



Generalizing Camera Models

CS535

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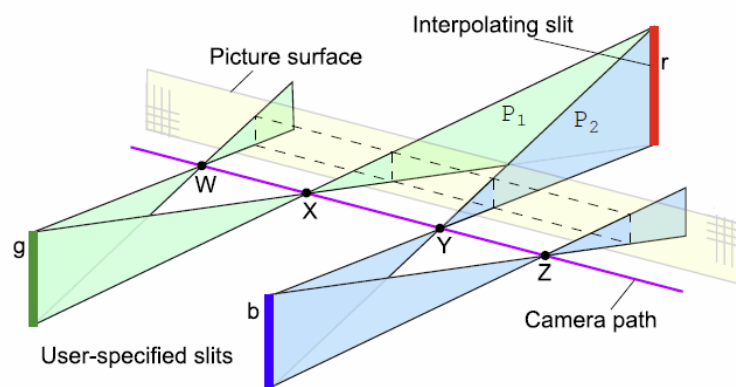


Multiperspective Imaging



Hand-crafted

semi-automated...



to produce this...



[Roman-Vis04]



Multiperspective Imaging



(a)



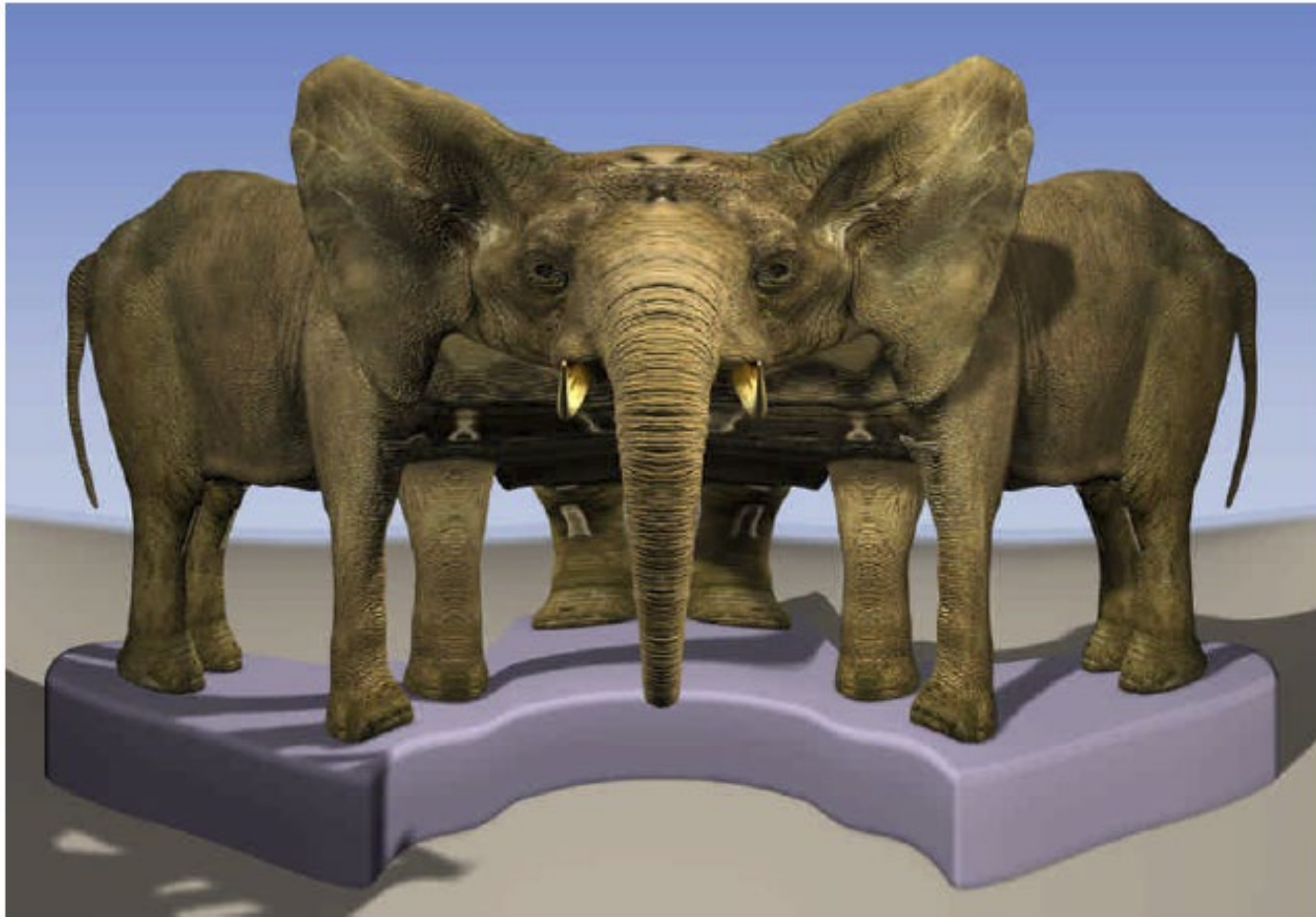
(b)



(c)

[Seitz-CGA03]

Multiple COP Images



[Rademacher-SIG98]

Multiple COP Images

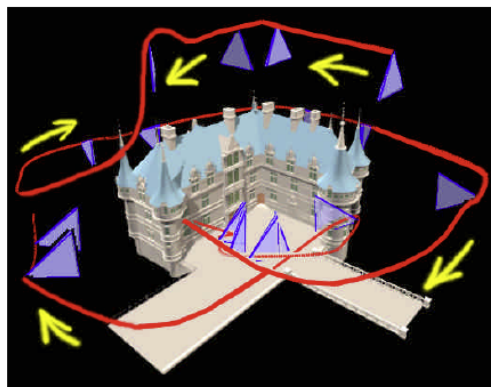


Figure 5 Castle model. The red curve is the path the camera was swept on, and the arrows indicate the direction of motion. The blue triangles are the thin frusta of each camera. Every 64th camera is shown.

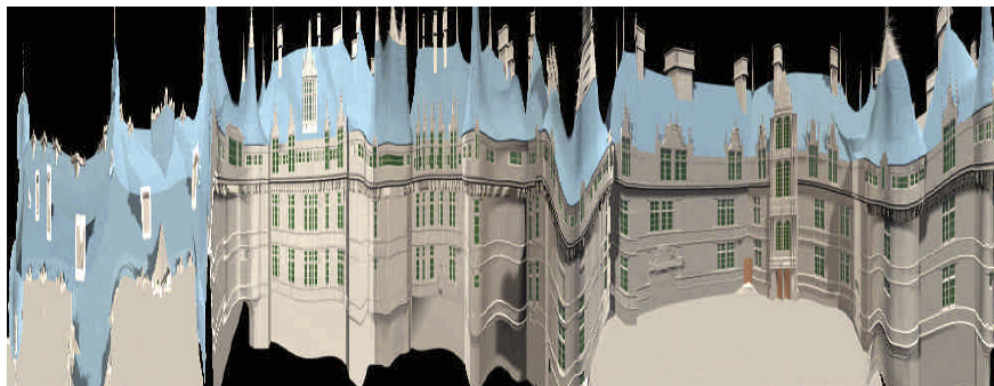


Figure 6 The resulting 1000×500 MCOP image. The first fourth of the image, on the left side, is from the camera sweeping over the roof. Note how the courtyard was sampled more finely, for added resolution.

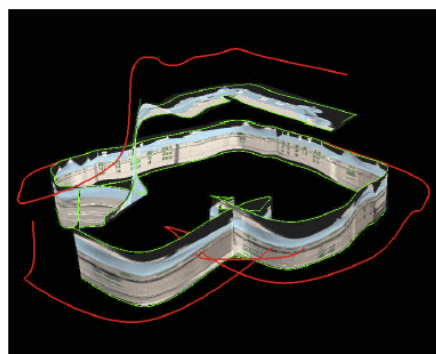


Figure 7 The projection surface (image plane) of the camera curve.



Figure 8 Three views of the castle, reconstructed solely from the single MCOP image above. This dataset captures the complete exterior of the castle.

[Rademacher-SIG98]

Multiperspective Imaging for Cel Animation

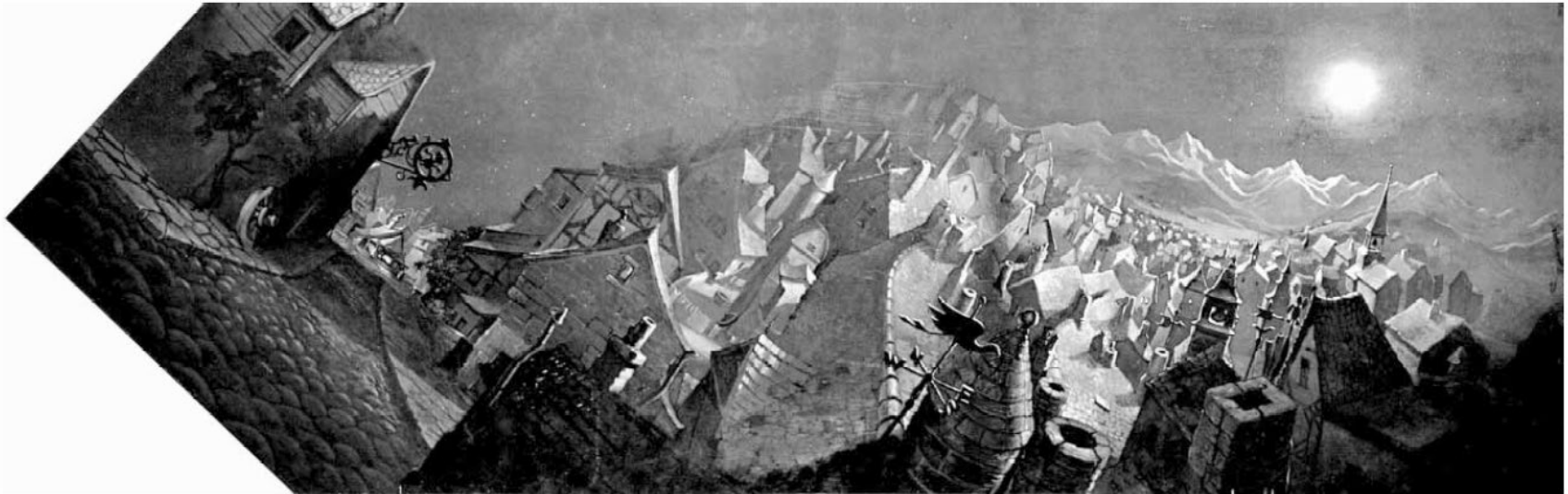
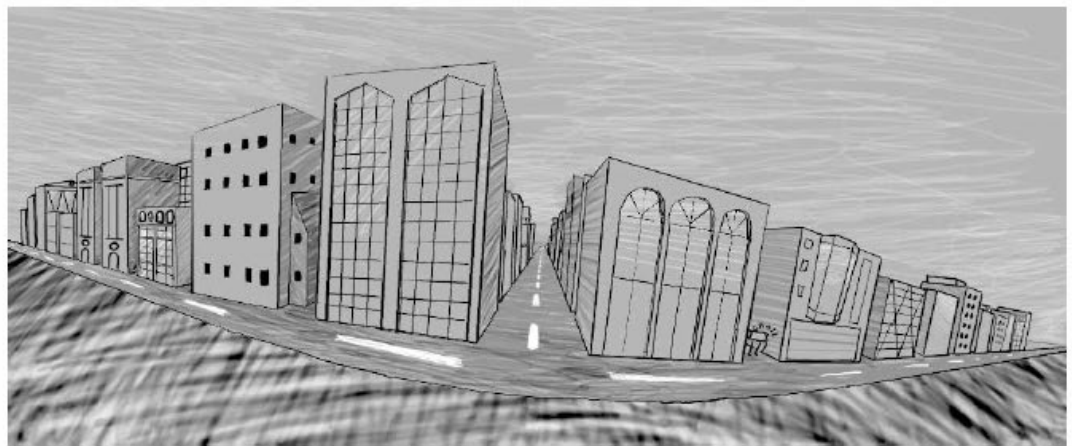
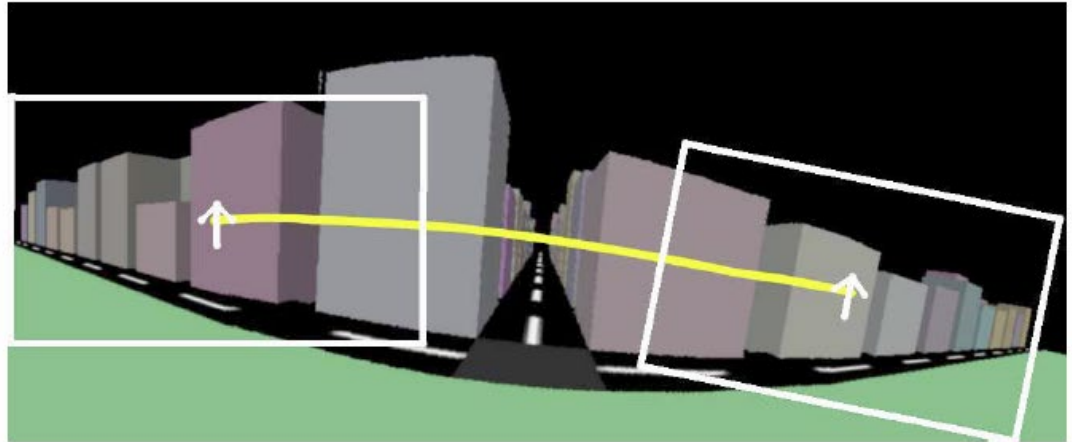
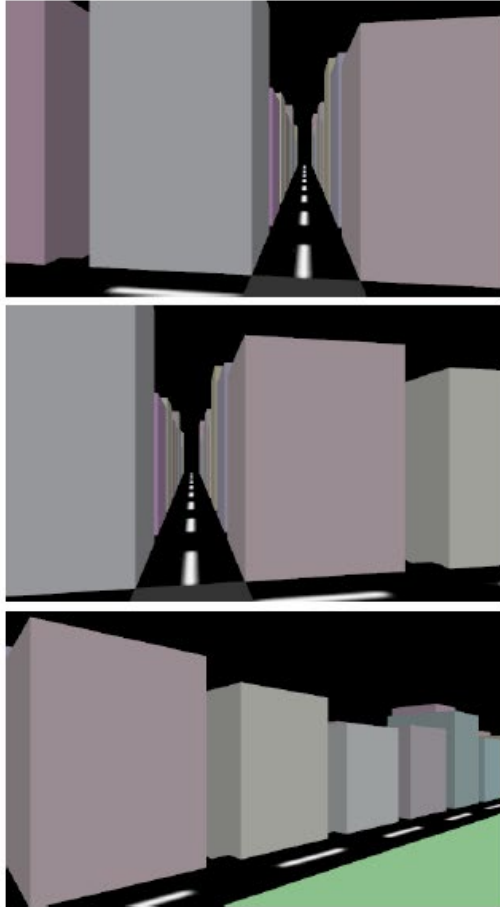


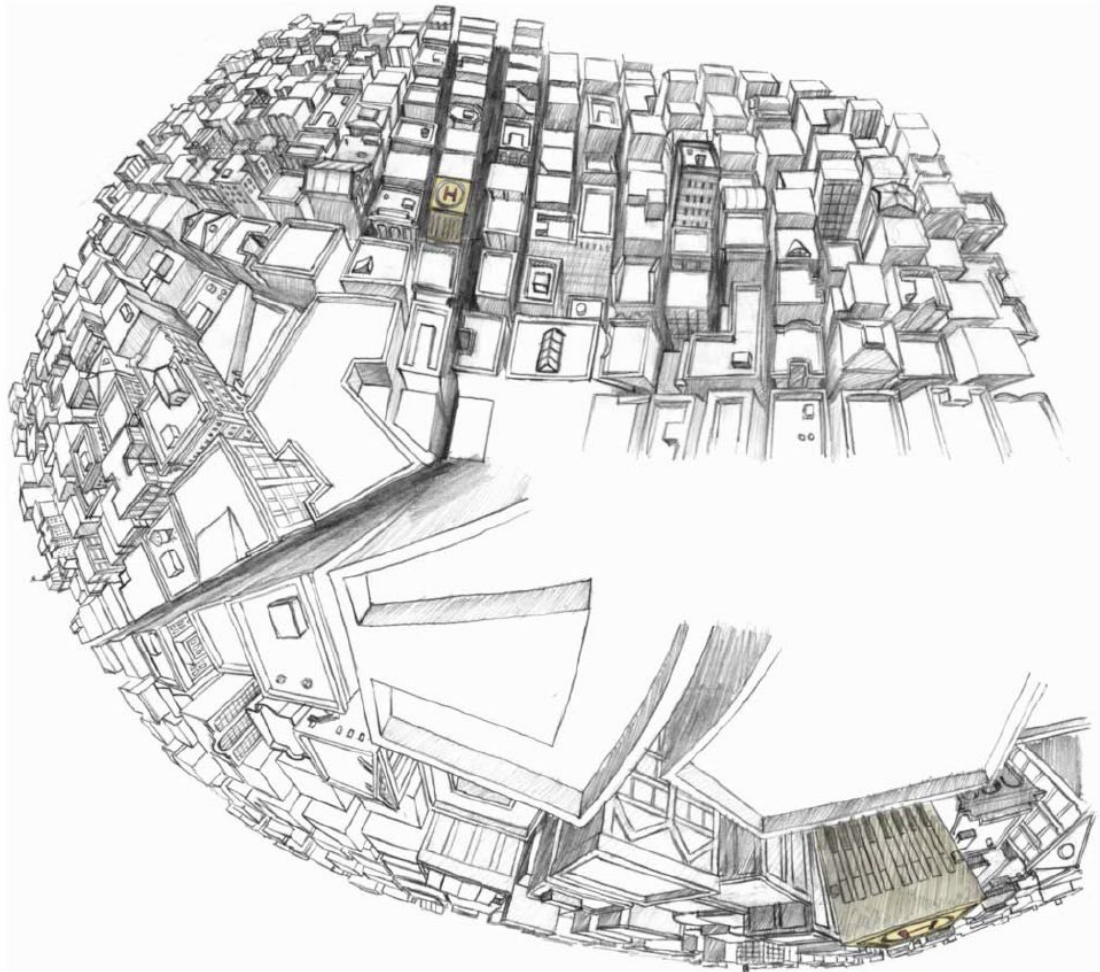
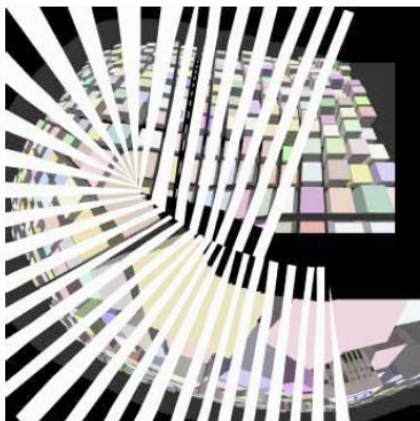
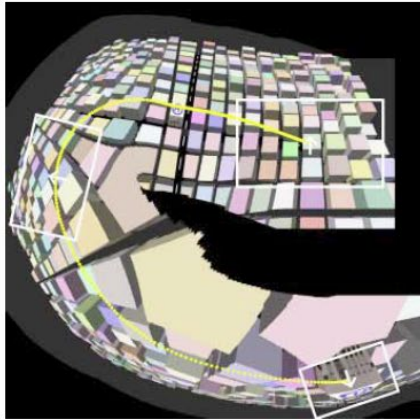
Figure 1 A multiperspective panorama from Disney's 1940 film *Pinocchio*. (Used with permission.)

Multiperspective Imaging for Cel Animation



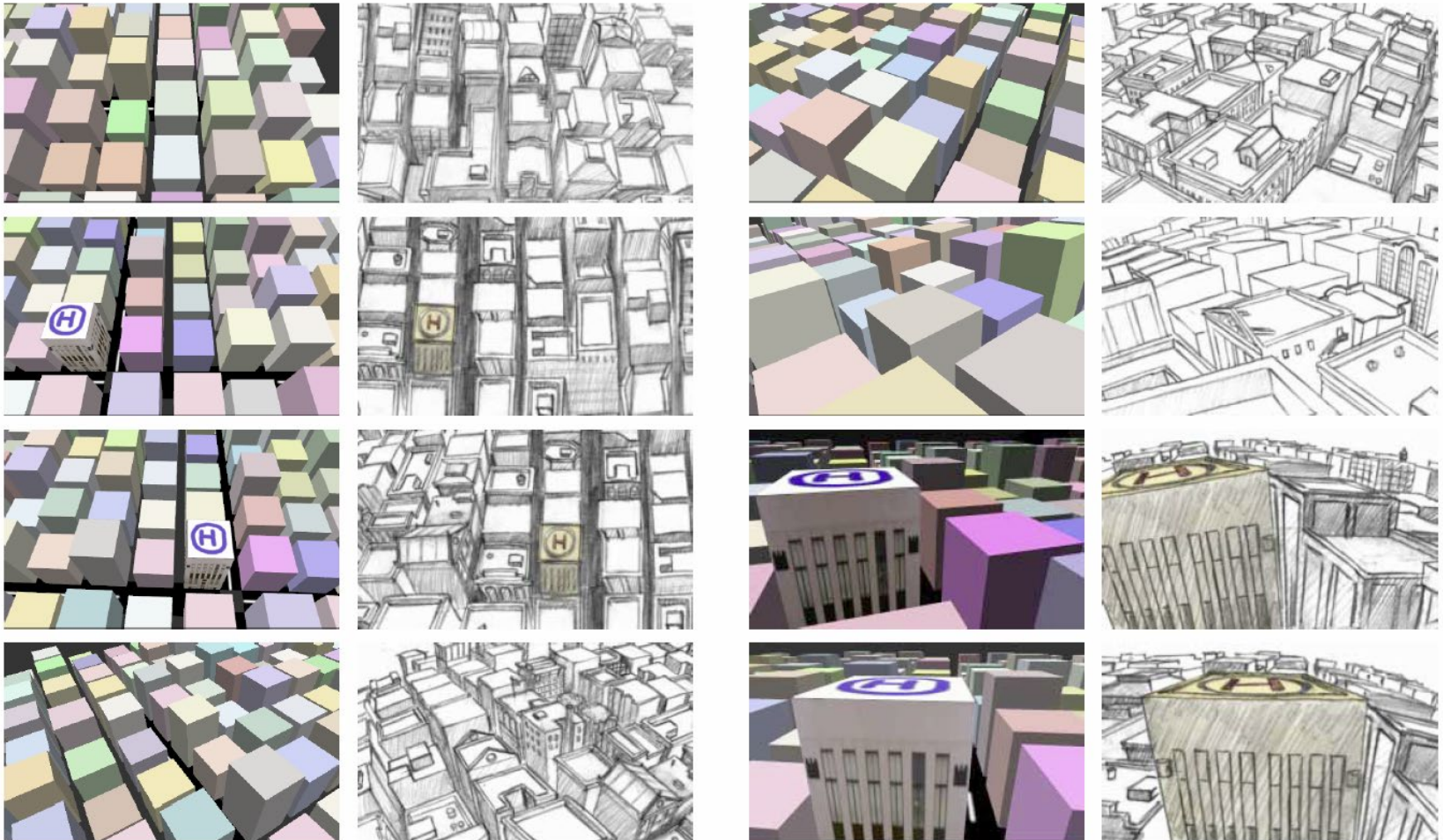
[Wood-SIG97]

Multiperspective Imaging for Cel Animation



[Wood-SIG97]

Multiperspective Imaging for Cel Animation

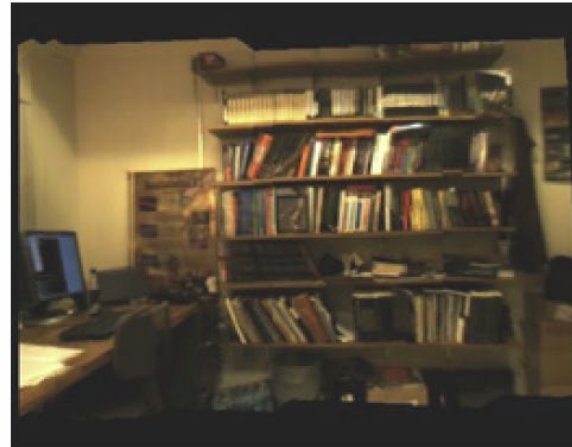


[Wood-SIG97]

Occlusion-Resistant Cameras



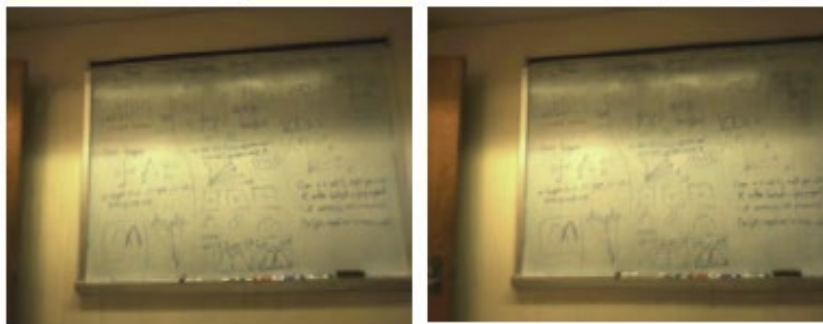
Input images



Output images

[Aliaga-CGA07]

Occlusion-Resistant Cameras



d)



[Aliaga-CGA07]



Occlusion-Resistant Cameras

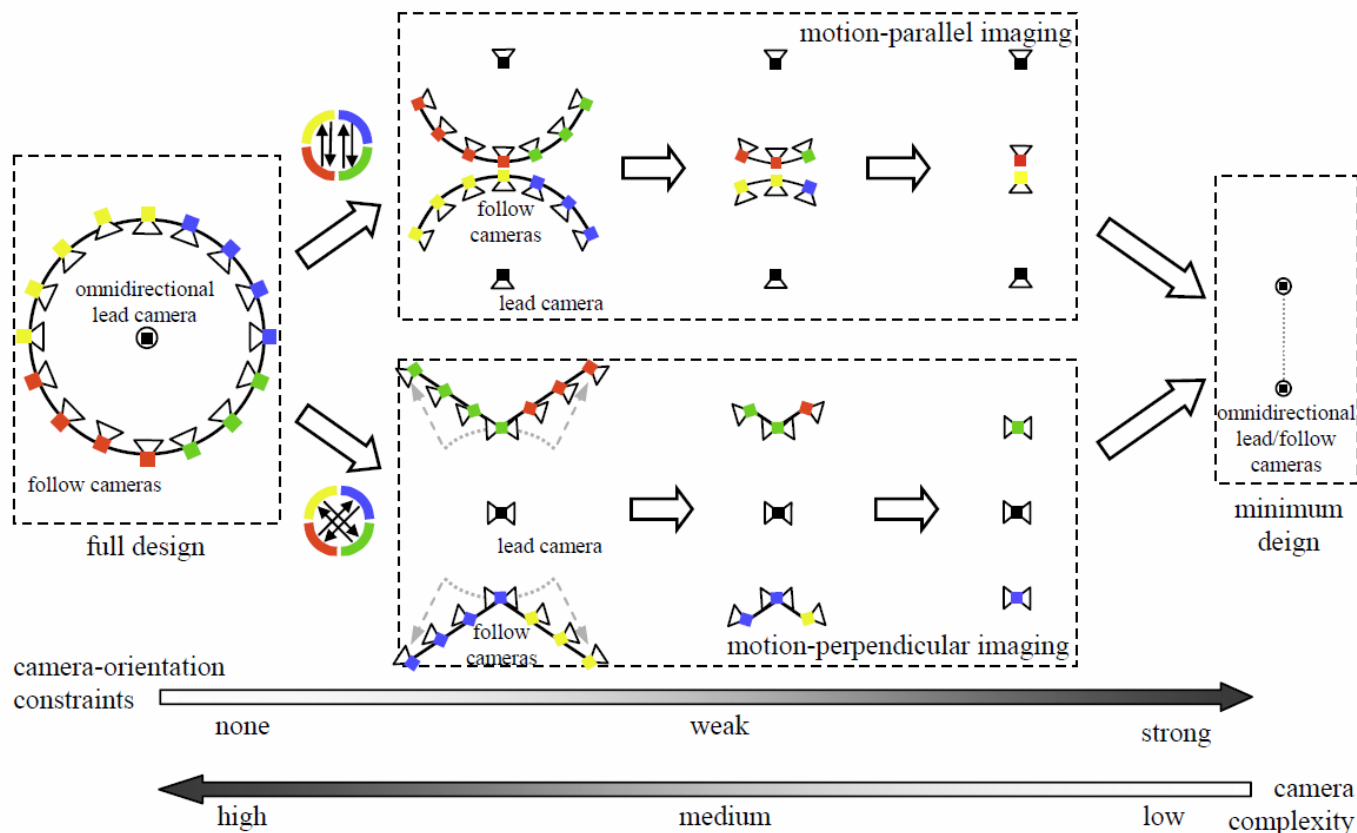
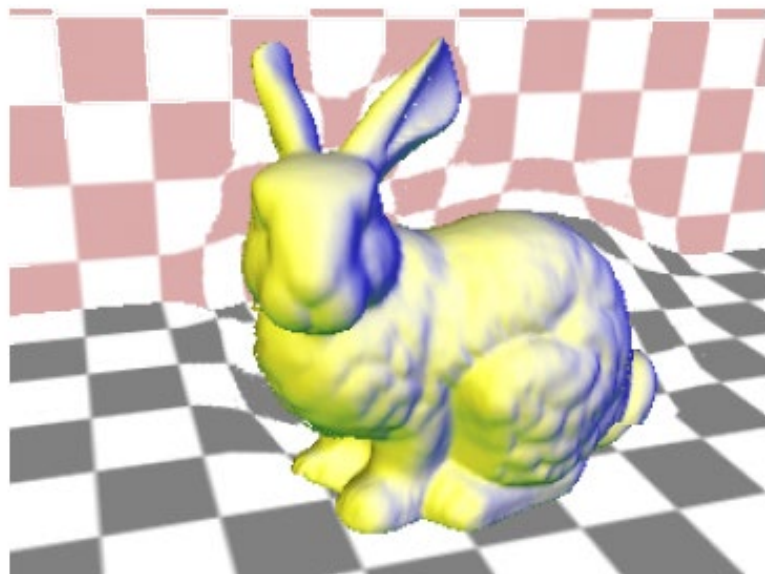


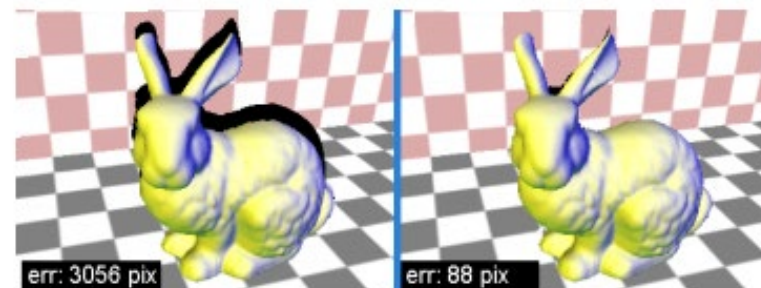
Figure 1. Family of ORC Designs. This diagram shows 2D versions of our family of cameras. Individual cameras are represented by small (colored) squares. The camera's field-of-view is drawn using a small triangle for limited field-of-view cameras and as a circle for omnidirectional cameras. Left: a full design of a sphere of follow cameras (color-coded) surrounding an omnidirectional lead camera (black) produces occlusion-resistant images for all imaging directions and camera orientations. Middle: progressively simpler cameras require stricter control of the camera's orientation, providing



Occlusion Cameras

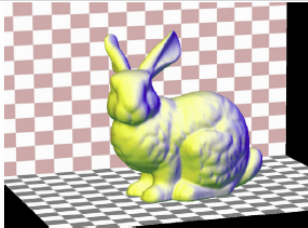
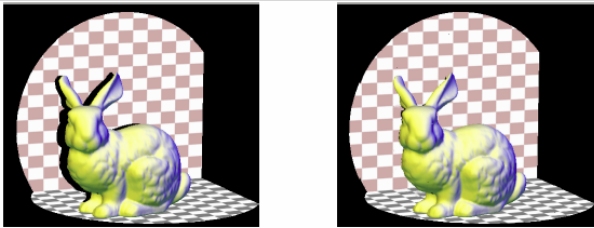
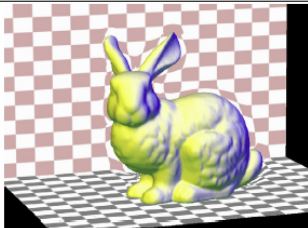
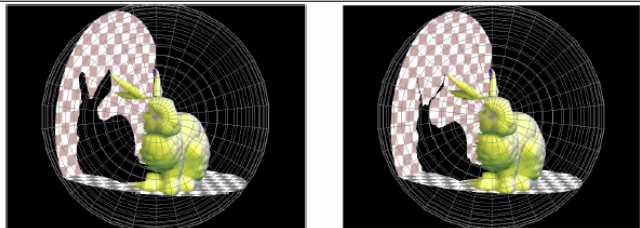
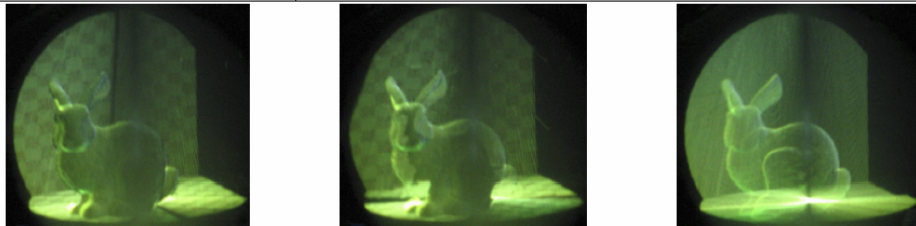
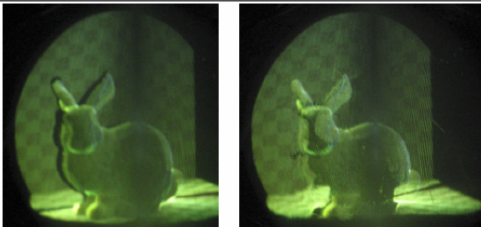
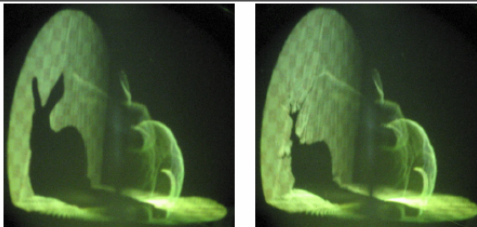


DDOC reference image.



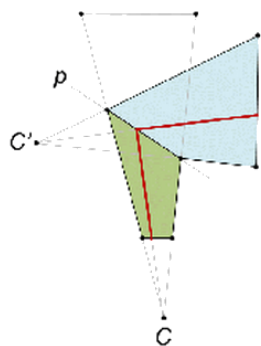
Frames rendered from depth image and DDOC image

Occlusion Cameras

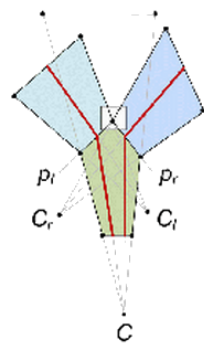
SIMULATOR IMAGES			
	Figure 1 Depth image (DI).	Figure 2 Images rendered from DI and OCRI, viewpoint 4" left of reference viewpoint.	
			
	Figure 3 OCRI.	Figure 4 Images rendered from DI and OCRI. Wireframe shows spherical display volume.	
PHOTOGRAPHS OF 3D DISPLAY			
	Figure 5 3D images rendered from DI (<i>left</i>), OCRI (<i>middle</i>), and original geometric model (<i>right</i>), all photographed from reference view.		
			
	Figure 6 DI and OCRI 3D images from viewpoint translated 4" left.		
PHOTOGRAPHS OF 3D DISPLAY			
	Figure 7 DI and OCRI 3D images from side view.		



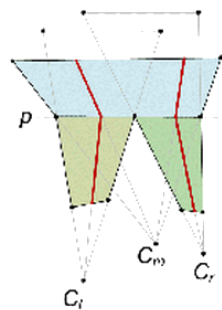
Graph Cameras



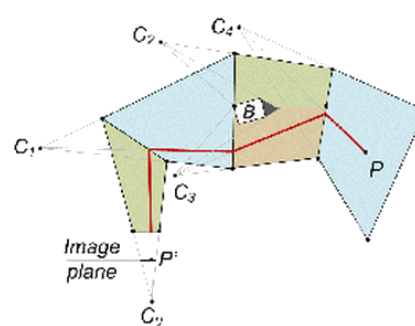
Bend Operation



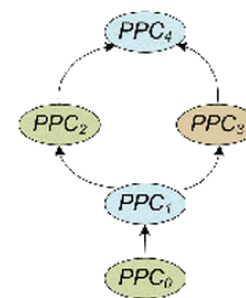
Split Operation



Merge Operation



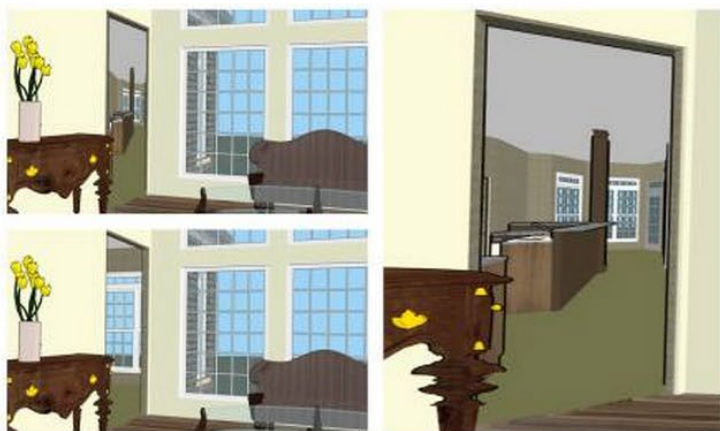
Graph Camera Frustum



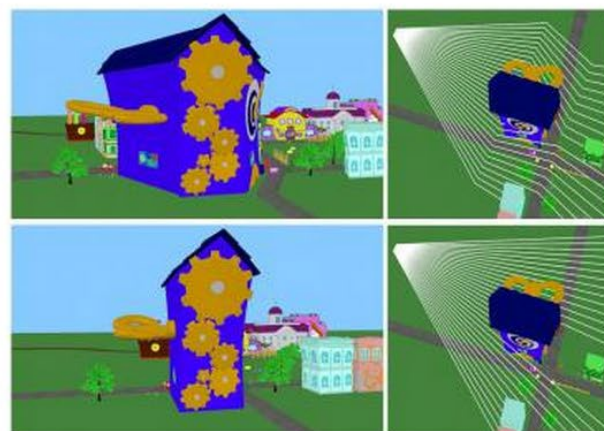
Graph of Frusta



Graph Cameras



Portal-based graph camera image (top left and fragment right) and PPC image for comparison (bottom left)



Occluder-based graph camera image (top left), PPC image for comparison (bottom left), and ray visualizations (right)



Enhanced street-level navigation

[Popescu-SIGA09]



Paraboloidal Catadioptric Camera

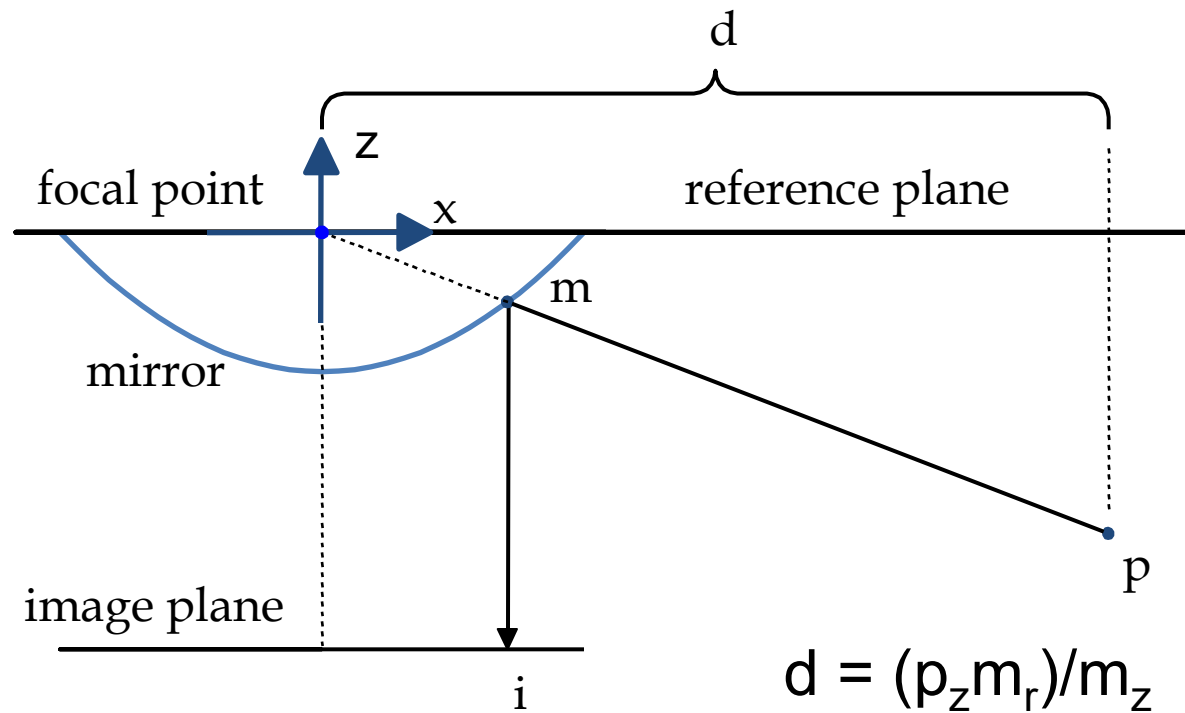


A paraboloidal
catadioptric camera

Motorized cart with
camera, computer, battery,
radio remote control



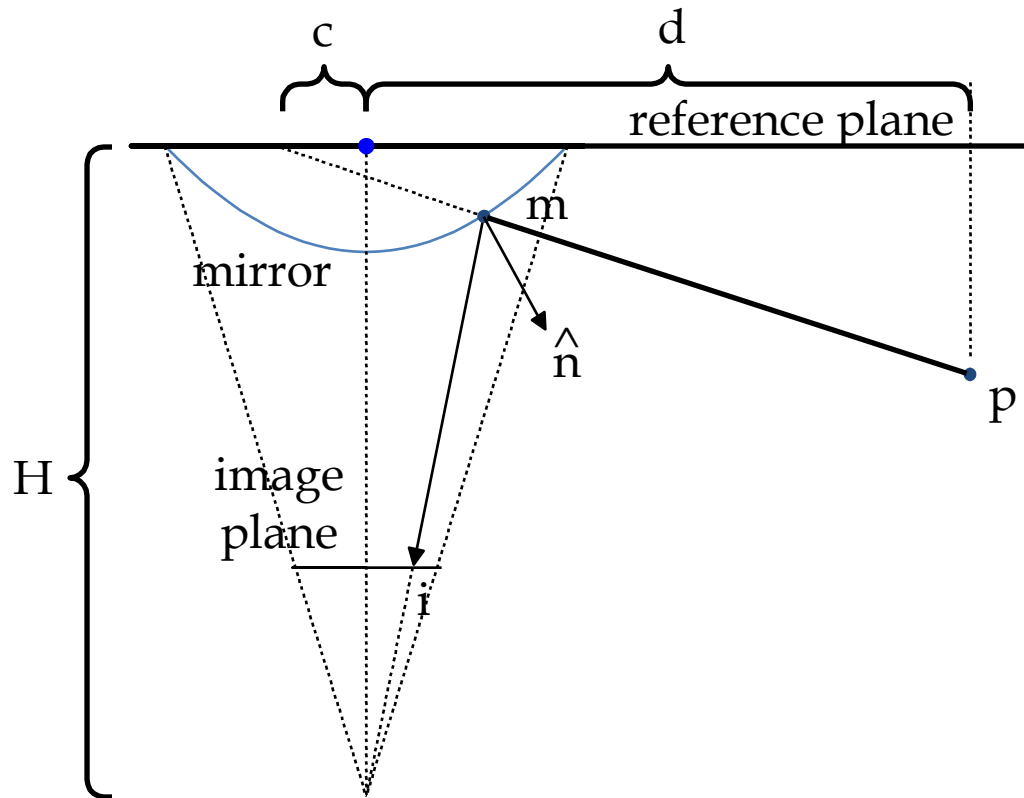
Ideal Camera Model



An ideal paraboloidal catadioptric setup for computing distance between the mirror's focal point and a 3D point



Our Camera Model



A paraboloidal catadioptric setup that accounts for perspective projection occurring in a practical system



Our Camera Model

- Assuming incident equals reflected angle:

$$\frac{i - m}{\|i - m\|} \cdot \frac{\hat{n}}{\|\hat{n}\|} = \frac{p - m}{\|p - m\|} \cdot \frac{\hat{n}}{\|\hat{n}\|}$$

- And given a 3D point p , mirror radius r , convergence distance H , we group and rewrite in terms of m_r :

$$m_r^5 - p_r m_r^4 + 2r^2 m_r^3 + (2p_r r H - 2r^2 p_r) m_r^2 + (r^4 - 4r^2 p_z H) m_r - (r^4 p_r + 2r^3 H p_r) = 0$$

- To obtain a new expression for distance d :

$$d = (p_z m_p) / m_z - m_z / \tan(\alpha) + m_r$$



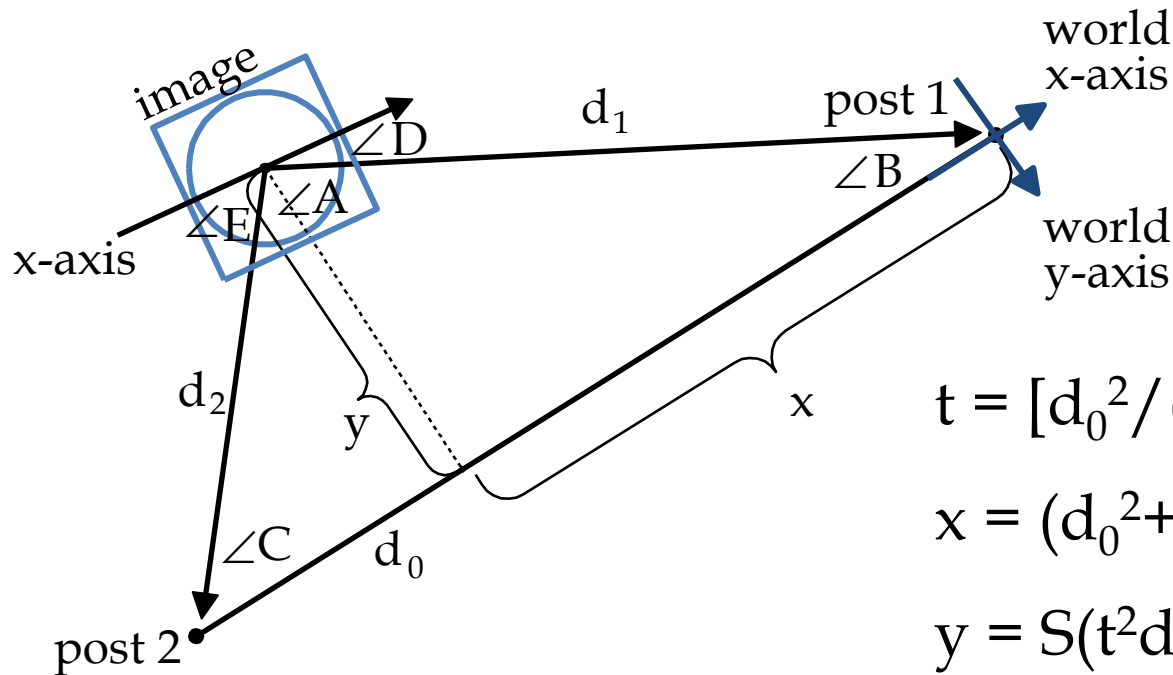
Pose Estimation Setup



Our pose estimation algorithm uses beacons placed in the environment to triangulate position and orientation of the camera moving in a plane.



Position and Orientation



$$t = [d_0^2 / (d_1^2 + d_2^2 - 2d_1d_2\cos A)]^{1/2}$$

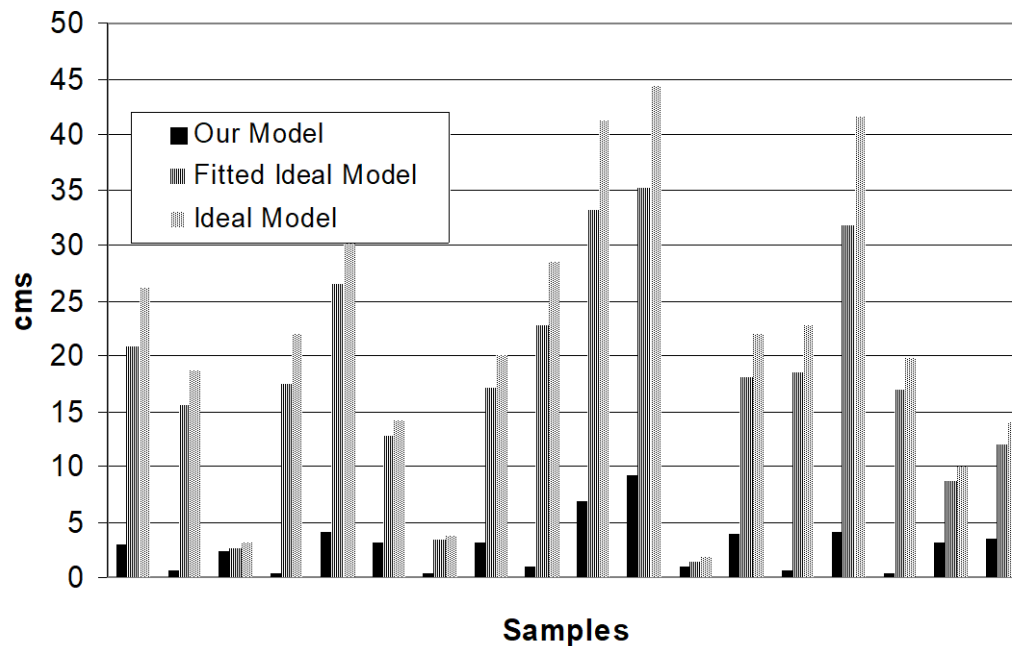
$$x = (d_0^2 + t^2d_1^2 - t^2d_2^2) / (2d_0)$$

$$y = S(t^2d_1^2 - x^2)^{1/2}$$

Our algorithm tracks the positions of small light bulbs and obtains camera position and orientation by solving an over-determined system.



Pose Estimation Error



We achieve approximately an order of magnitude improvement over assuming an ideal catadioptric camera setup (as a percentage of the room diameter, mean error is 0.56% and $\sigma=0.48\%$).



General Linear Camera

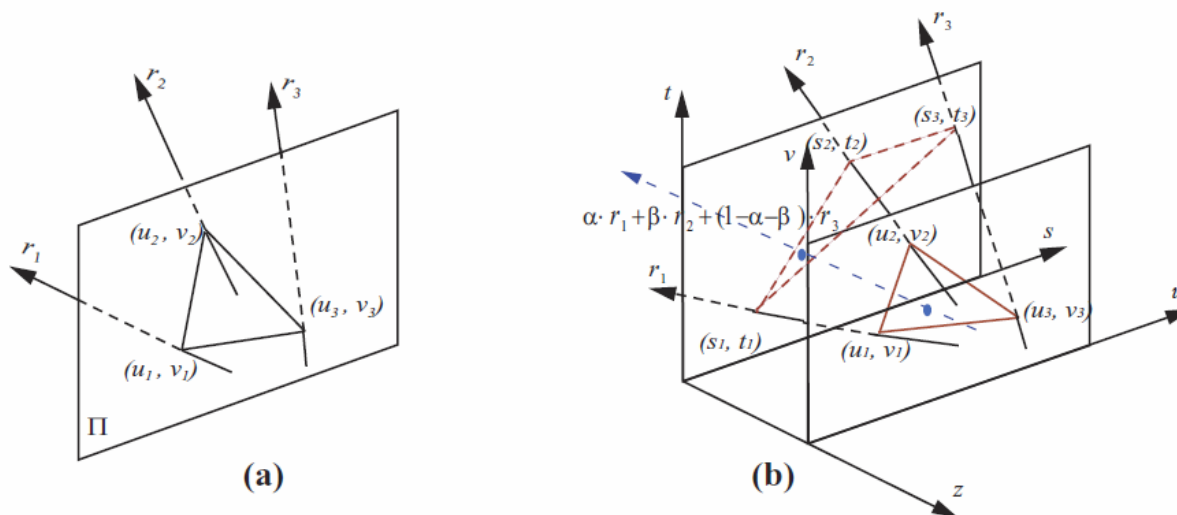


Fig. 1. General Linear Camera Model. a) A GLC is characterized by three rays originated from the image plane. b) It collects all possible affine combination of three rays.



General Linear Camera

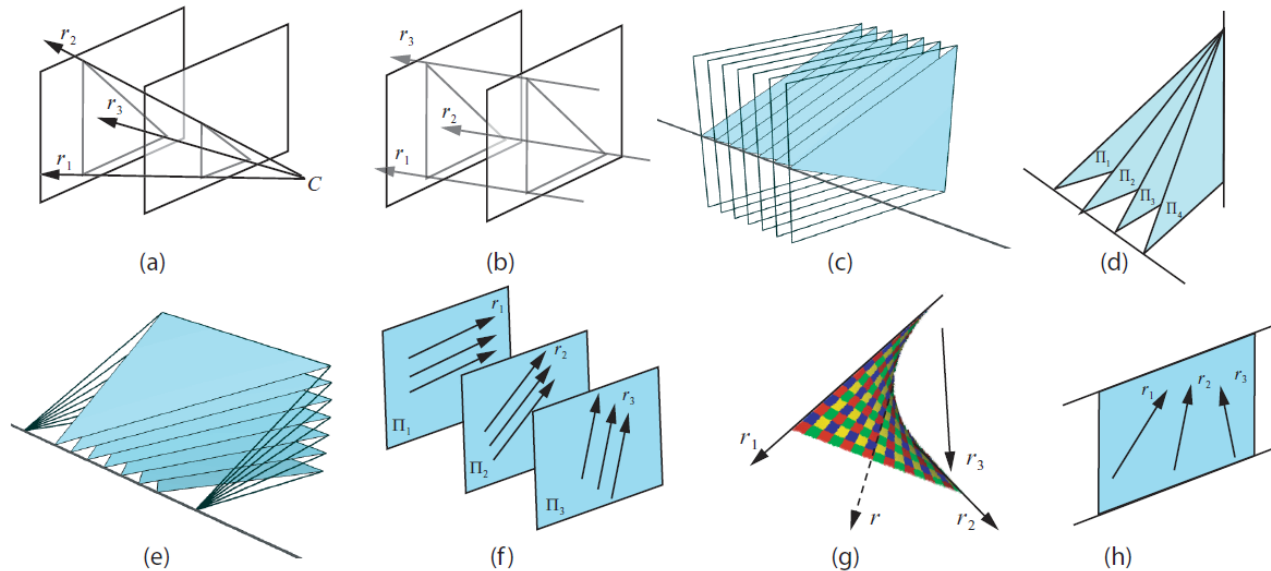


FIG. 1. *General Linear Camera Models.* (a) In a pinhole camera, all rays pass through a single point. (b) In an orthographic camera, all rays are parallel. (c) In a pushbroom, all rays lie on a set of parallel planes and pass through a line. (d) In a cross slit camera, all rays pass through two non-coplanar lines. (e) In a pencil camera, all coplanar rays originate from a point on a line and lie on a specific plane through the line. (f) In a twisted orthographic camera, all rays lie on parallel twisted planes and no rays intersect. (g) In a bilinear camera, no two rays are coplanar and no two rays intersect. (h) In an EPI camera, all rays lie on a 2D plane.



General Linear Camera

- See blackboard...



General Linear Camera

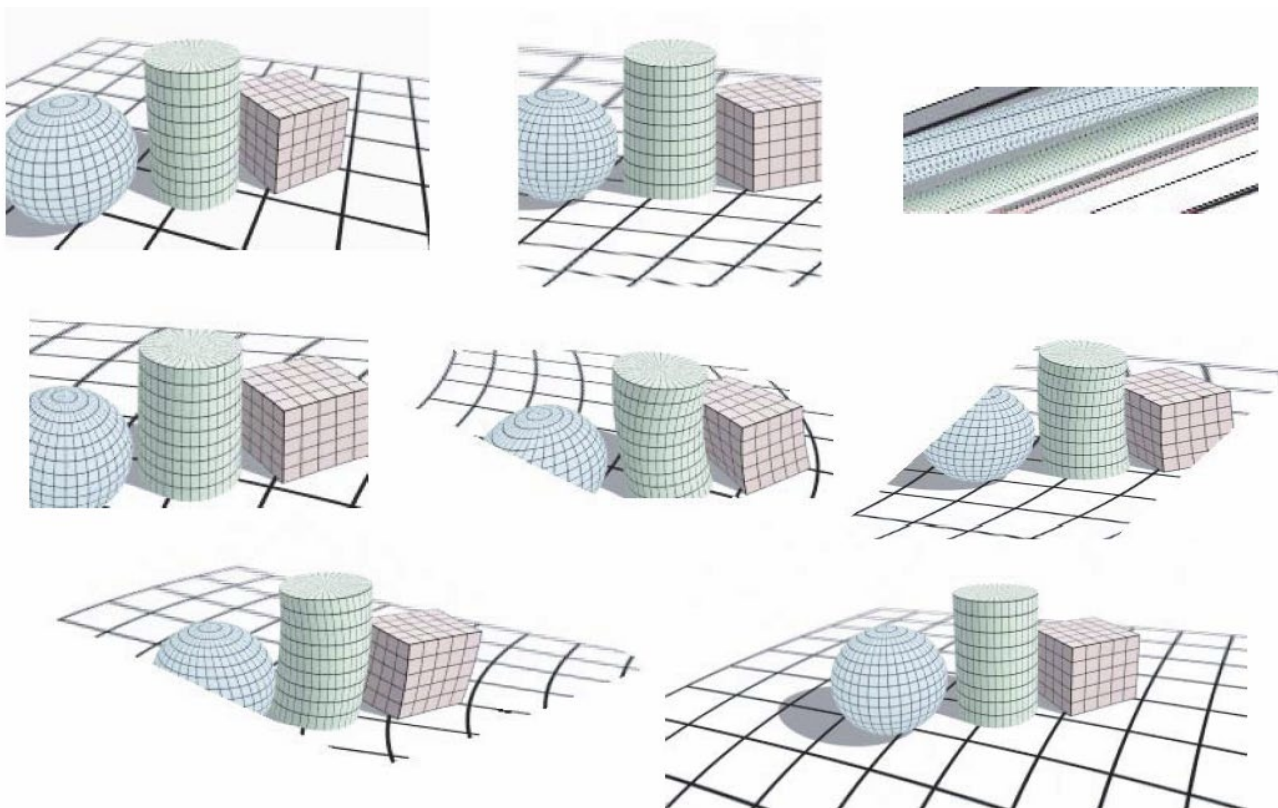


Fig. 5. Comparison between synthetic GLC images. From left to right, top row: a pinhole, an orthographic and an EPI; middle row: a pushbroom, a pencil and an twisted orthographic; bottom row: a bilinear and an XSlit.

[Yu-ECCV04]



General Linear Camera

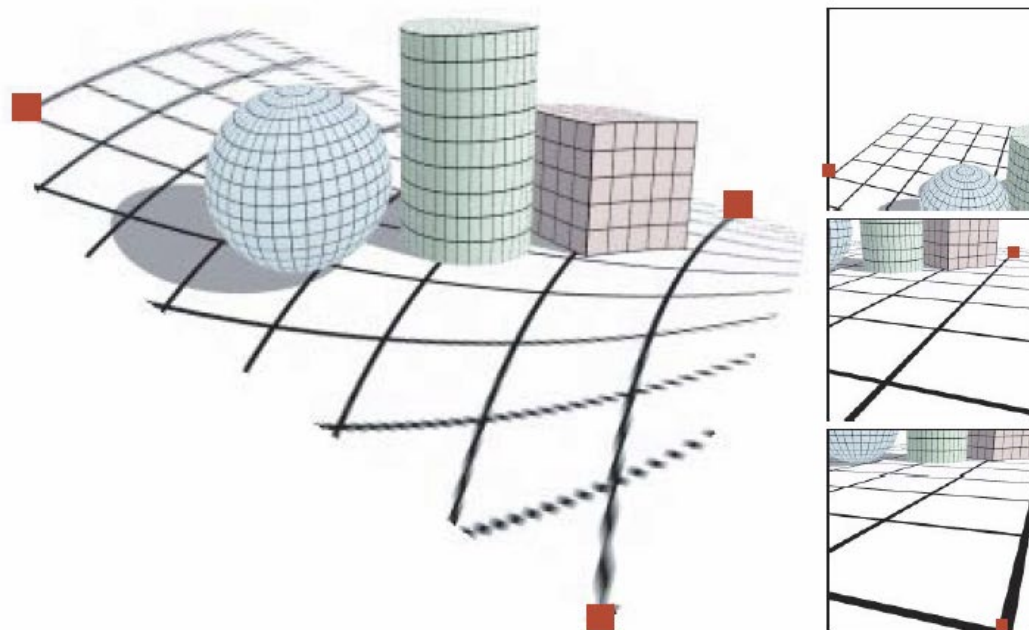
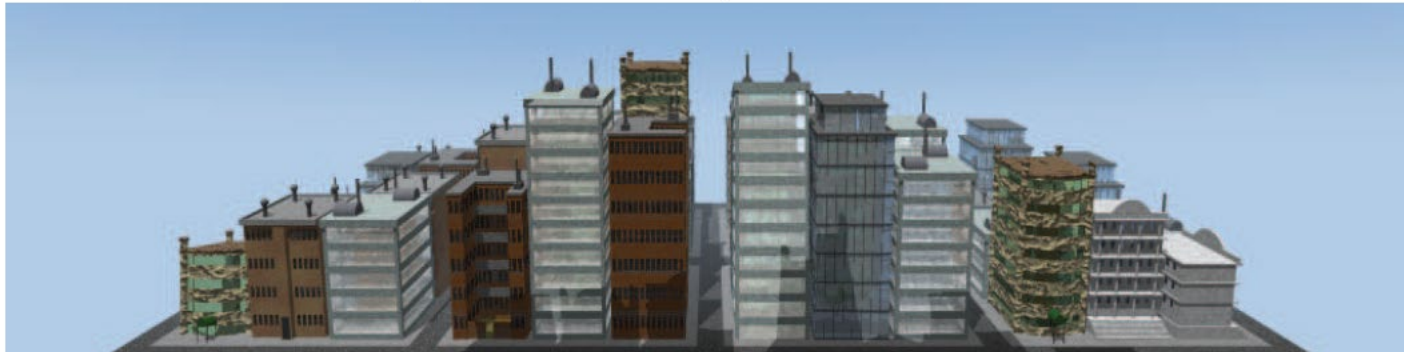


Fig. 7. A multiperspective bilinear GLC image synthesized from three pinhole cameras shown on the right. The generator rays are highlighted in red.

[Yu-ECCV04]



General Linear Camera

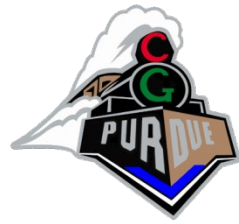


(a) Pinhole



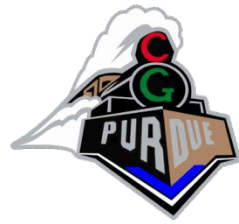
(b) Cross-Slit

FIG. 11. *Panoramas of city scene rendered using (a)pinhole camera and (b)cross-slit camera.*



GLC Papers

- Multiperspective Modeling and Rendering using General Linear Cameras
 - Yu, Ding, McMillan; Comm in Info Systems, 7(4), 2007
- General Linear Cameras
 - Yu, McMillan, ECCV, 2004



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- Multiperspective Modeling and Rendering using General Linear Cameras
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 - Yu, McMillan, ECCV, 2004