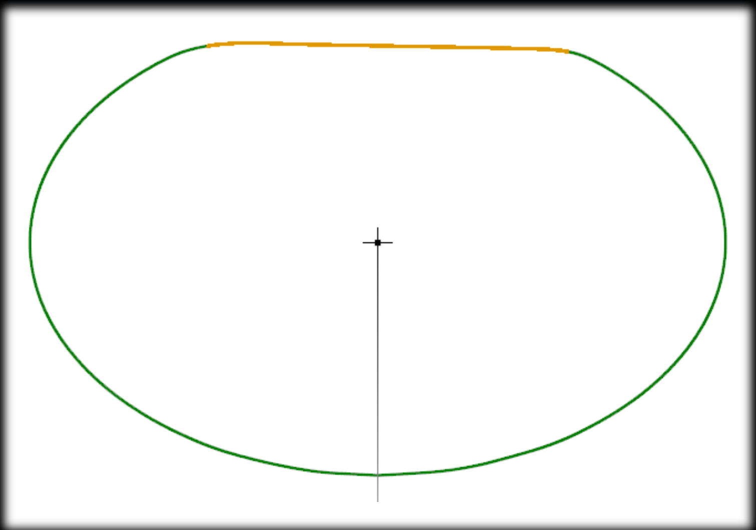
Seams

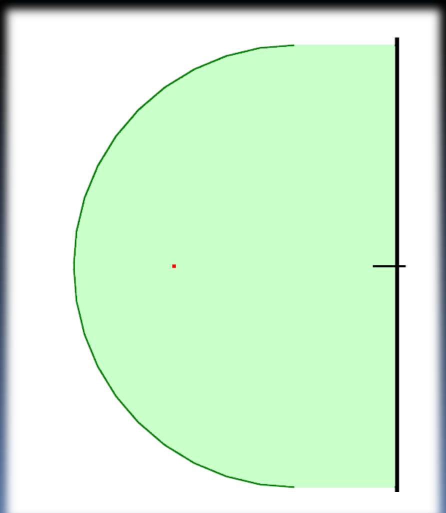


Rendering Performance

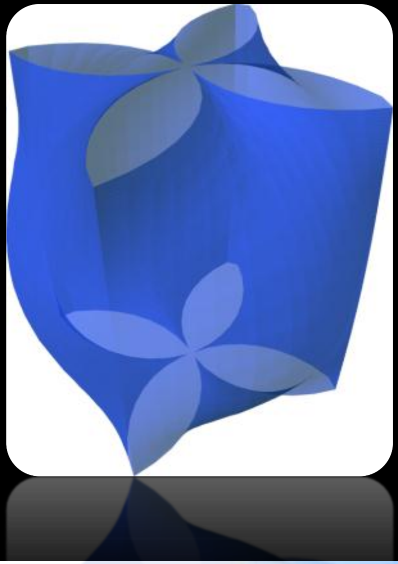
- Single pass algorithm
- 60 fps with 100K polygons on NVIDIA 8800 GTS

Application:
Custom Panorama

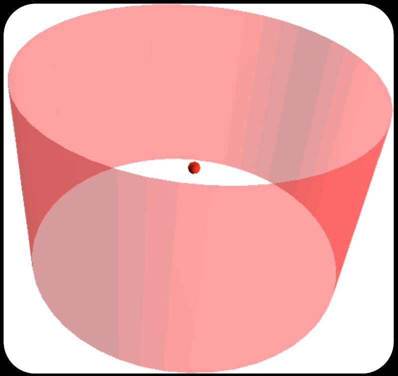


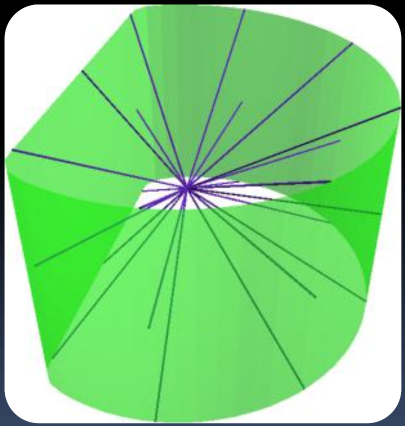


Application:
Re-projecting Panoramas

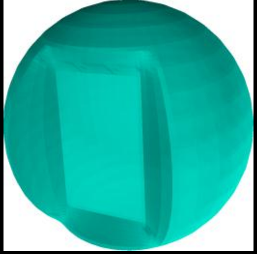


Application:
Animated Projection





Application:
Interactive Local Editing



Application:
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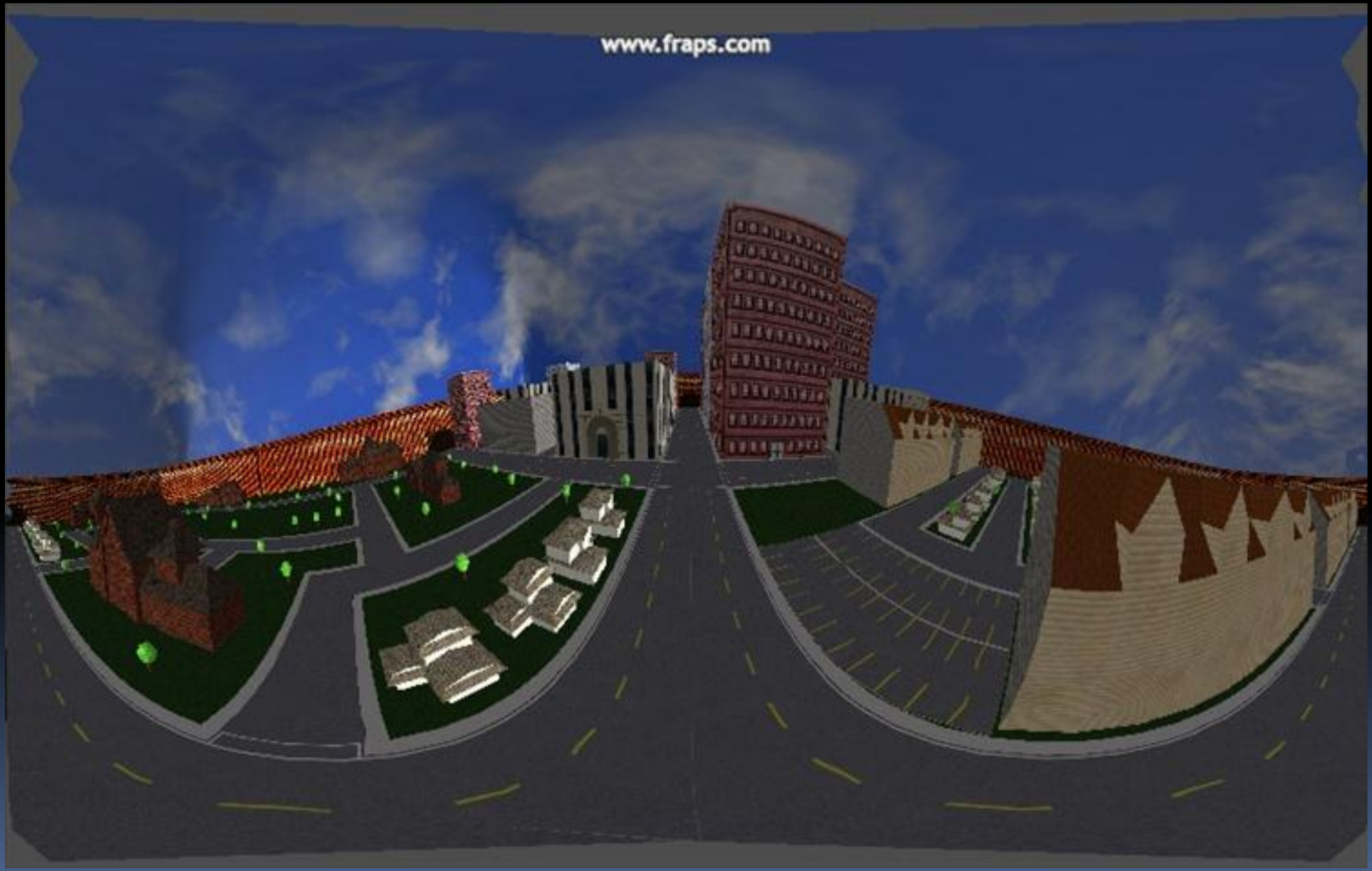

Conclusions

- Use of modeling to define a projection.
- Use of Arc-length to dictate parameterization.
- Visual means for creating panoramas.
- Realtime GPU based rendering of panoramas.

THANK-YOU