Fundamentals of Image Formation and Re-use

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What is an image?

- ✓ Digital image (point samples)
- ✓ Ideal observation mechanism
- ✓ Simple capture geometry

Goal: find out what can be done with an image.

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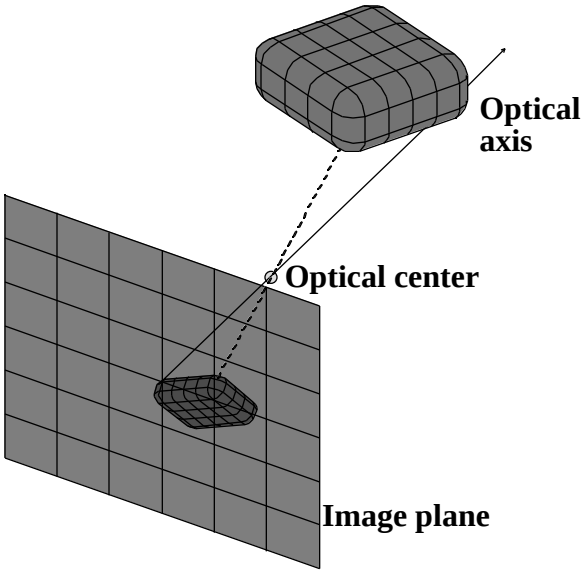
Pinhole camera model



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Light and matter

- ✓ Light captured by the camera tells us about the object we see…
- ✓ … and a lot more!
- ✓ The *rendering equation*

$$L(x,\theta) = L_e(x,\theta) + \int L_i(x,\varphi)\ \ \rho(x,\theta,\varphi)\ \ d\omega$$

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Light sources

- ✓ Extended shape (light fixtures, sky)
- ✓ Complex near-field emission patterns
- ✓ Difficult to model from images
  - –Dynamic range
  - –Visibility

$$L(x,\theta) = L_e(x,\theta) + \int L_i(x,\varphi)\ \ \rho(x,\theta,\varphi)\ \ d\omega$$

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Material properties

- ✓ BRDF = Bidirectional Reflectance Distribution Function
- ✓ Characteristic response of each material
- ✓ Spectral distribution defines object color(s)
- ✓ Bi-directional nature of reflectance

$$L(x,\theta) = L_e(x,\theta) + \int L_i(x,\varphi)\ \ \rho(x,\theta,\varphi)\ \ d\omega$$

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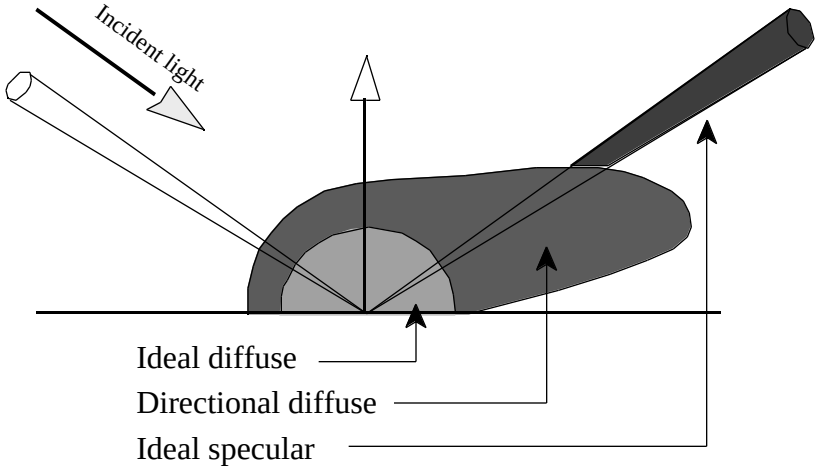
Components of a BRDF model



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Global illumination

- ✓ Visible objects are illuminated from all directions
- ✓ Simulation is costly
- ✓ Makes reflectance recovery difficult

$$L(x,\theta) = L_e(x,\theta) + \int L_i(x,\varphi)\ \ \rho(x,\theta,\varphi)\ \ d\omega$$

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IBR and specular reflections

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IBR and non-diffuse reflections

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Image-based relighting

- ✓ 3D approach, requires
  - –Depth information
  - –Reflectance parameters
  - –Light source description
- ✓ Radiance images are needed
- ✓ What can we do without 3D lighting?

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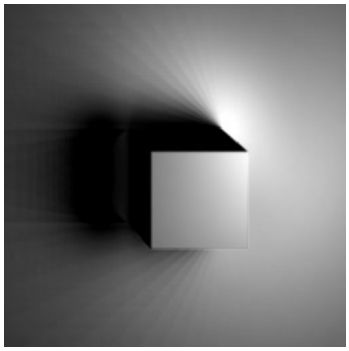
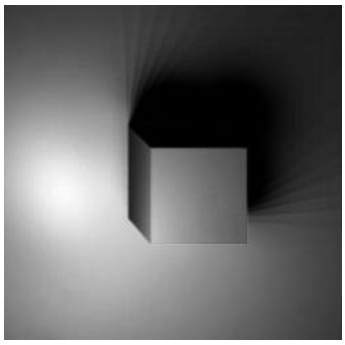
Adding more variables to images

- ✓ Add light source direction/position to the sampled variables





Wong *et al* 1997, EG rendering workshop

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Re-using images...

- ✓ Image caching
  - –Generate image fragments at their own refresh rate
  - –Composite on the fly at user display rate
- ✓ Warping pixels
  - –Render points
  - –Interpolate (mesh)
- ✓ Layered warping

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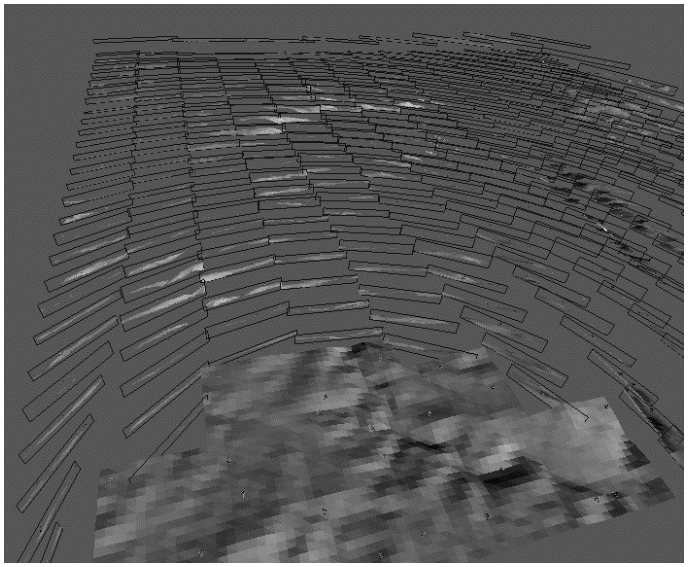
Perspective image caching



Use 3D billboard and perspective mapping

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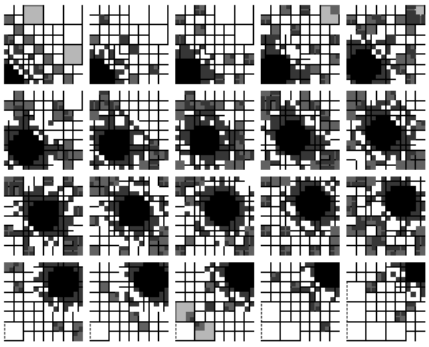
Hierarchical image caching

- ✓ Arrange scene in BSP
- ✓ Render minimal subtree
- ✓ Create images from subimages



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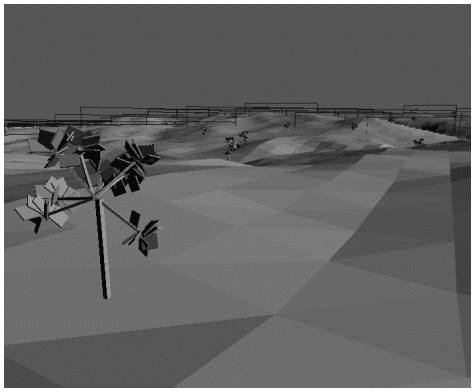
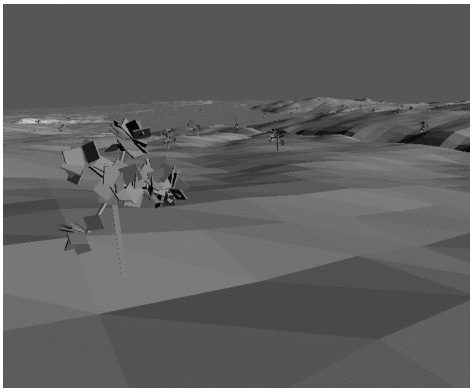
Hierarchical image caching





Images outlined

Final view

Schaufler/Stürzlinger EG 96, Shade *et al* SIGGRAPH 96

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Affine warping of sprites

- ✓ Talisman [Torborg 96]
  - –Layered model
  - –Apply affine transforms
  - –Render sprites on demand.

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Projective pixel warping

- ✓ Requires knowledge of depth
  - –Easy for synthetic images
  - –Relatively easy for sparse pixels with multiple real images
  - –Can use approximate geometry (plane)
- ✓ Apply (inverse) projective map

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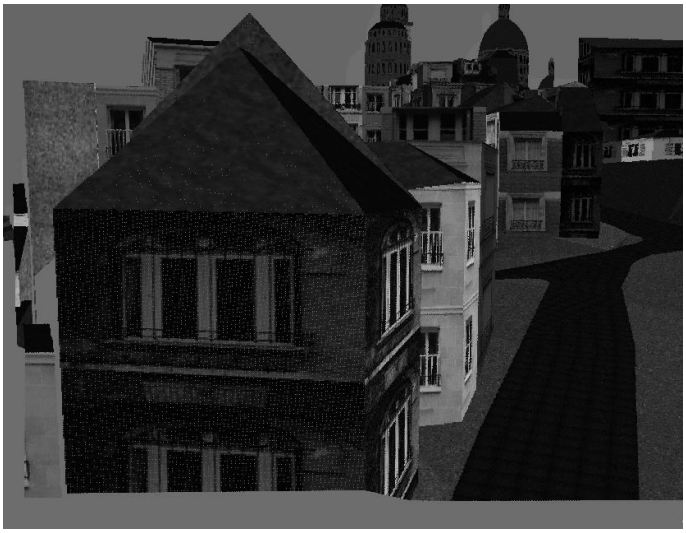
A warped image



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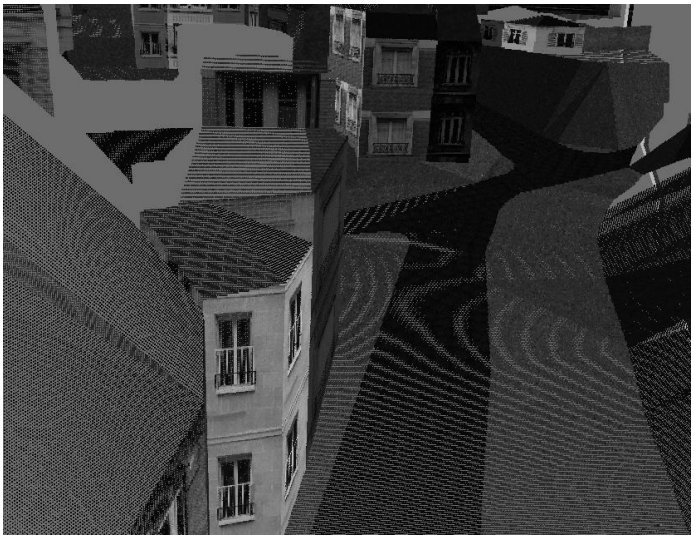
Another warped image



Note sampling artifacts

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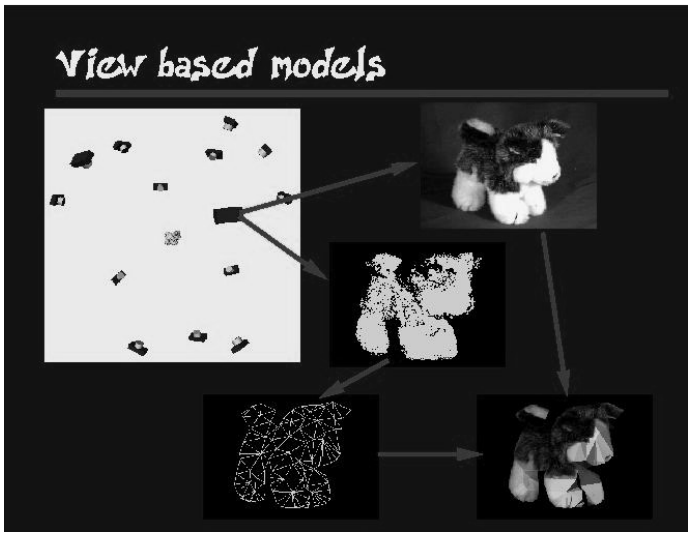
Textured 3D mesh from a range image



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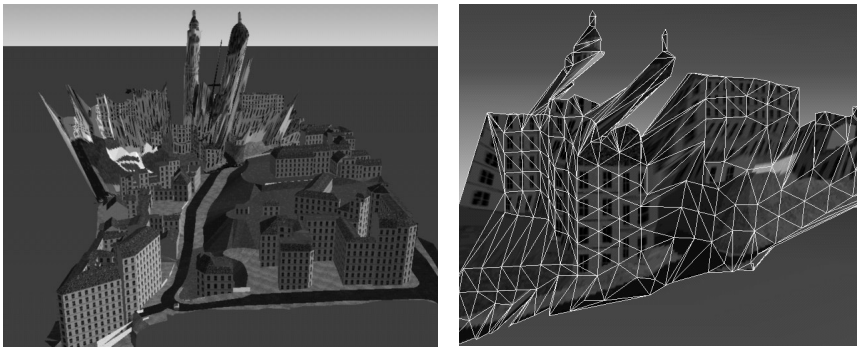
Pulli *et al.* 1997, EG rendering workshop

Impostors for accelerated rendering

- ✓ Use image to extract visible geometry
- ✓ Simplify image information



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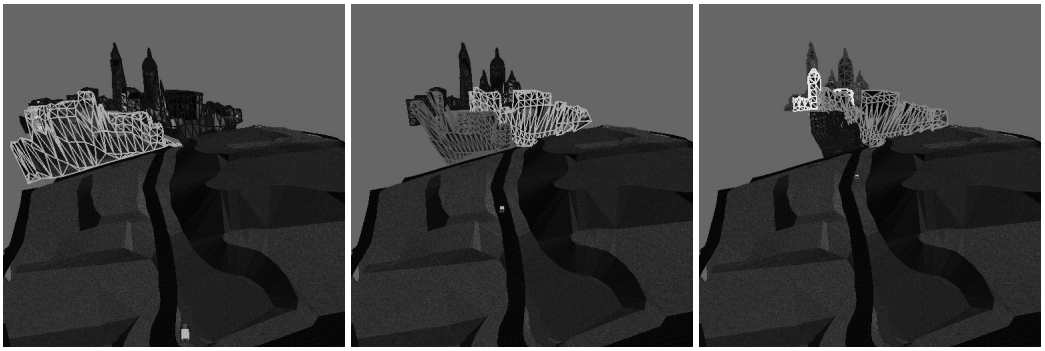
Creating impostors



Choose layers of geometry
according to relative visibility and masking criteria

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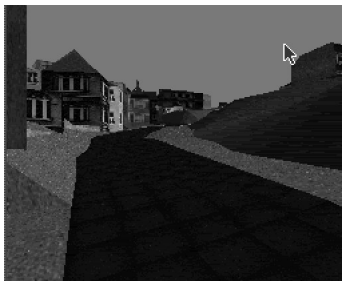
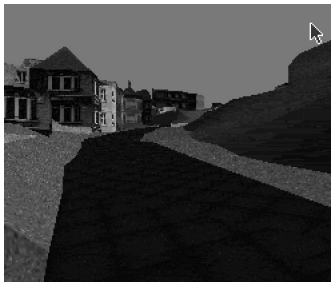
Multi-mesh impostors



Single mesh impostors



Multi-mesh impostors

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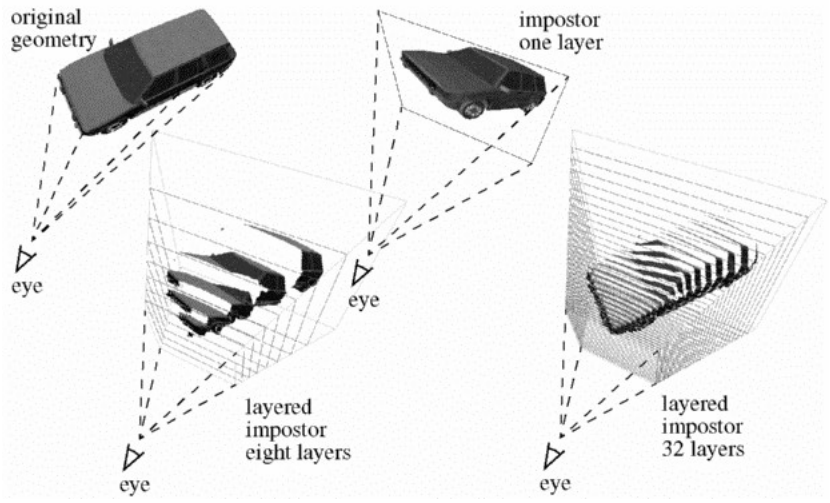
Layered warping



Schaufler 1998, EG rendering workshop

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Layered warping

- ✓ Combine strengths of
  - –Image caching (re-use images)
  - –Depth warping
  - –Projective map through use of 3D billboards
- ✓ Fast rendering using opacity test
- ✓ Per-object image-based model

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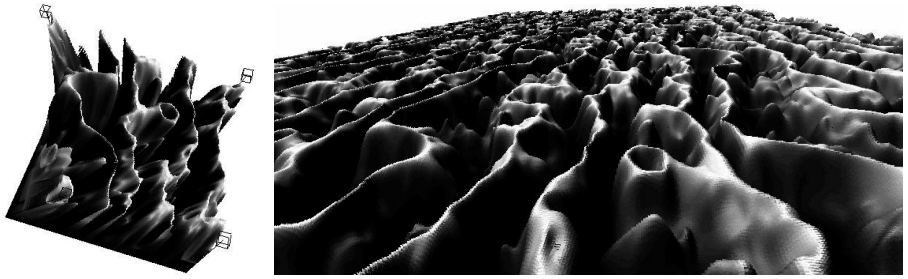
Layered warping for detail textures

- ✓ Allows interactive deformations



Meyer & Neyret 1998, EG rendering workshop

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Image re-use for synthetic imagery

(a possible strategy...)

- ✓ Create image-based representations
  - –Impostors
  - –Quality criteria depend on user / application
- ✓ Associate representations to view cells
- ✓ Update selected portions on the fly
  - –Layered object model allows low rendering cost for “sprite” generation

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Dynamic update: silhouettes

MMI Dynamic update Geometry

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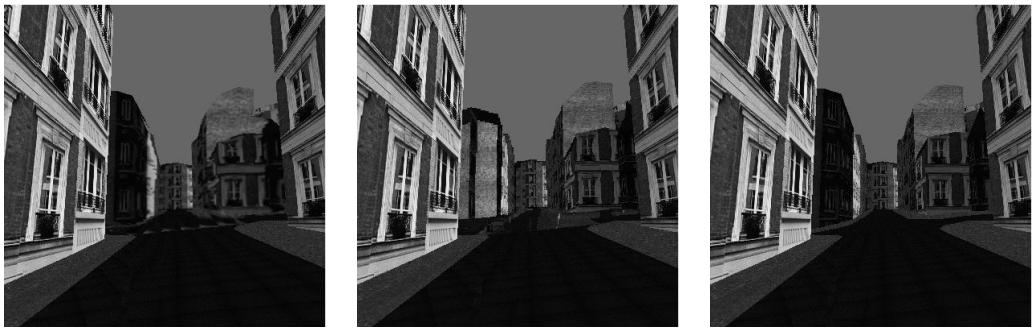
Dynamic update: resolution



MMI Dynamic update Geometry

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What can we do with images?

- ✓ Images represent the *appearance* of objects under specific lighting conditions
- ✓ Creating new views requires assumptions:
  - –Shape, geometry
  - –Material properties
  - –Light sources
- ✓ Some of this can be automated for faster image generation

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