Shadow Generation
Shadows

- Realistic illumination includes shadows
- An object casts a shadow if it “blocks” light
Shadow Map Algorithm

• A point is in shadow if it is not “seen” by a light source
• Idea: render the scene from the view of each light source to determine which points are visible (and should be illuminated by it)
Shadow Map Algorithm

- What does a light source “see”?
Shadow Map Algorithm

• Step 1: render scene as seen by each light source, to determine which points are visible
Shadow Map Algorithm

- Step 2: for each point in the scene, compute depth from light viewpoint
  - $d$ is the depth according to the z-buffer
  - $w$ is the actual depth
Shadow Map Algorithm

• Step 2: how to compute d?
  – Use the z buffer from the light viewpoint as texture (why?)

Scene viewed by camera

Z buffer – from light viewpoint

Camera view, depth from light viewpoint used as texture
Shadow Map Algorithm

- **Step 2**: Use the z buffer from the light viewpoint as texture.

Texture coordinates are given by screen coordinates.
Shadow Map Algorithm

• Step 3, depth test: at each pixel, compare $d$ and $w$ to determine if it is in shadow
  – If it is, do not use this light source for illumination at this point

\[ d < w \Rightarrow p \text{ is in shadow!} \]
Shadow Map Algorithm

• Conclusion:
  
  – “shadow map” uses the z buffer from the light viewpoint to determine which points are in shadow
  
  – Use texture transfer to map the z buffer to the scene
  
  – Requires a separate z-buffer for each light source
Shadow Map Algorithm

• More examples:
Shadow Map Algorithm

- More examples:
Shadow Map Algorithm

• We are not done, severe aliasing can occur if the light source is at a significantly different orientation from the viewpoint.
Shadow Map Algorithm

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Shadow Volume Algorithm

- Compute an extrusion of silhouettes along light direction

- Shadow is in the intersection of the extruded volume and other objects

Leonardo da Vinci
Shadow Volume Algorithm

• For each light source and object:
  – Compute silhouette from light viewpoint
  – Extrude each silhouette
  – Compute a **stencil buffer** (camera viewpoint, this buffer determines for each point if it is in shadow or not):
    • First, all **front** facing faces are marked as “shadow” in the stencil buffer
    • Second, all **back** facing faces are marked as “non shadow” in the stencil buffer
Shadow Volume Algorithm

Shadow Map  Shadow Volume