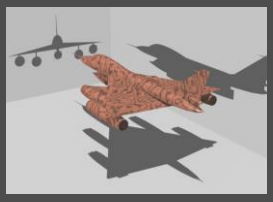
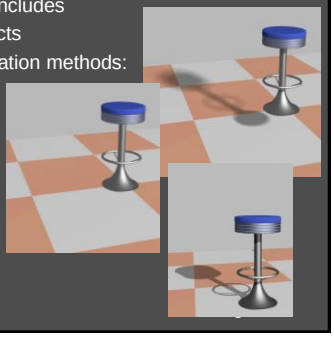
Shadow Algorithms



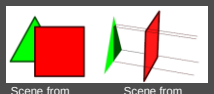
Shadows

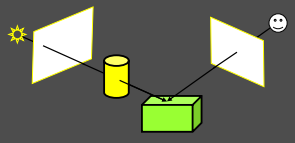
- Realistic illumination includes shadows cast by objects
- Simple shadow generation methods:
  - Shadow maps
  - Shadow volumes
- Advanced methods:
  - Ray-tracing
  - Radiosity



Shadow Map Algorithm

- Object is in shadow if not "seen" by light source
- Idea – compute the discrete visibility of the scene from light source to decide if a pixel is shadowed





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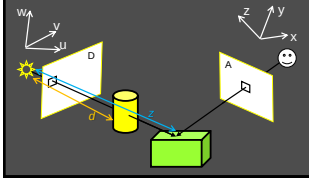
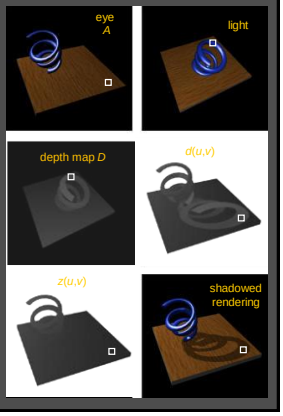
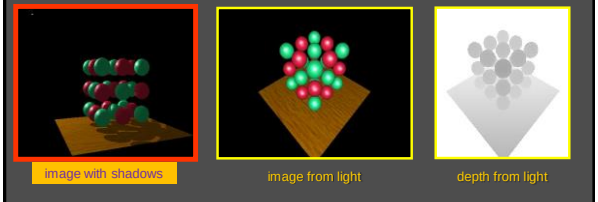
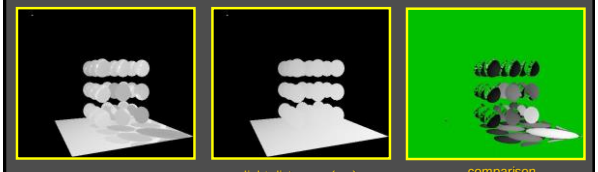
procedure SHADOWMAPPING
render z-buffer from light's point of view to depth map *D*
store *D* as texture map *d*(*u*,*v*)
render scene *S* from the eye's point of view into image *A*
for each rasterized pixel of *A* with texture coords (*u*,*v*) in eye space and transformed distance *z*(*u*,*v*) do
  if *d*(*u*,*v*) < *z*(*u*,*v*) then
    pixel is shadowed
  end if
end for









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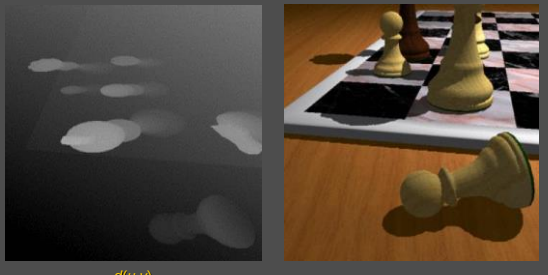

d(*u*,*v*)

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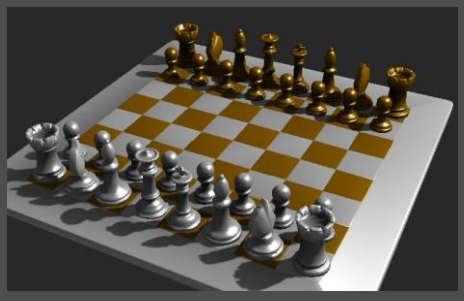

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Summary

- Shadow map algorithm can approximate the shadows of **any** scene which can be rendered using a Z-buffer
- Requires separate Z-buffer for each light source
- Every polygon is rendered **N+1** times (for **N** light sources)

Shadows from three light sources

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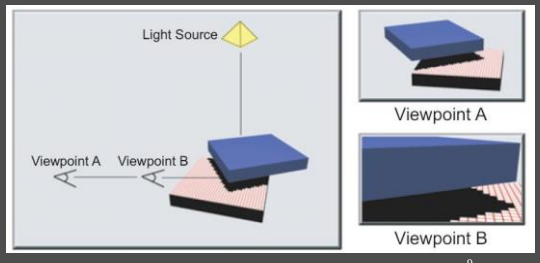
Disadvantage

- Image space algorithm: severe aliasing can occur if the light source is at orientation significantly different from the viewpoint.



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demo

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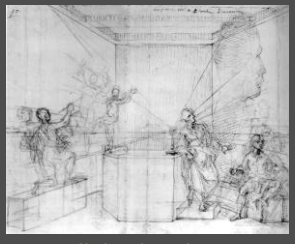
Shadow Volume Algorithm

- The shadow boundary separates illuminated and shaded regions.
- Compute as extrusion of **silhouettes** along light direction
- Compute intersection of extruded volume with other objects



Shadow volumes circa Leonardo da Vinci

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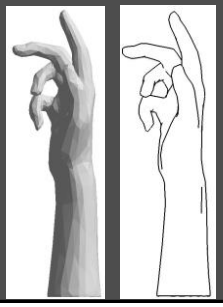
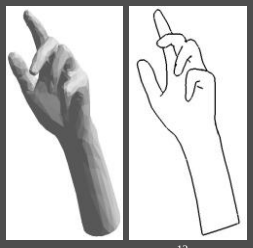
Sihouettes

The edges between front-facing polygons and back-facing polygons.



demo



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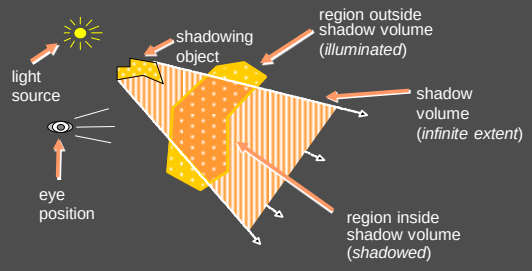
Shadow Volumes



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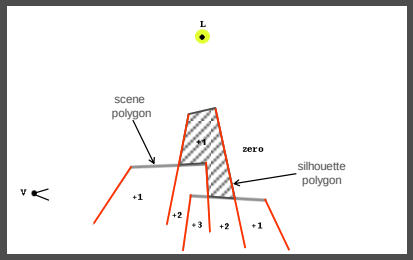
The Shadowed Regions



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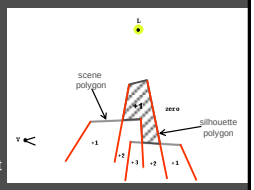
Shadow Volume Algorithm

- For each object and light source compute object silhouette (and boundary if open) from light source viewpoint
- Extend each silhouette (and boundary) to form semi-infinite volumes
- Feed boundaries into regular Z-buffer as fully transparent polygons
- Front facing shadow polygons cause object behind to be shadowed
- Back facing shadow polygons cancel effect of front facing ones
- Usually implemented using *stencil buffer*



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Properties of Shadow Volumes

- Object space algorithm - does not depend on view point
- High complexity per object, function of scene
- Requires geometric methods
  - Silhouette computation
  - Extrusion

demo

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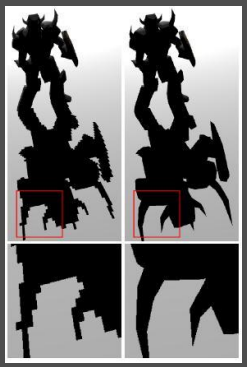

shadow map shadow volume

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