CSI 3200 Micro-Computer Graphics Shadow

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Outline

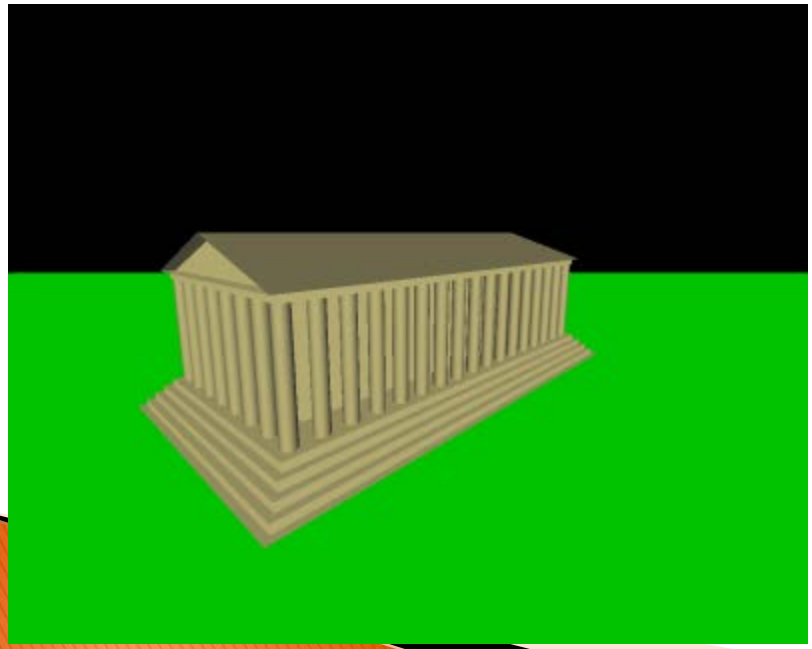
- What is Shadow?
- API Shadow Support
- Hard vs. Soft Shadow
- Types of Shadows
- Approaches
  - Radiosity
  - Ray Tracing
  - Shadow Maps (Projection Shadow)
  - Shadow Volumes
  - Stencil Buffer
- Questions?
- Review Questions

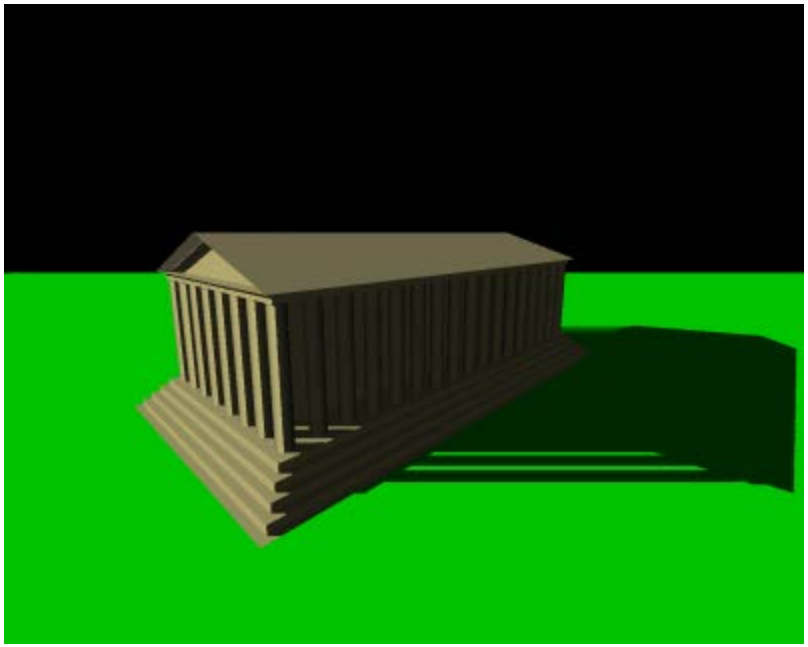
What is shadow?

- An area where the full intensity of light is cut off by one or more objects
- A point on a surface is in shadow if a ray drawn the point to the light source is intersected by an object

Why shadow might be important?

- Shadows provide visual cues about the spatial relationships between the different components in a scene
- Additional information and views of objects Improved "realism“
- Lighting environment cues Anchors: Without shadows objects seem to float/hover

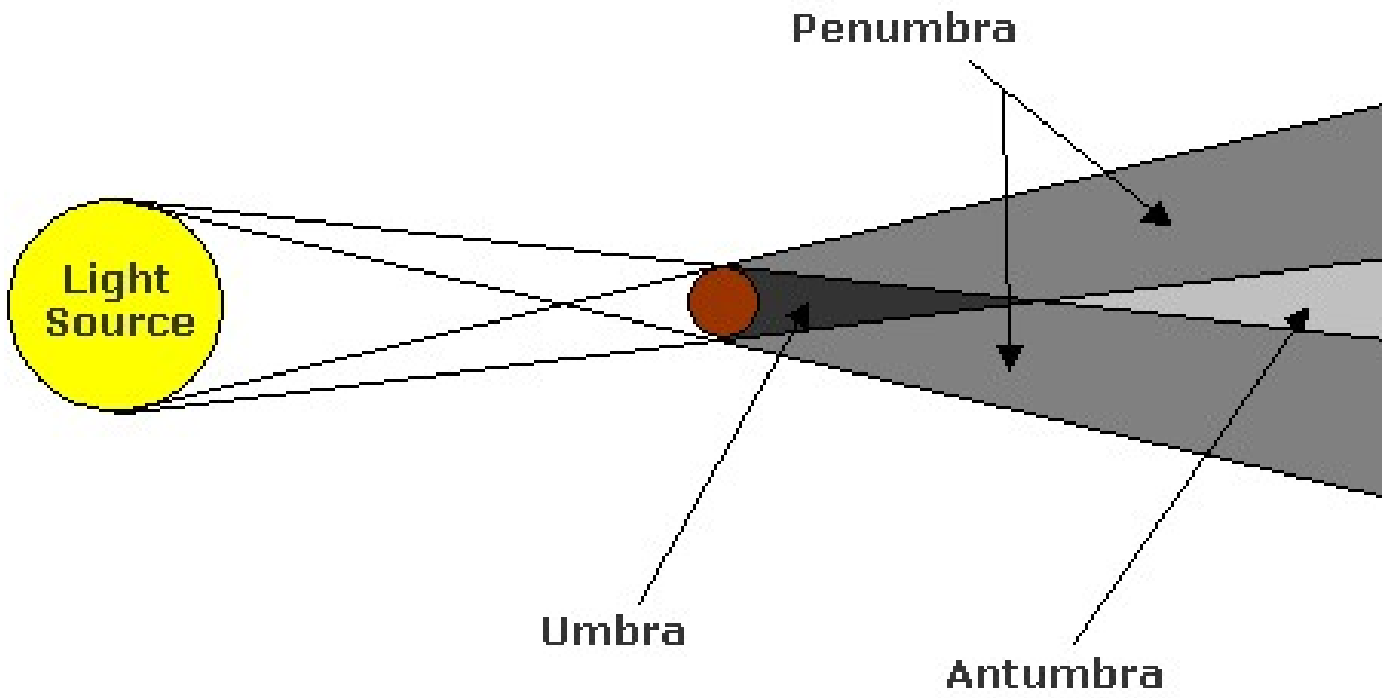




Why shadow might be important?

Hard & Soft Shadows

Soft Shadow



Types of Shadow(s) in a scene

- No Shadow (invisible shadow)
  - caused by an abundance of light sources or a high level ambient light
- Single Point Shadow
  - Shadow cause by one light source
- Multi-point Shadow
  - Shadow caused by more than one light sources
- Simple Shadow
  - Shadow falling on a flat surface (usually a plane)
- Not So Simple Shadows
  - Shadow falling on the surfaces of other objects with one or more light sources

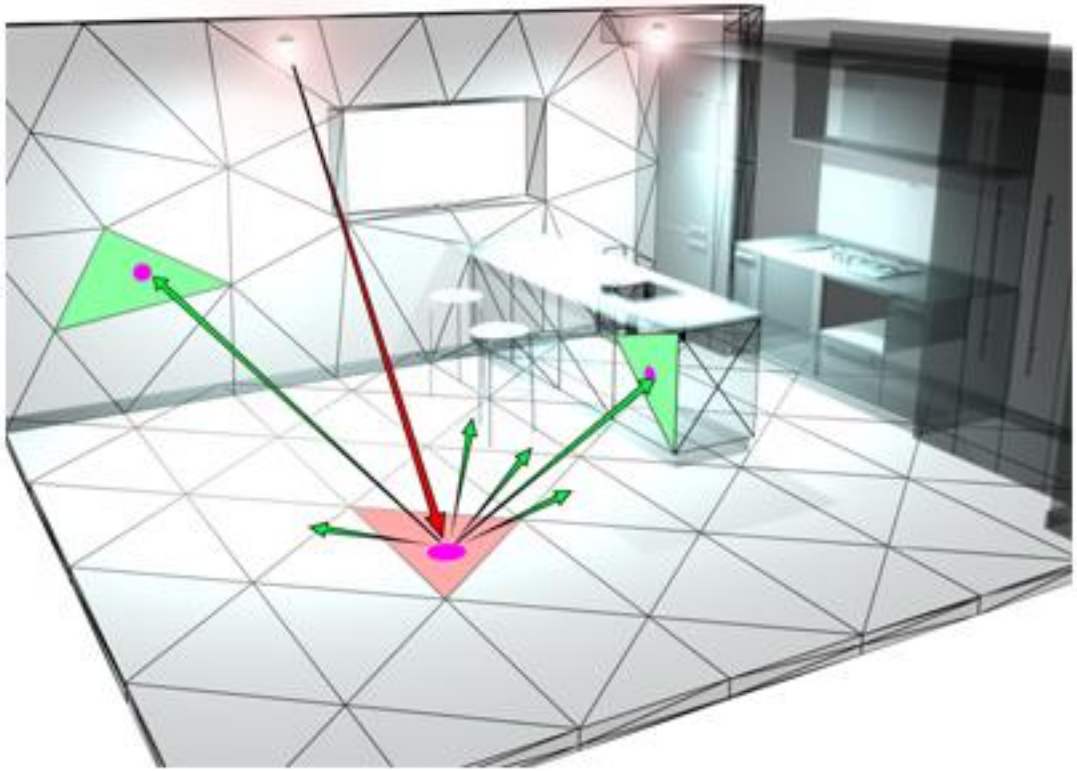
CG API support for shadow

- Most graphics API do not directly support shadow, this is so for a number of reasons associated to the type of scene, the amount of light sources and the level of details required…

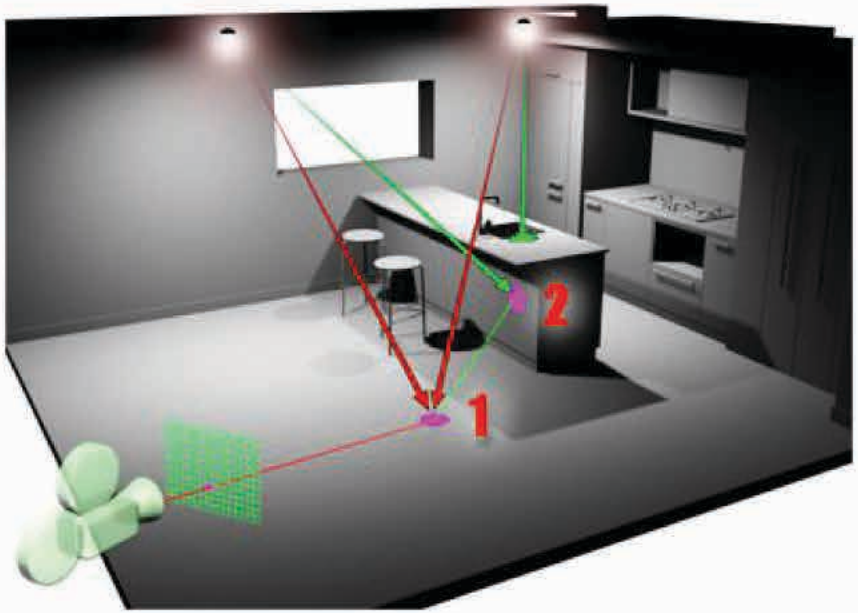
Approaches

- Several techniques to simulate shadow in a scene and these are based on what results you are hoping for…
- Fake (No computation…) (ex. Tomb Raider 1)
  - Gives impression of global computation
- Radiosity
- Ray Tracing
- Shadow Map
- Shadow Volume

Radiosity



Ray Tracing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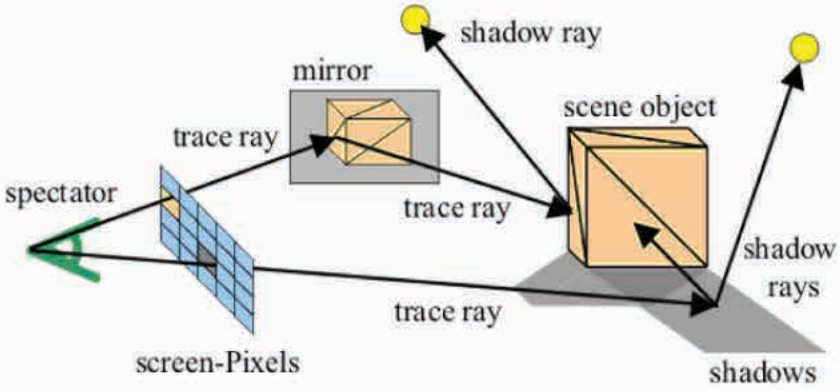
1


shadow ray
mirror
scene object
trace ray
spectator
trace ray
shadow
rays
trace ray
screen-Pixels
shadows

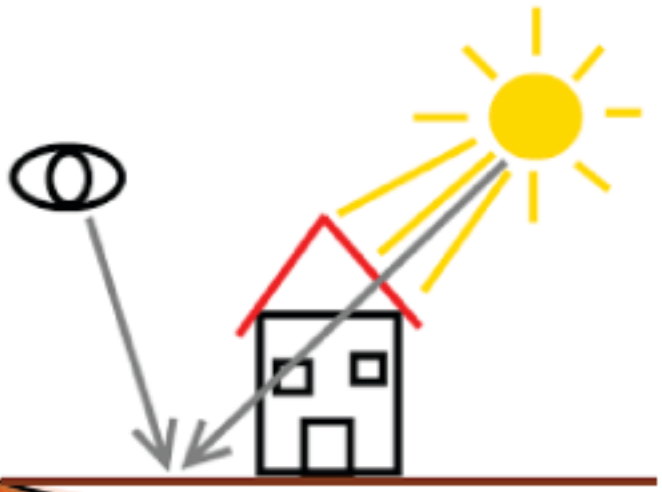
Radiosity Vs Ray Tracing

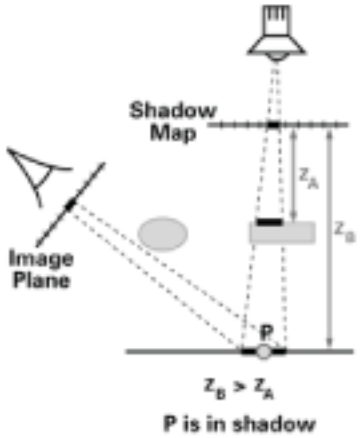
Lighting Algorithm	Advantages	Disadvantages
Ray-Tracing	Accurately renders direct illumination, shadows, specular reflections, and transparency effects. Memory Efficient	Computationally expensive. The time required to produce an image is greatly affected by the number of light sources. Process must be repeated for each view (view-dependent). Doesn't account for diffuse interreflections.
Radiosity	Calculates diffuse interreflections between surfaces. Provides view-independent solutions for fast display of arbitrary views. Offers immediate visual results.	3D mesh requires more memory than the original surfaces. Surface sampling algorithm is more susceptible to imaging artifacts than ray-tracing. Doesn't account for specular reflections or transparency effects.

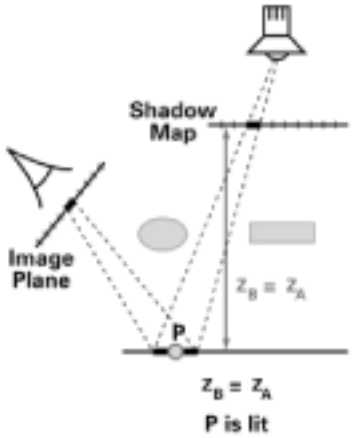
http://www.3dmax-tutorials.com/Radiosity_Solution.html

Shadow Maps

- Popular
- Hardware Supported
- The scene is rendered from the perspective of the light source to fill a depth buffer that is stored with the light







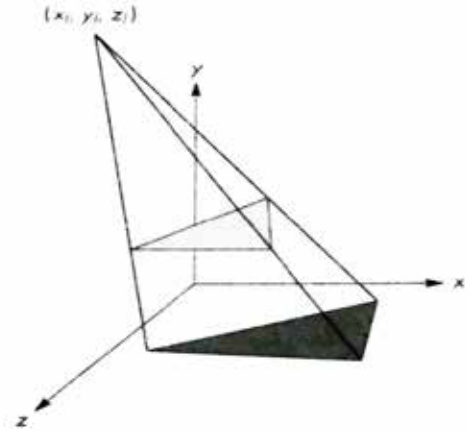
http://http.developer.nvidia.com/CgTutorial/cg_tutorial_chapter09.html

Shadow Maps

- The z-coordinate rendered polygon for a pixel is converted with a transformation matrix to a corresponding z-coordinate in the light source coordinate system

- If the light source z-buffer has a smaller value for an object then the part of the polygon projected to the current pixel is in shadow

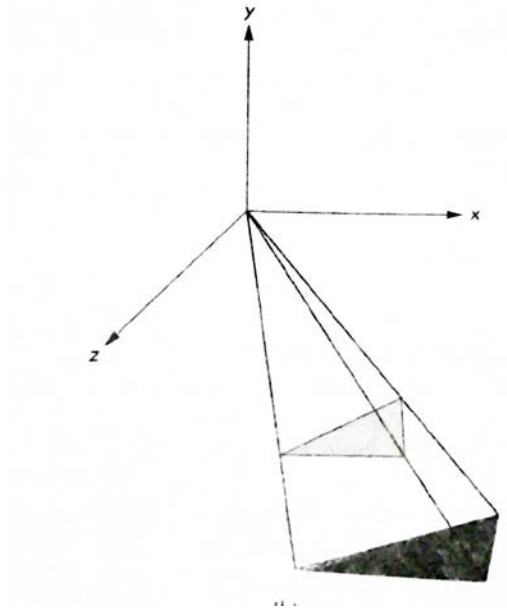
Shadow Maps



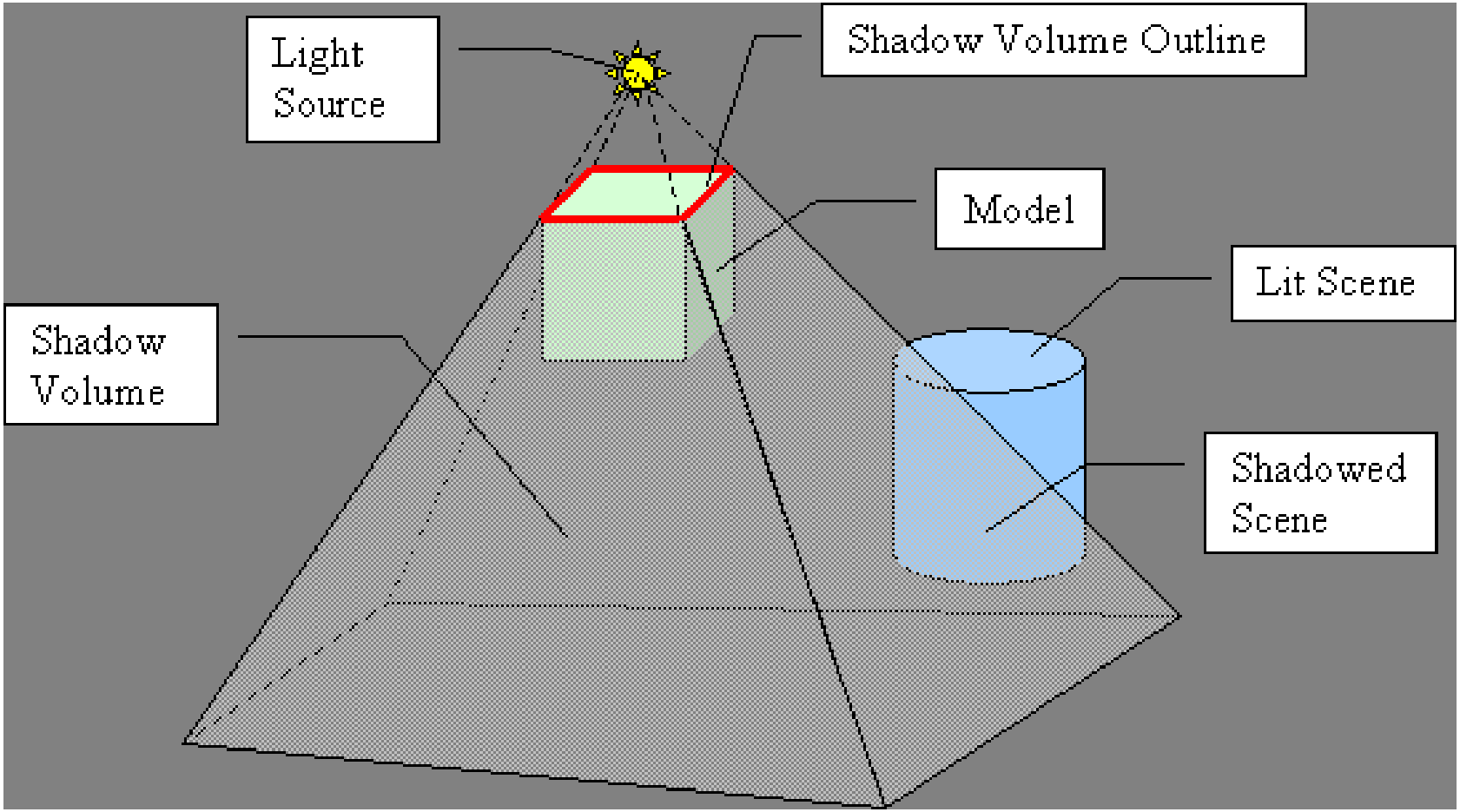
- Algorithm
  - Light Source (xL, yL, zL)
  - Reorient (T(−xL, −yL, −zL) the scene so as to move the light source at the origin in order to have a simple projection matrix

$$M = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & \frac{1}{-y_l} & 0 & 0 \end{pmatrix}$$

  - Therefore the object with vertex (x, y, z):
    xp = xL – (x – xL)/((y – yL)/yL),
    yp = 0,
    zp = xL – (z – zL)/((y – yL)/yL)

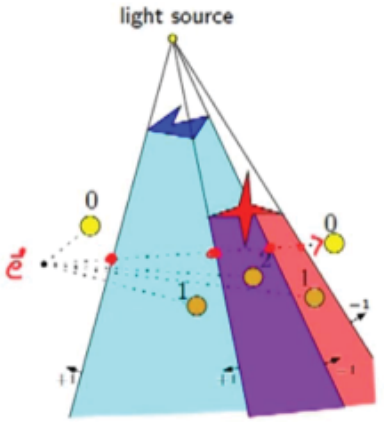


Shadow Volumes



Shadow Volumes

- Light source & occluder
- The volume is determined by the edges of the occluder w.r.t to the light source
- The shadow volume is a polygon and simple tests for a point in a polygon is used to decide if the point on the object lies in the shadow volume.
- Polygon test…



Shadow Volumes

- Not very efficient but there is hardware support in the stencil buffer…
- More efficient than Ray Tracing
- Algorithm:
  - Draw Scene with Ambient Light (everything in Shadow)
  - Compute Shadow Volumes
  - “Draw” the shadow volume faces in the stencil buffer

Shadow Volumes

- Drawing a Pixel in the stencil buffer means:
  - Test the shadow face of the “pixel” against the z-buffer
  - IF the z value (of the shadow volume) is smaller than the drawn (real) object then we conduct the polygon test

Using the Stencil Buffer

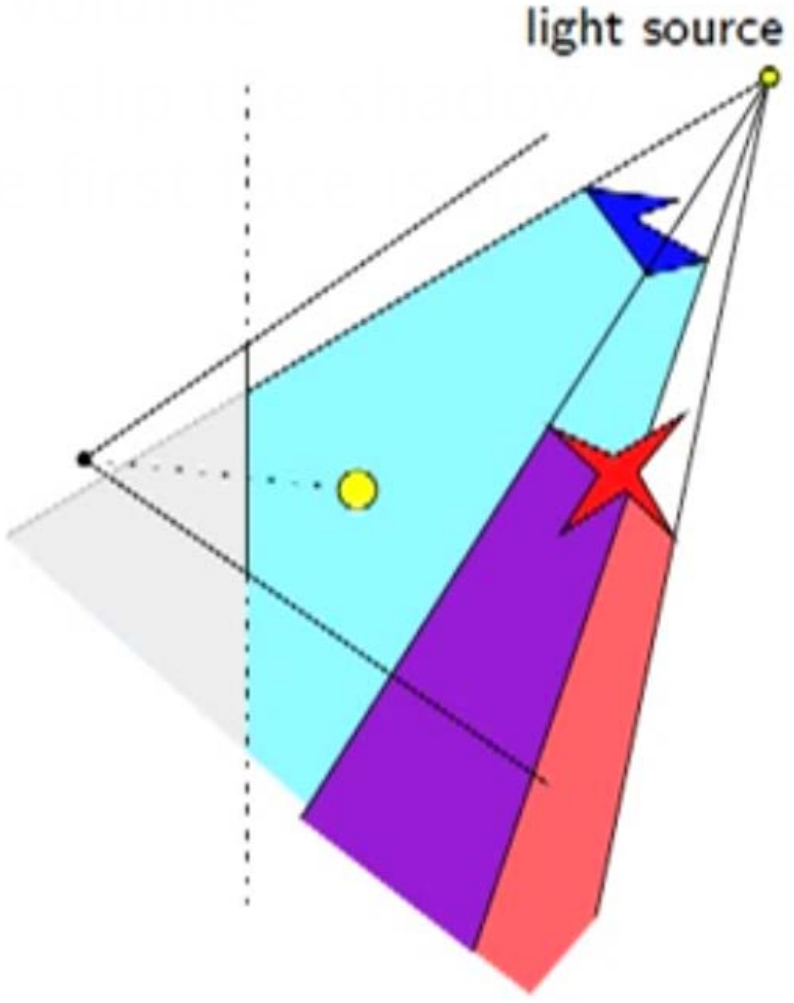
- The Stencil buffer is comparable to the z-buffer but each entry is recoded as a counter.
- It supports resetting, incrementing and decrementing
- Used for conditional drawing of the frame buffer – only draw a pixel if the corresponding counter is zero/non-zero

Hardware Support – Stencil Buffer

- Once the shadow volume face has been drawn, the stencil buffer contains 0 for pixels not in shadow
- Next draw the entire scene again (only real objects) including the lighting calculations but tell the video card to ignore pixels that have non-zero stencil buffer entries

Shadow Volume Problems

- Camera in the shadow
- Near clipping plane ca volume (so in effect th z-buffer)



Review

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Conclusion

- Shadow is important as it adds a realistic feel to the scene, it erases the hover effect that objects can exhibit, and it adds spatial information to the scene
- There are several approaches and are all related to the accuracy/realism you are willing to achieve
- Processing time is a strong consideration

Questions?

References

- http://www.3dmax-tutorials.com/Radiosity_Solution.html
- http://www.csci.csusb.edu/tongyu/courses/cs520/notes/shadow.php
- **Computer Graphics 2012, Lect. 10(2) – Shadows** https://www.youtube.com/watch?v=IZRqx2WIpR4

Review Question

- What might be the steps for Shadow Projection is there is 4 light sources (at different locations) and 5 objects with some overlapping and intersection