Computer Graphics

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ICL/ITRI

Shadow

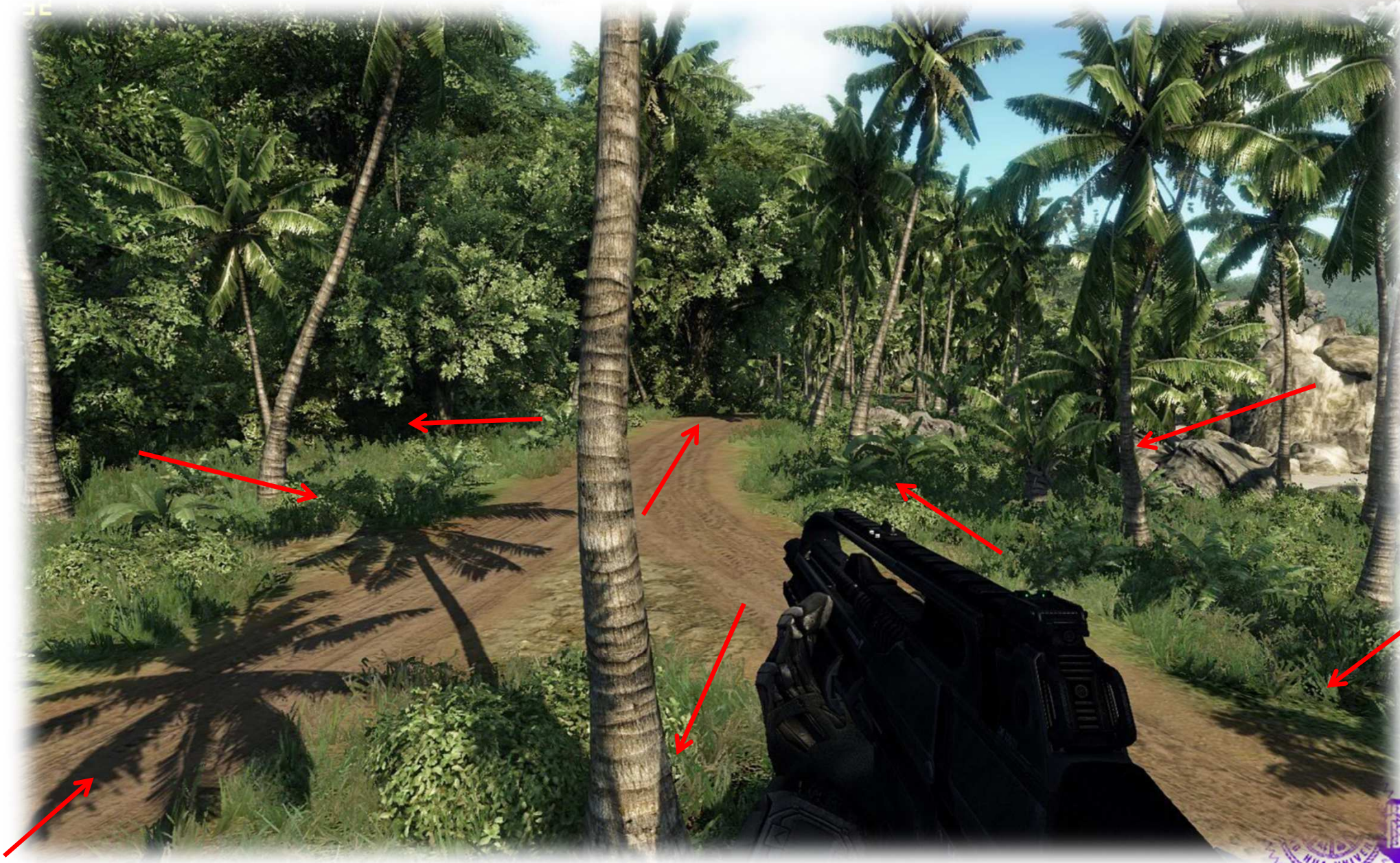
Shadow Volume

Shadow Map

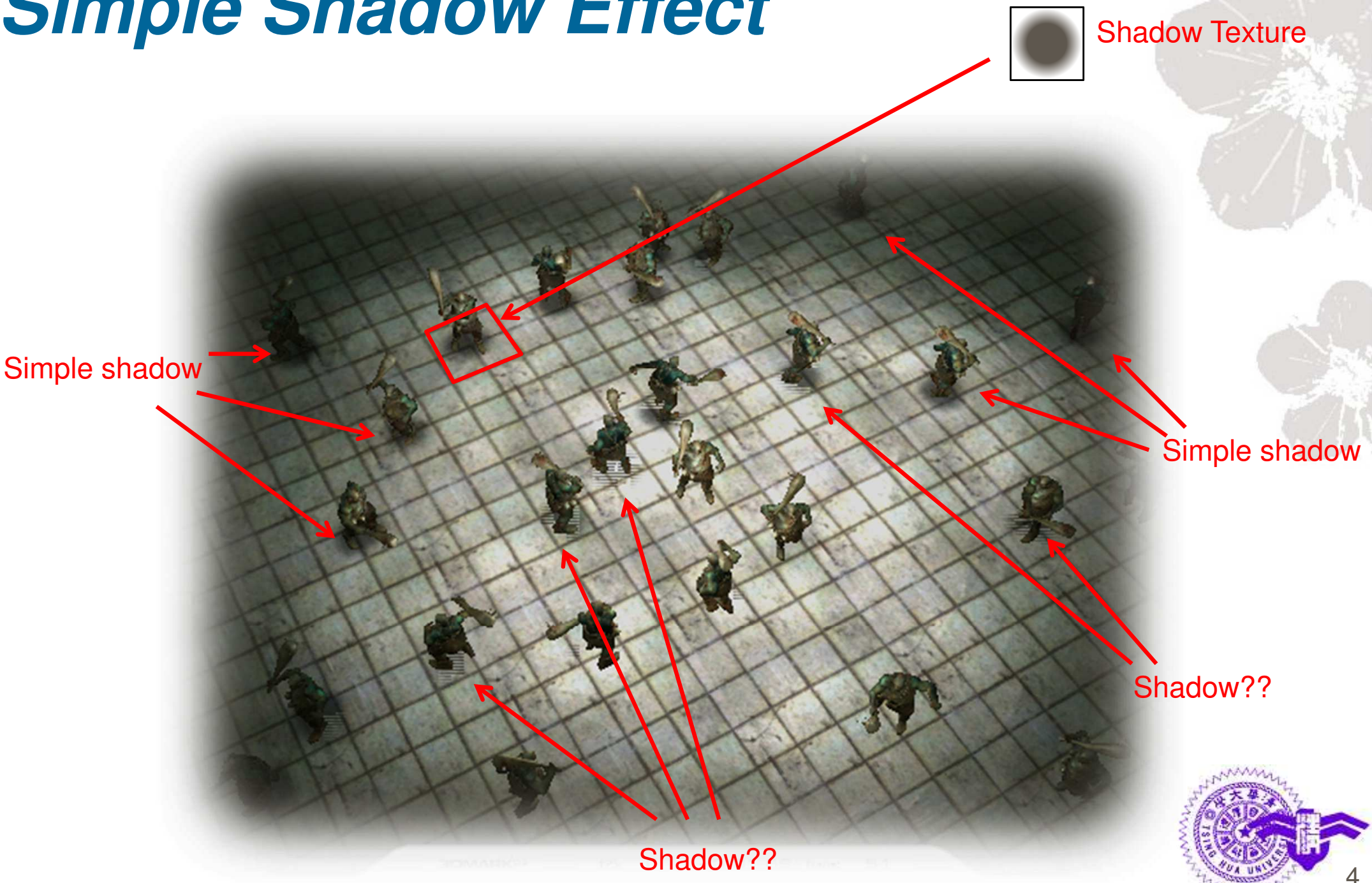
Ambient Occlusion

Ray Tracing

Shadow Effect



Simple Shadow Effect

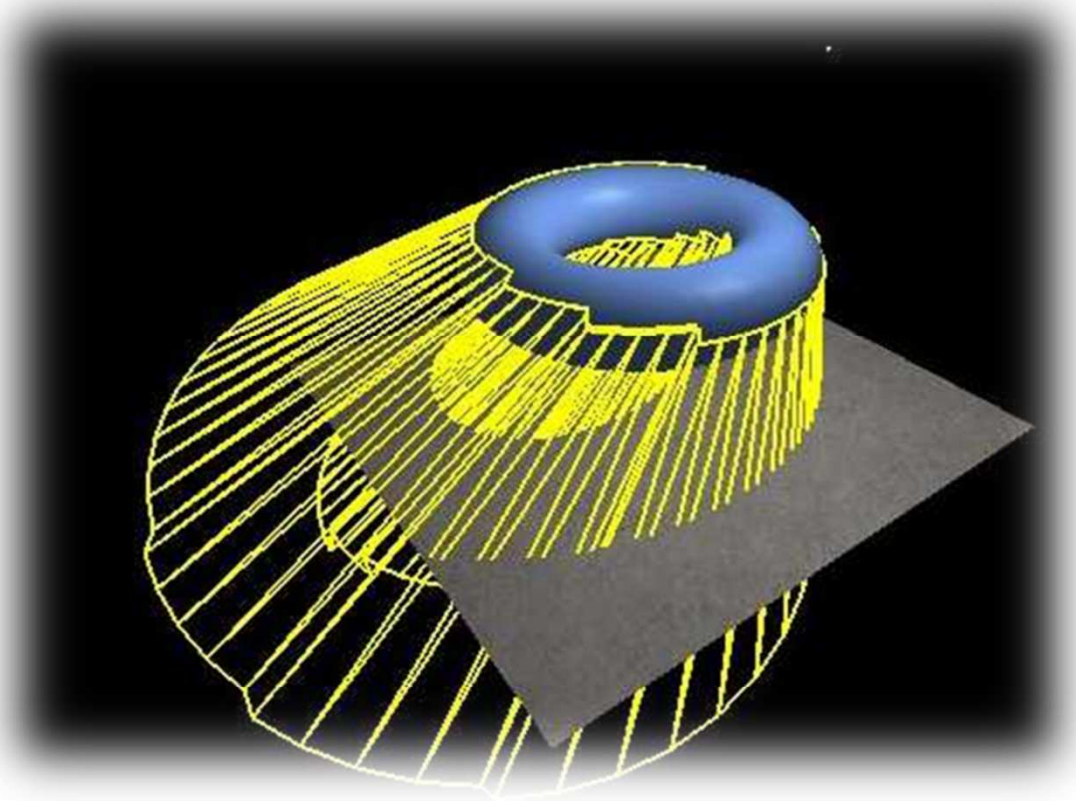


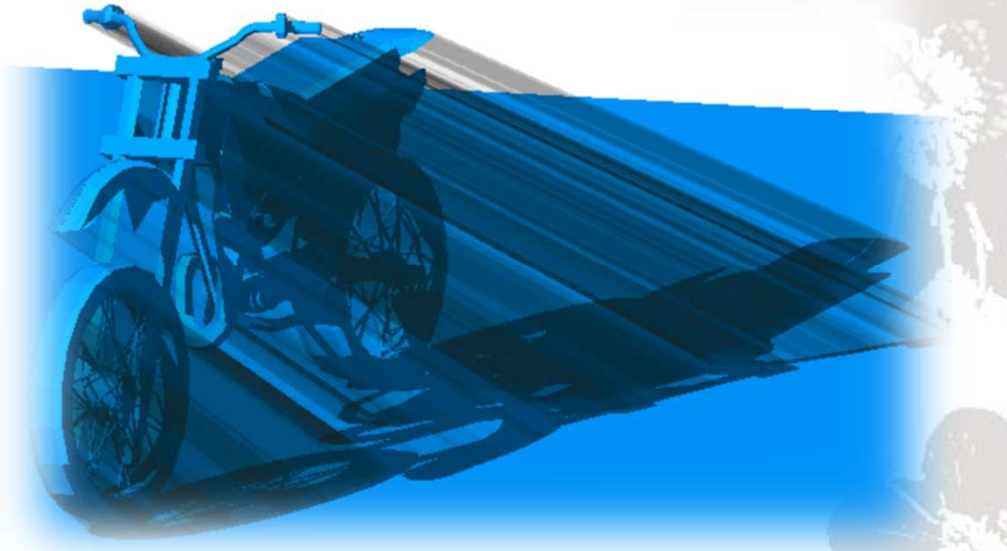
Simple Shadow Effect

- Simple and fast
  - A simple shadow image (or a set of shadow images) is sufficient
  - Texture mapping with blending to the ground
- Have to resolve Z-fighting issue
- Cannot generate shadows on non-planner surface
- No dynamic shadows
  - Can use a set of static shadows to simulate the shadow change

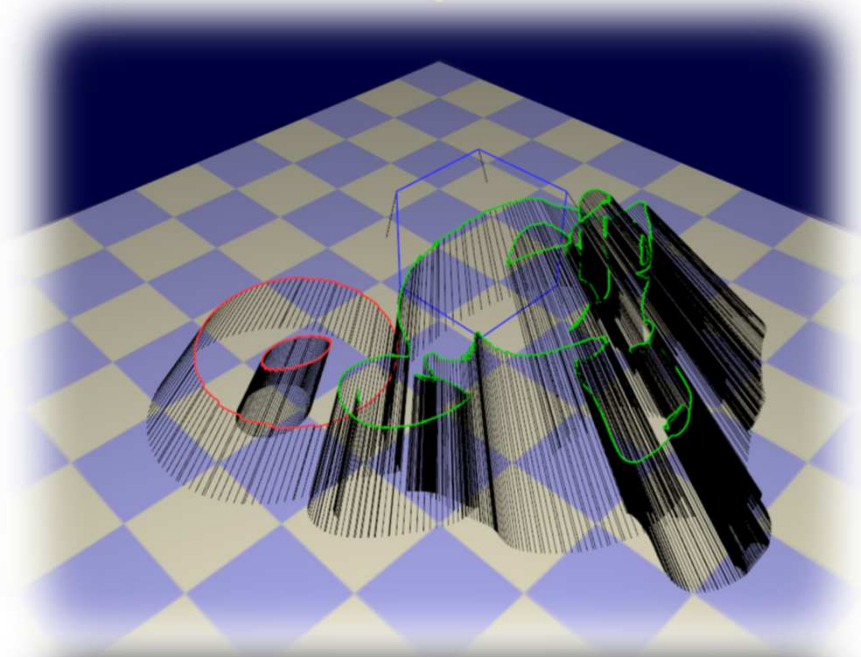
Shadow Volume

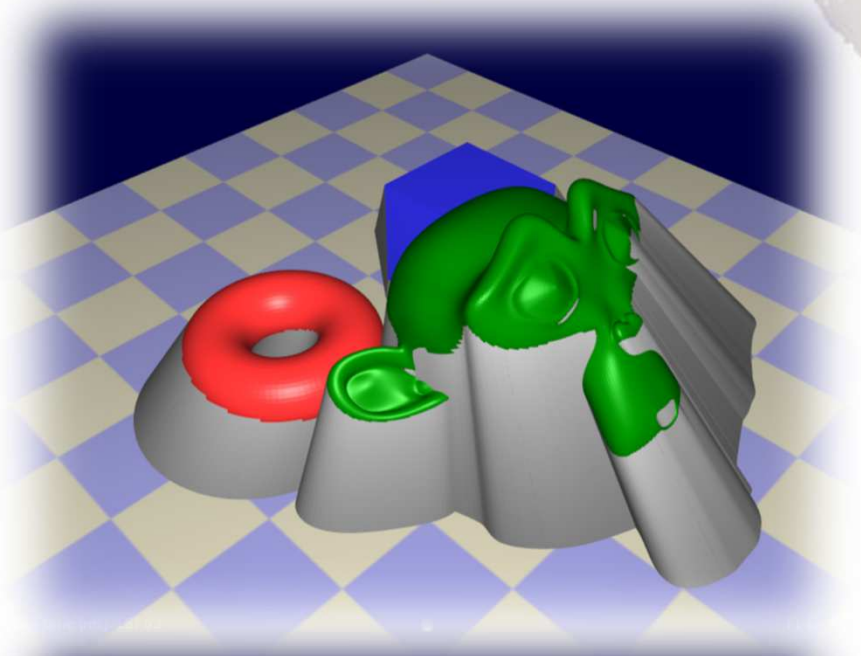
- Examples

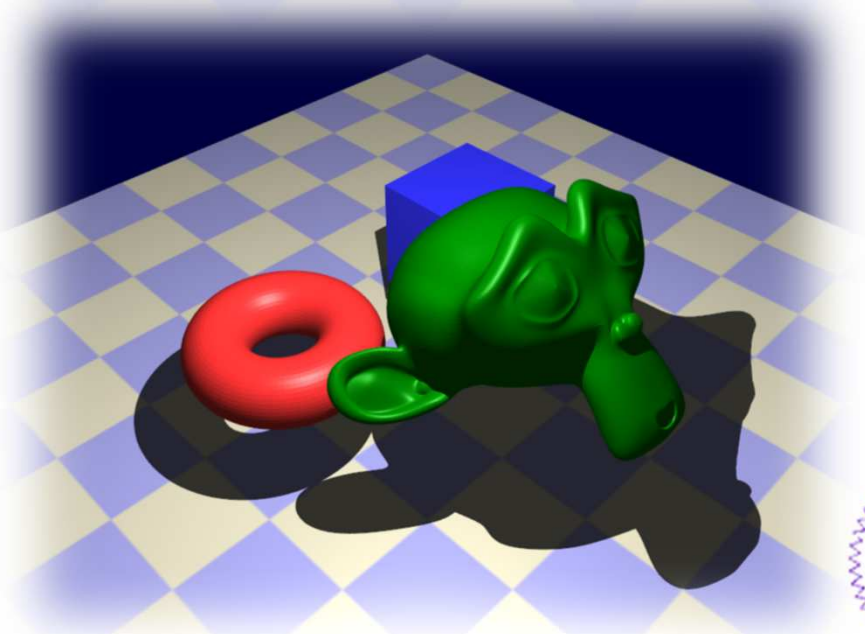




Shadow Volume

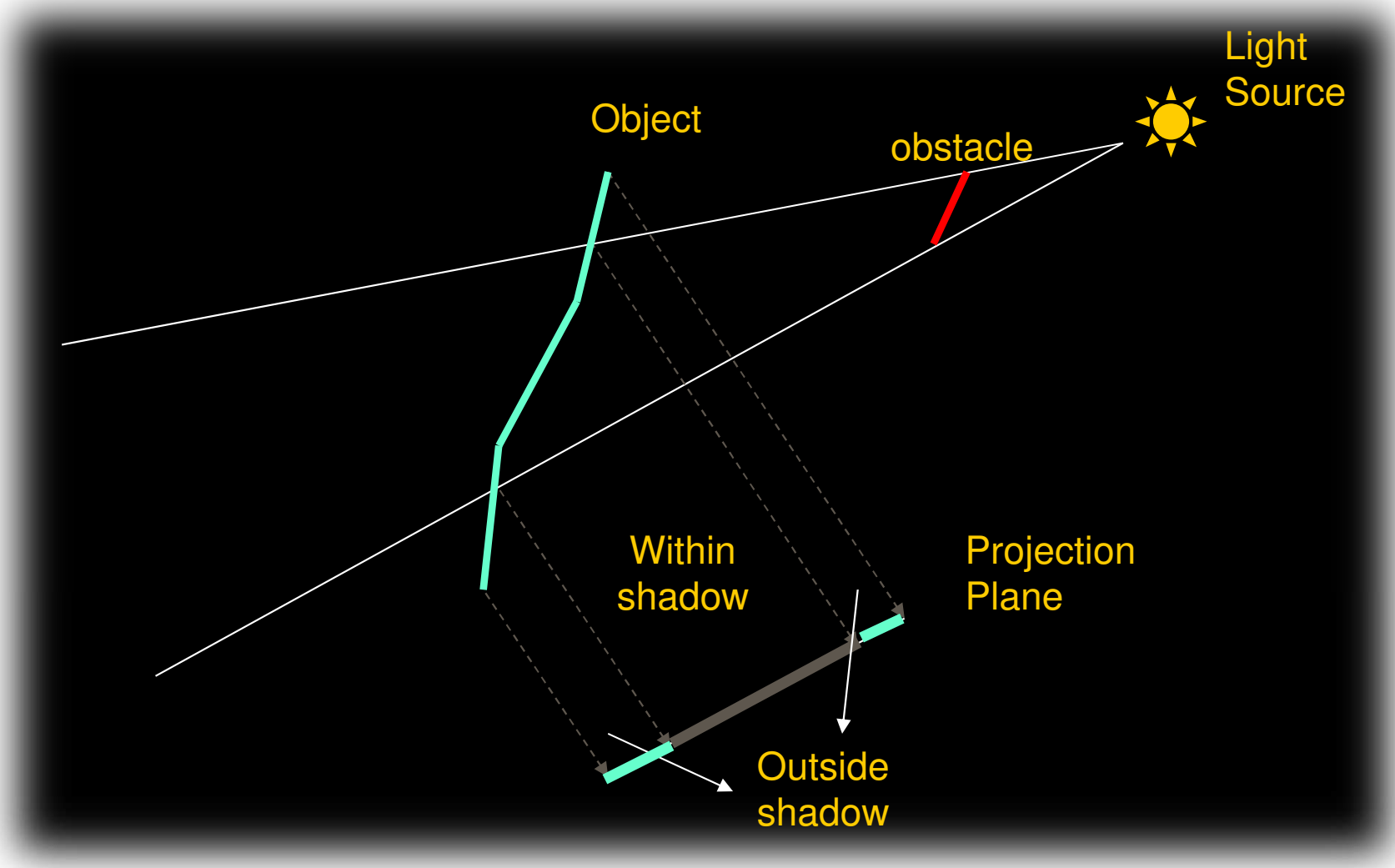




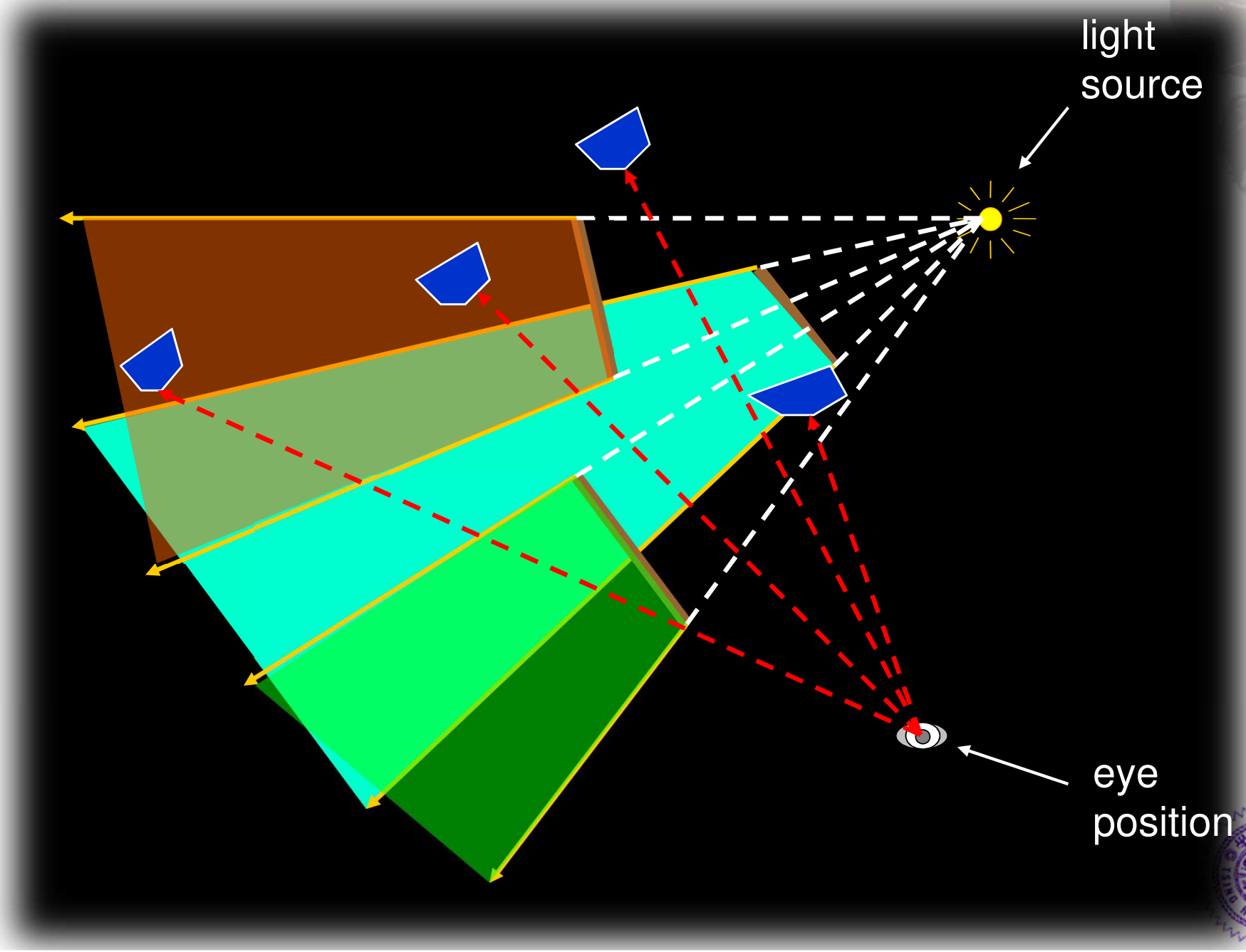


Shadow Volume

- **Shadow Region**



Shadow Volume



Shadow Volume Algorithm

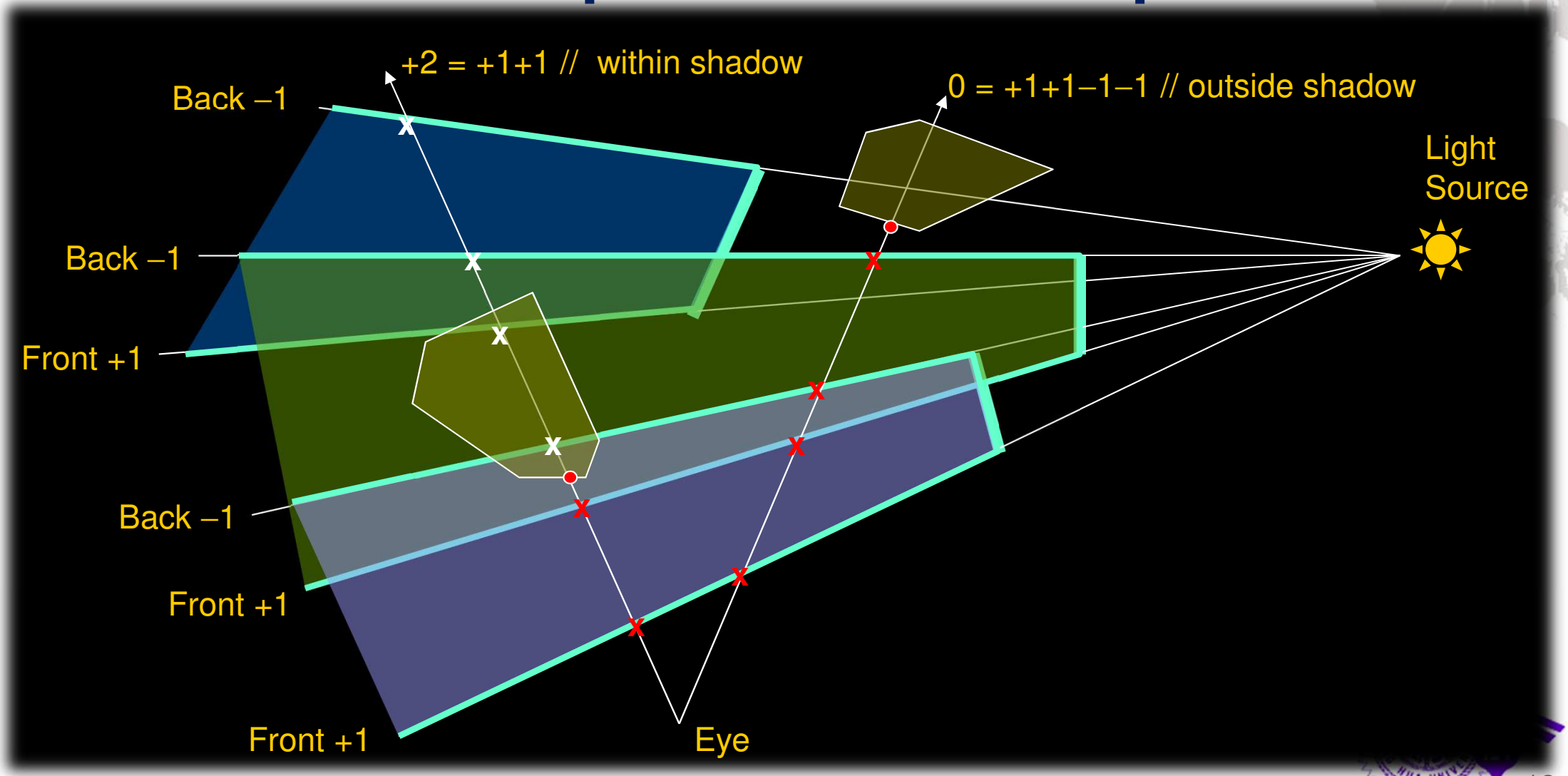
- Generate shadow volumes
- Generate depth buffer for the scene
- Update stencil buffer based on the Zpass or Zfail algorithm
- Render scene with lighting effect
  - If the corresponding stencil value is not zero, then it is inside shadow
  - If the corresponding stencil value is zero, then it is outside shadow

Shadow Volume Algorithm

- Stencil Buffer Update Rules
  - Zpass Algorithm
    - Zpass for front face shadow volume polygons: +1
    - Zpass for back face shadow volume polygons: -1
    - Zfail for either front or back face shadow volume polygons: No Update
  - Zfail Algorithm
    - Zfail for front face shadow volume polygons: -1
    - Zfail for back face shadow volume polygons: +1
    - Zpass for either front or back face shadow volume polygons: No Update

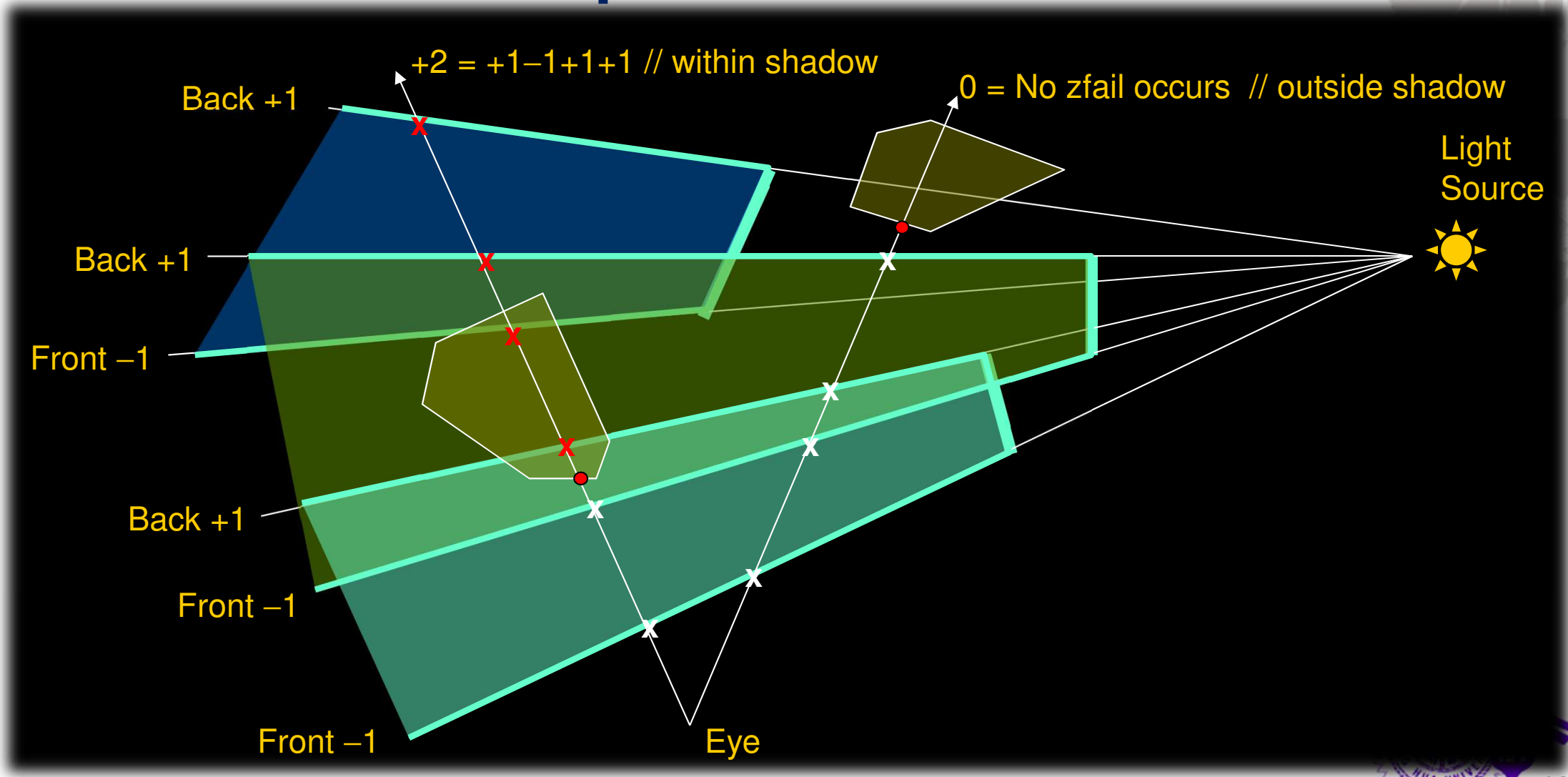
Shadow Volume

- **Stencil Buffer Update Rules: on Zpass**



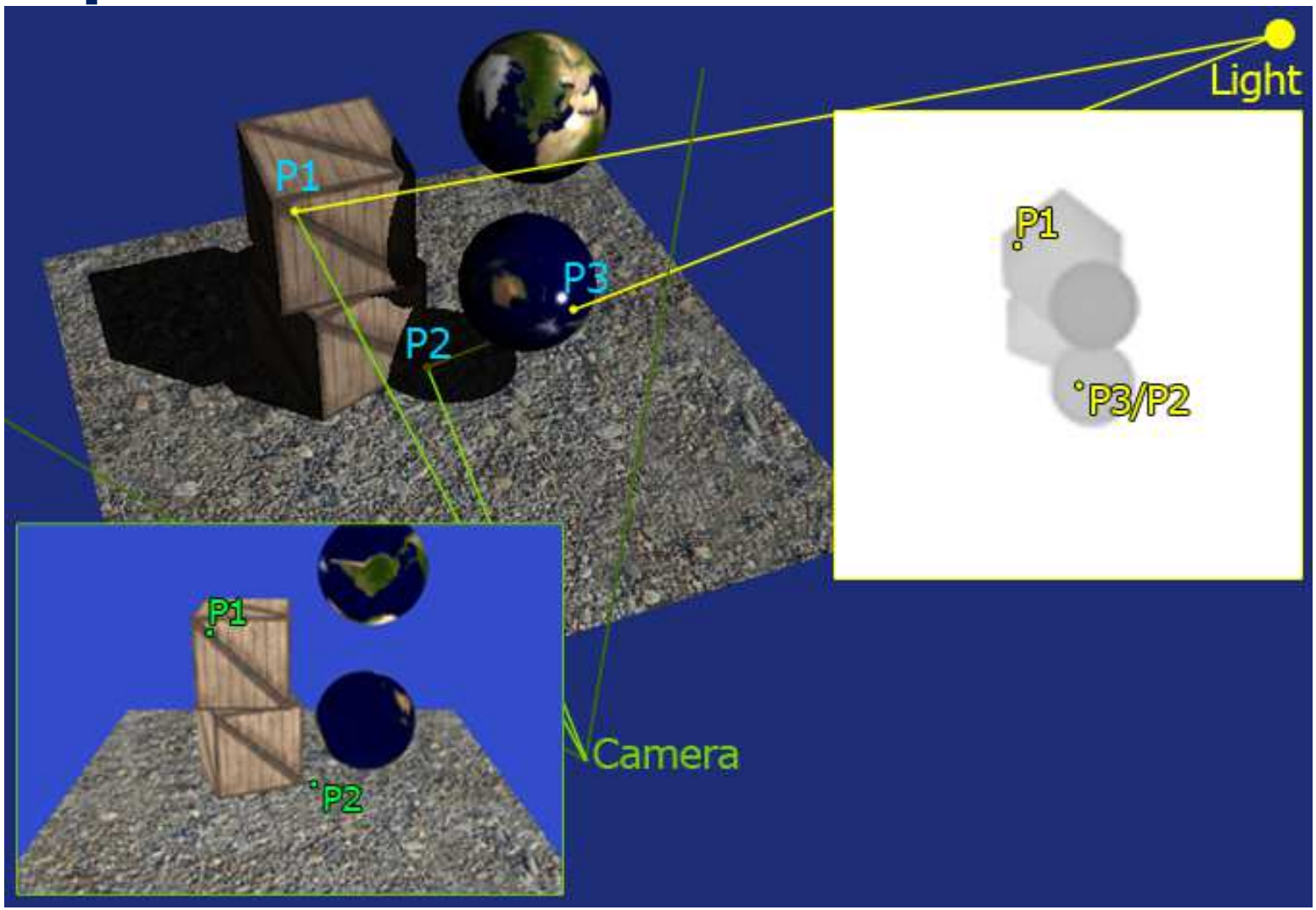
Shadow Volume

- **Stencil Buffer Update Rules: on Zfail**



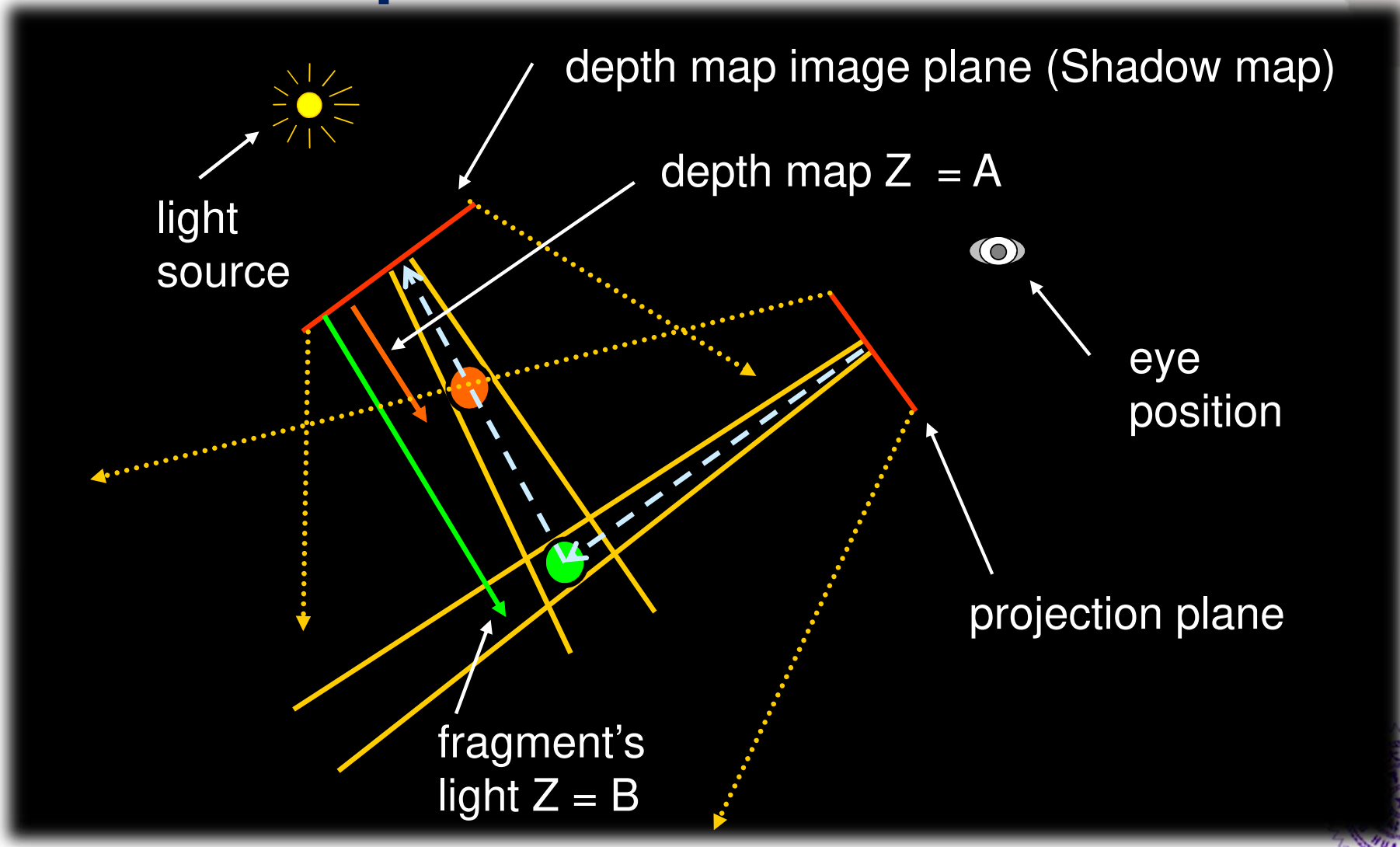
Shadow Mapping

- Example



Shadow Mapping

- **Basic Concept**

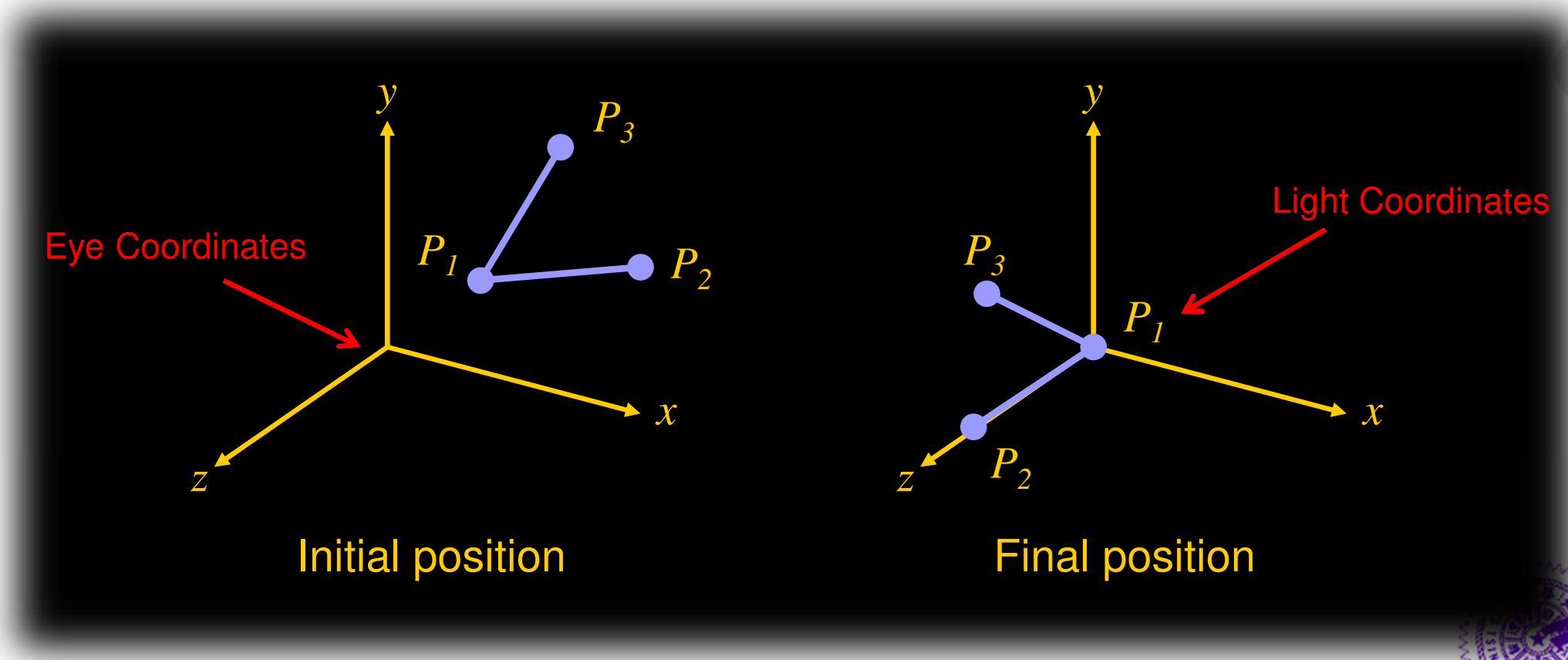


Shadow Mapping Algorithm

- Create the shadow (depth) map from the light's point of view
- Render the scene from camera's point of view
  - Transform the coordinates from camera to light coordinates
  - Compare the coordinates with the light depth map
  - If the depth test fail, then it is in shadow; otherwise, it is not in shadow

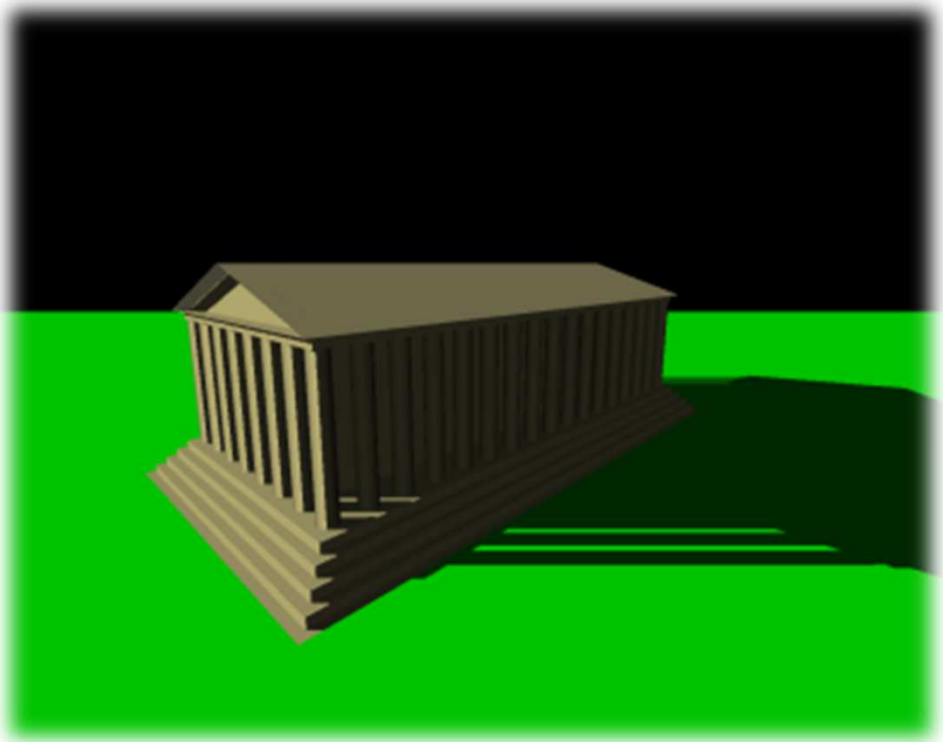
Coordinates Transformation

- From eye coordinates to light coordinates
- Similar to the viewing transformation

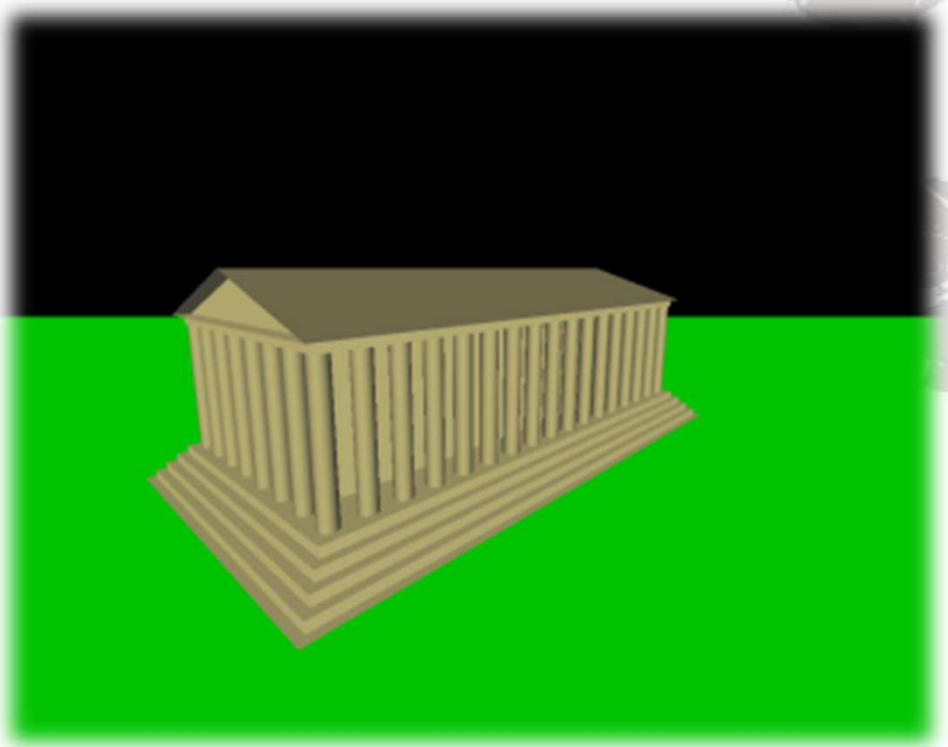


Shadow Mapping Illustration

- With and without shadows



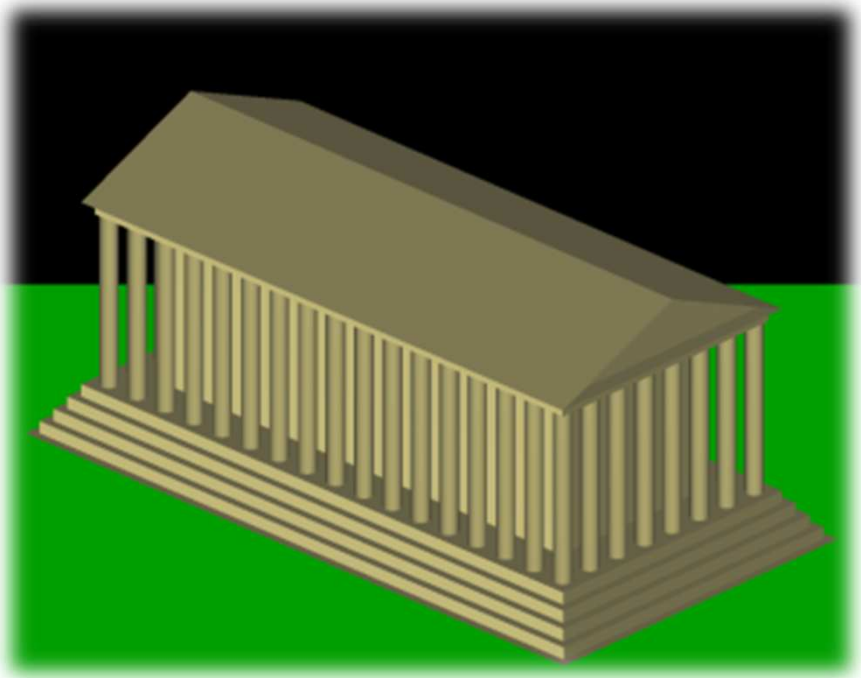
with shadows



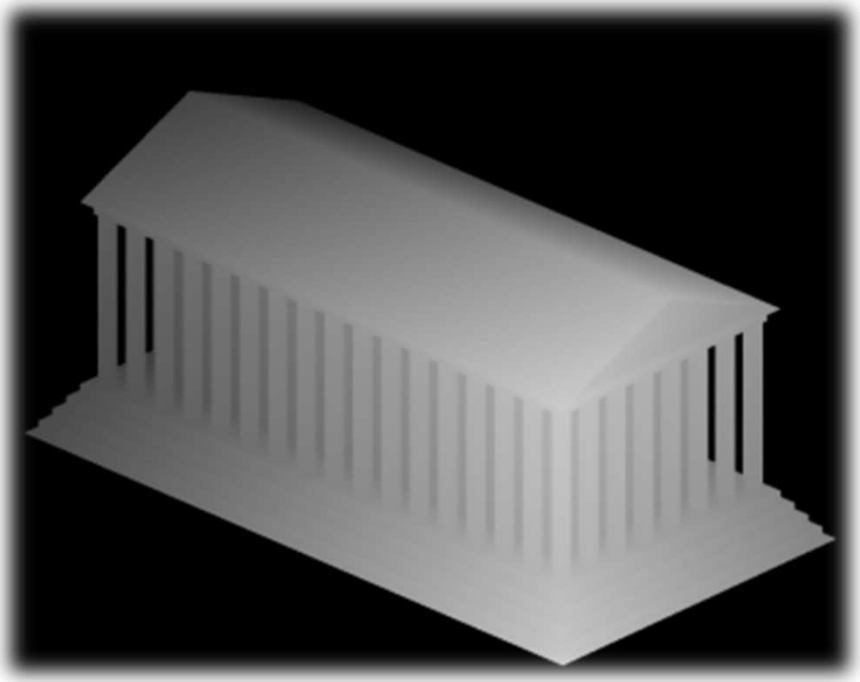
without shadows

Shadow Mapping Illustration

- The scene from the light's point-of-view



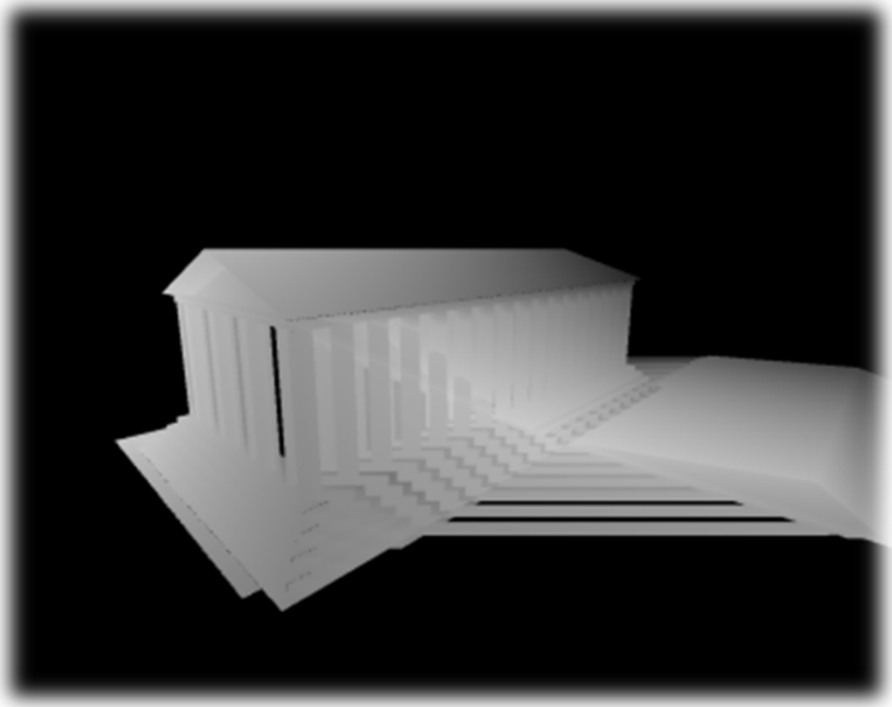
Scene rendered from light view



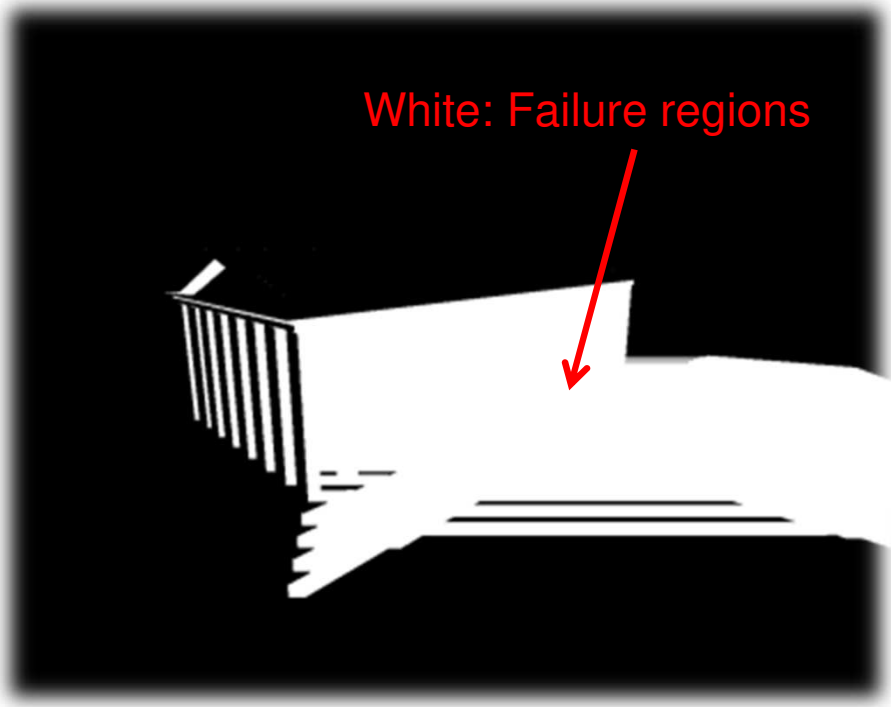
Depth map from light view

Shadow Mapping Illustration

- Comparing light distance to light depth map



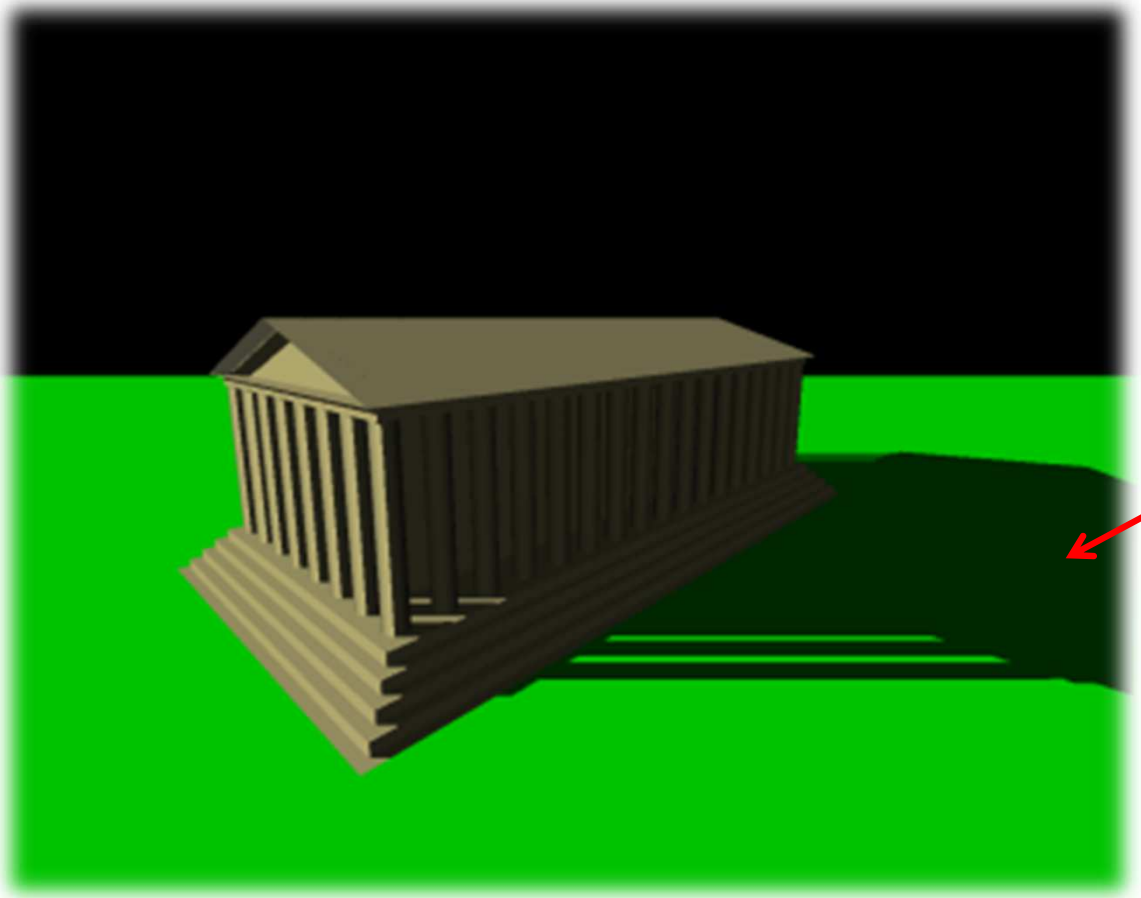
Depth map projected onto scene



Depth map test failure

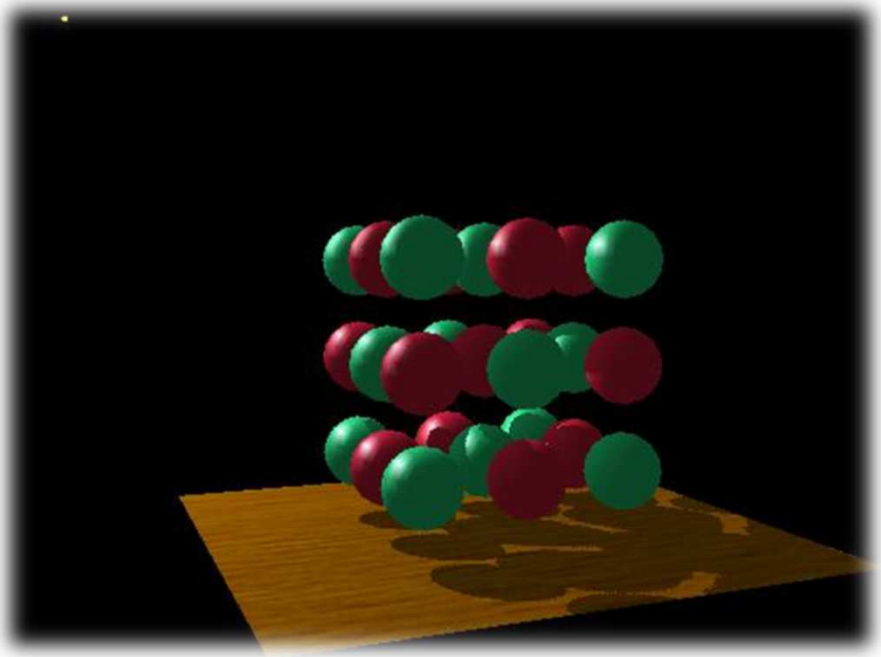
Shadow Mapping Illustration

- **Final Result**

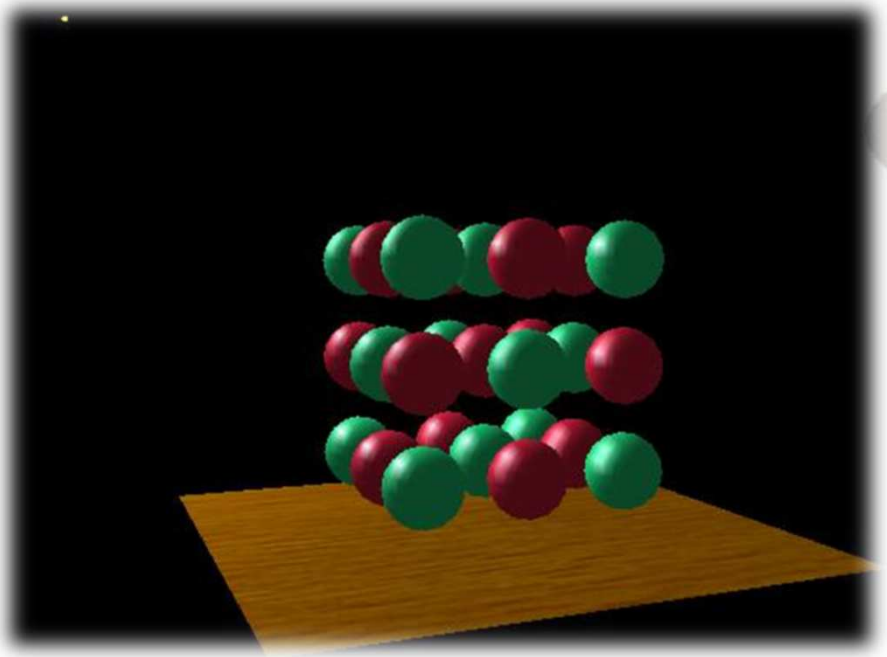


Shadow Mapping Illustration

- Another Example



with shadows

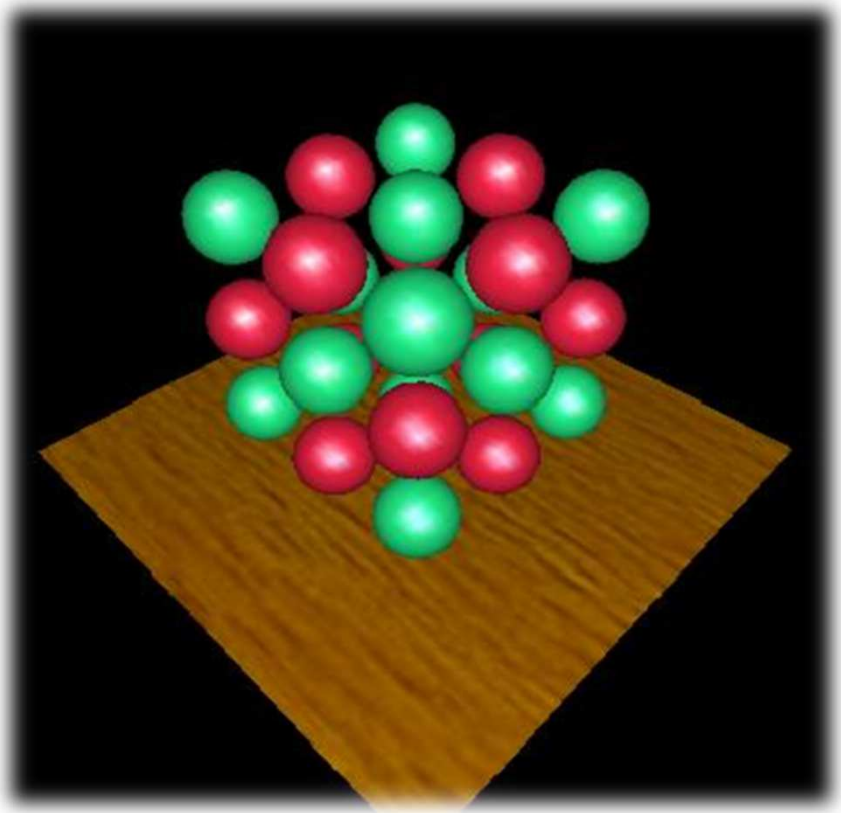


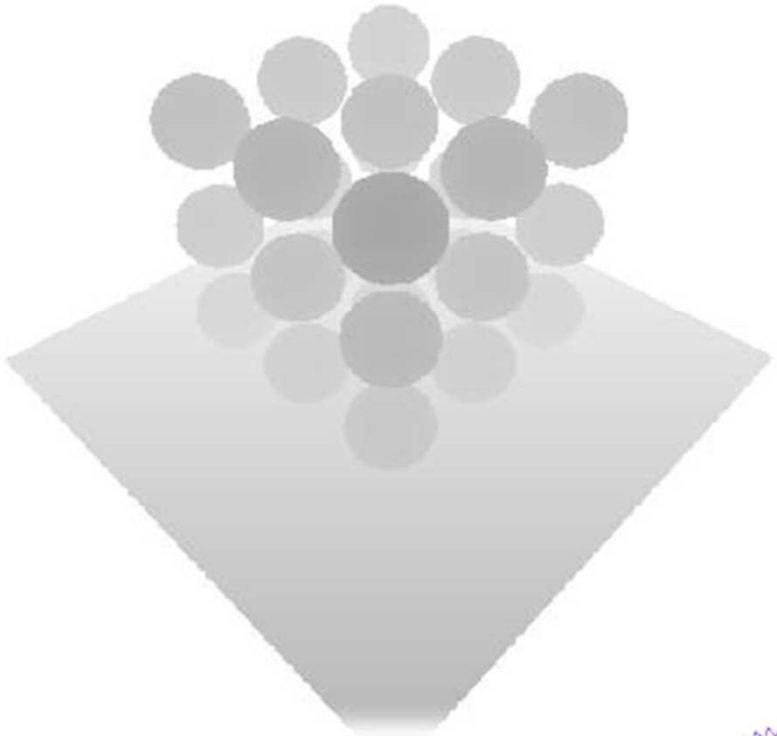
without shadows

Example from NVIDIA's GDC2001 presentation

Shadow Mapping

- The scene from the light's point-of-view

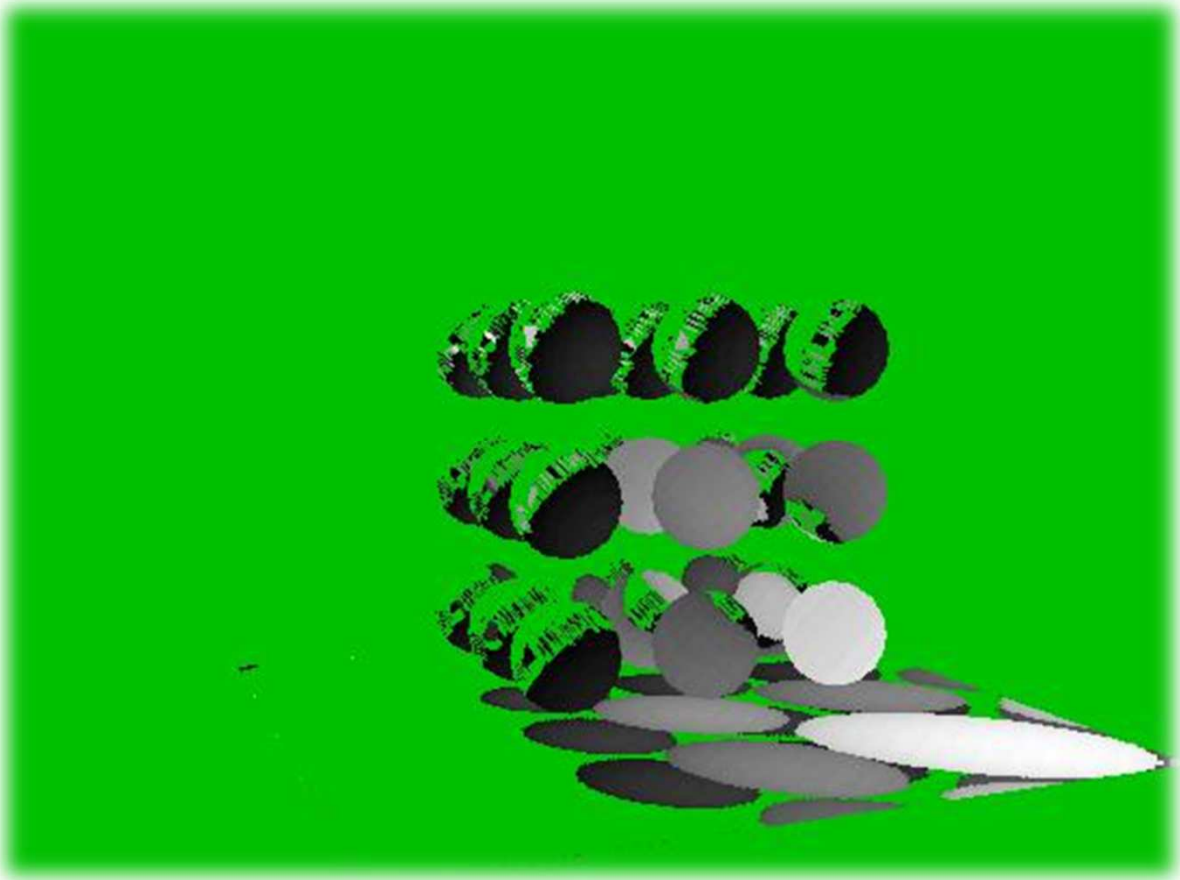




Shadow Mapping

- Comparing light distance to light depth map

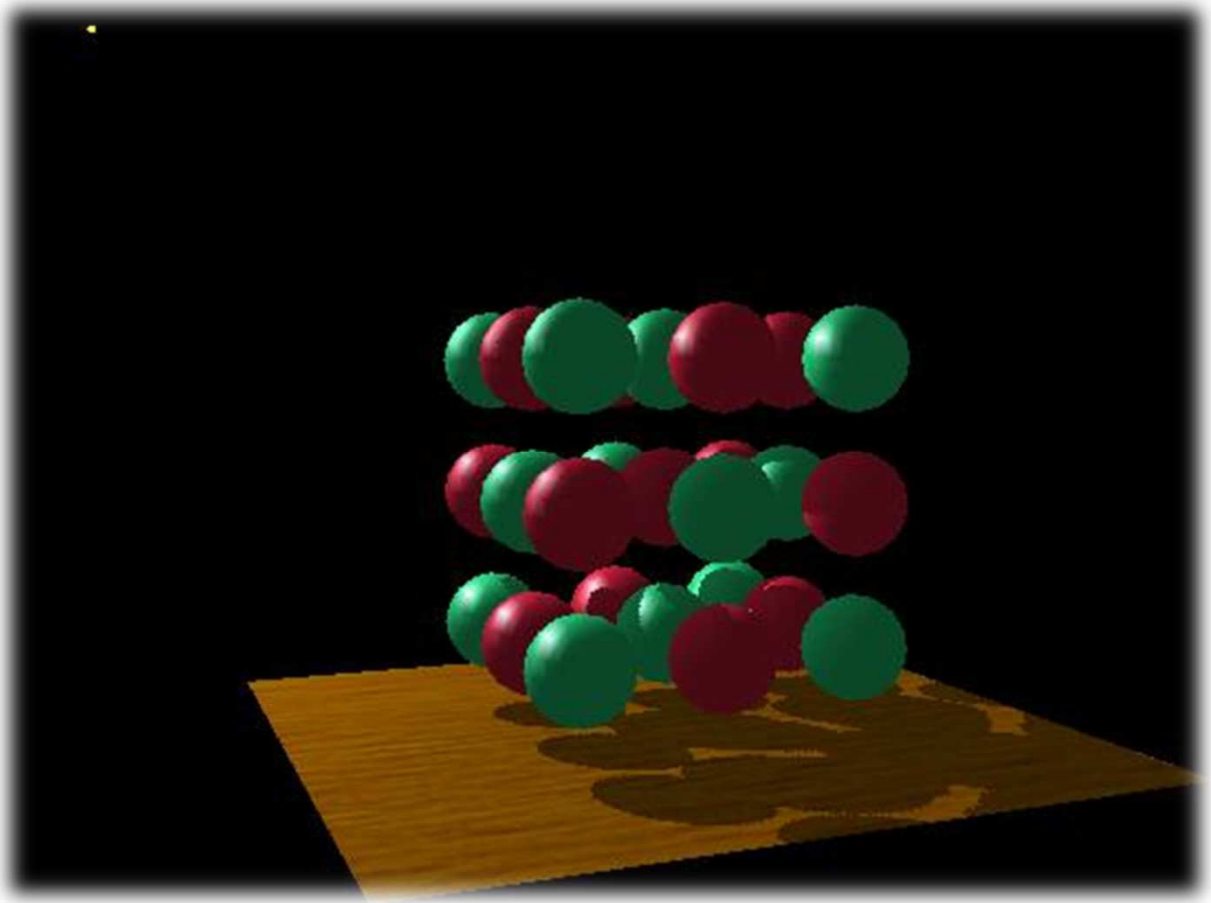
Green is where the light planar distance and the light depth map are approximately equal



Non-green is where shadows should be

Shadow Mapping

- **Results**



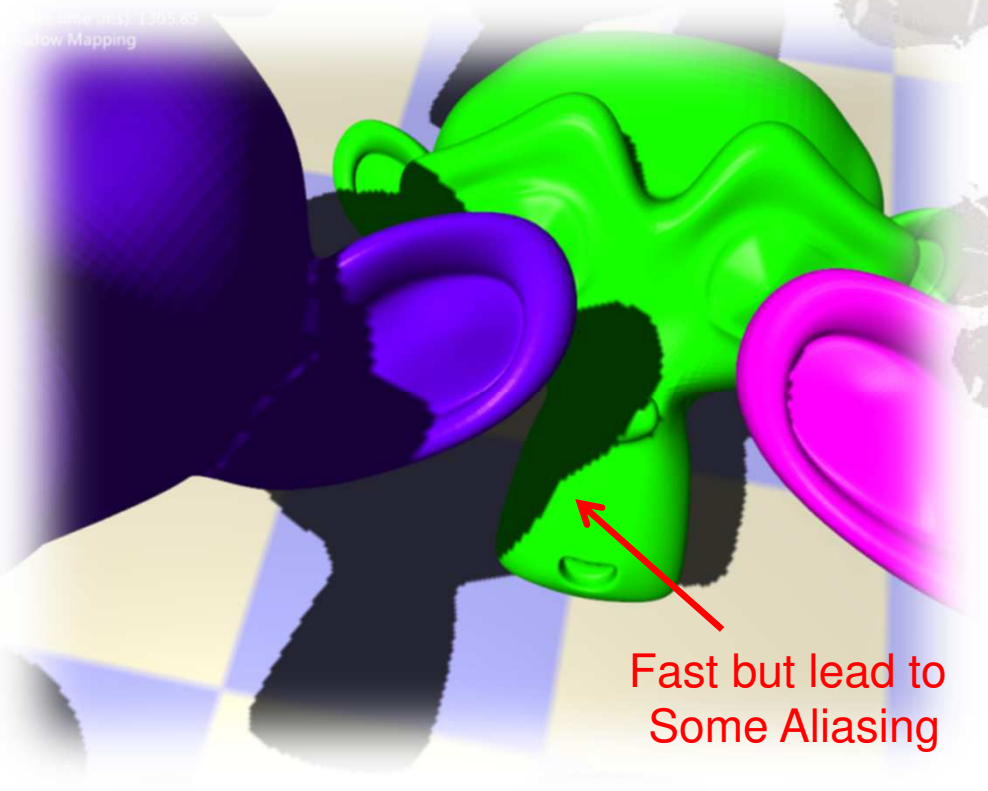
Comparison

- Shadow Volume
  - Might result in large amount of shadow volumes
  - More accurate
  - Slow due to render extra shadow volumes
- Shadow Map
  - No extra polygon is generated
  - Less accurate. Depends on shadow map resolution
  - Fast for only applying a coordinate transformation

Comparison

- **Quality vs. Performance**

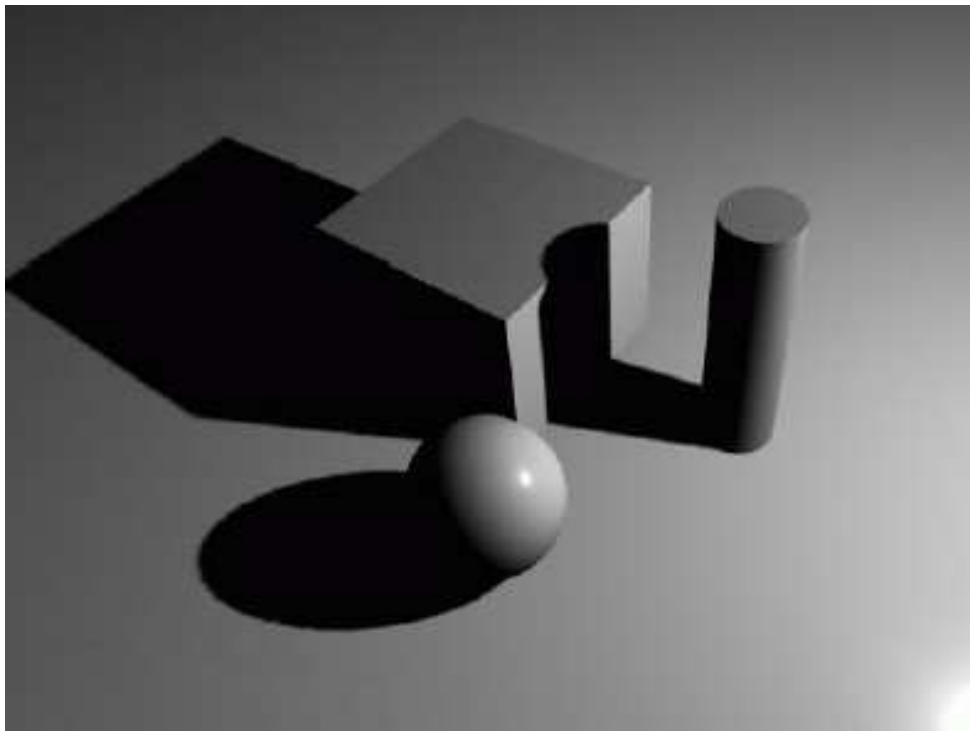
Shadow Volume



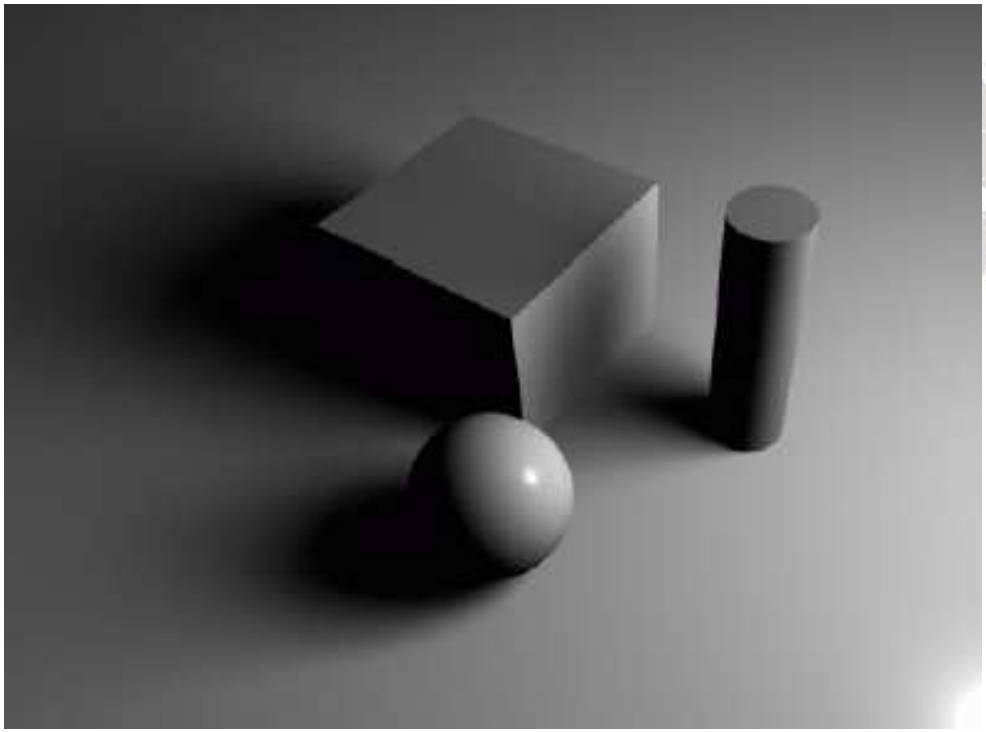
Shadow Mapping

Soft Shadow

- **Difference between Hard Shadow and Soft Shadow**



Hard Shadow



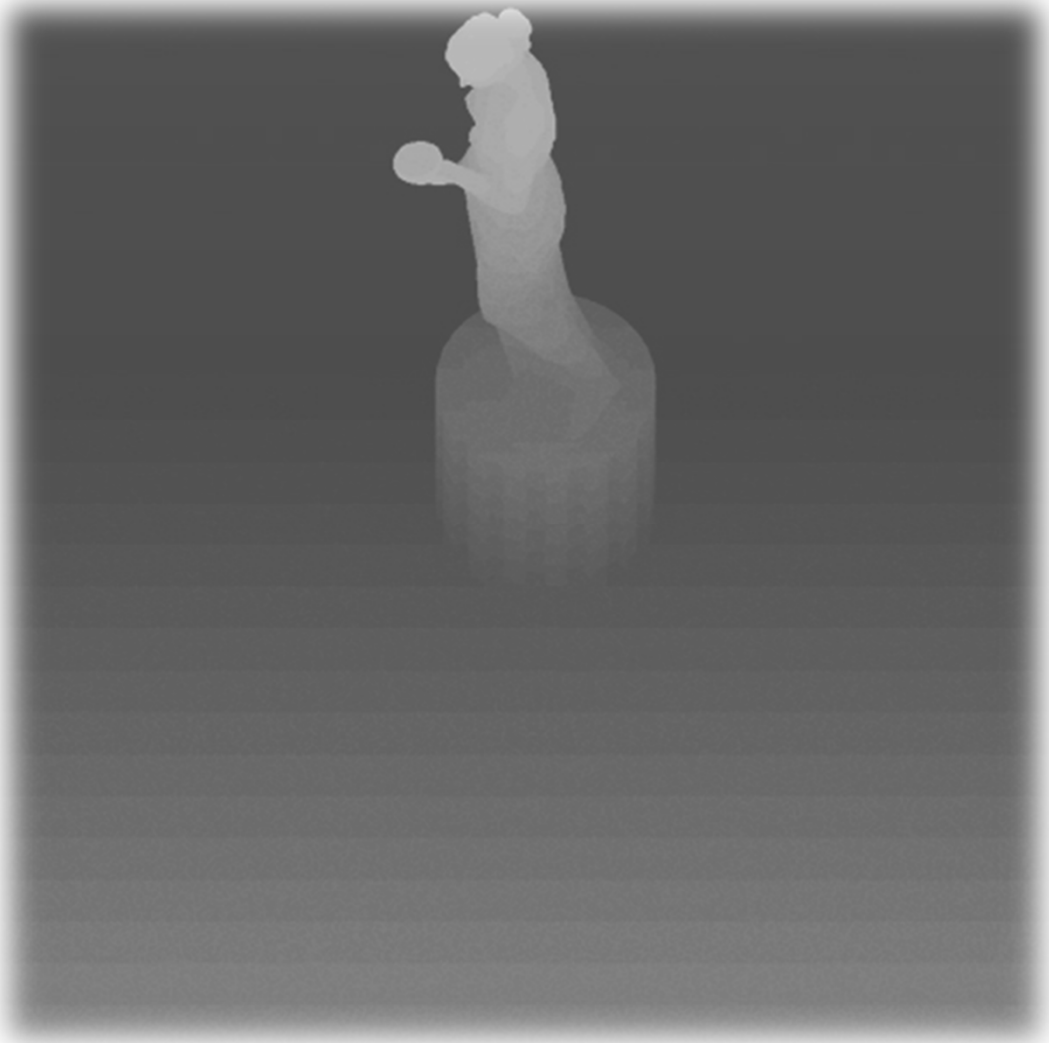
Soft Shadow

Soft Shadow

- **Soft Shadow Technique**

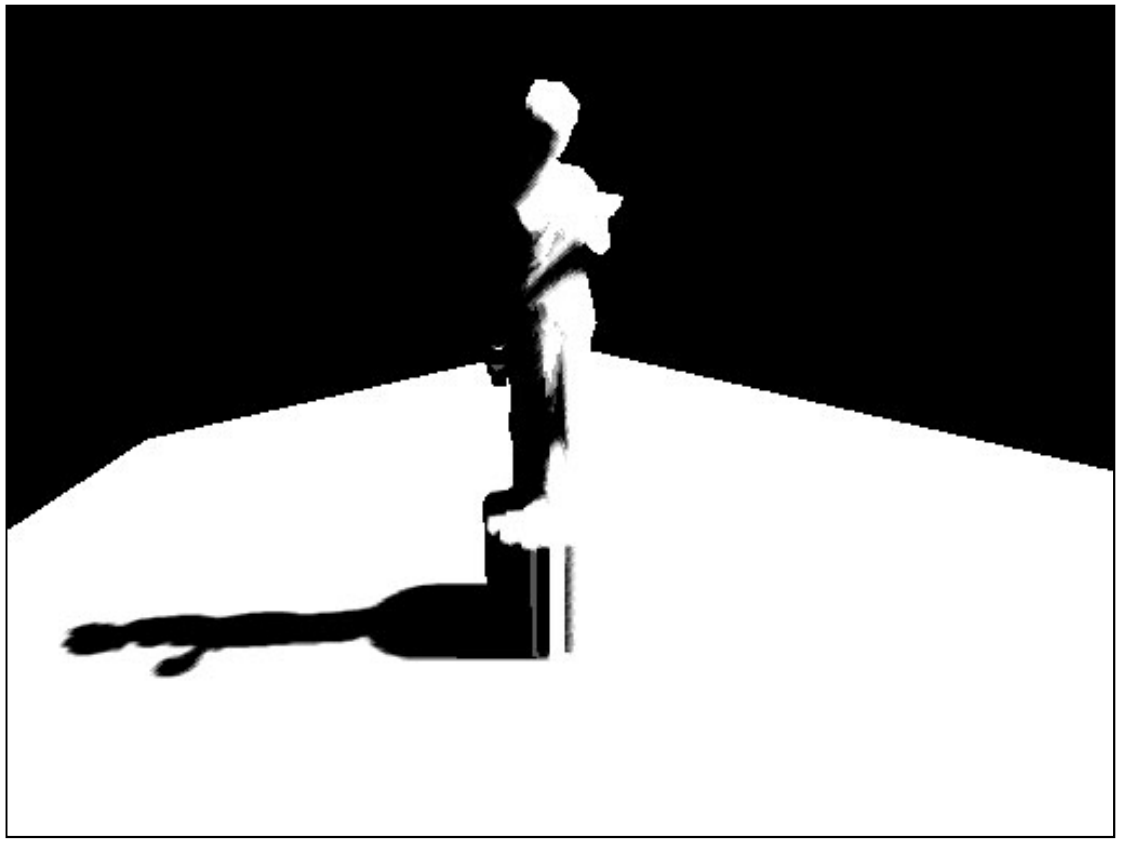
Soft Shadow

- **Step 1: Render the shadow map from light view**



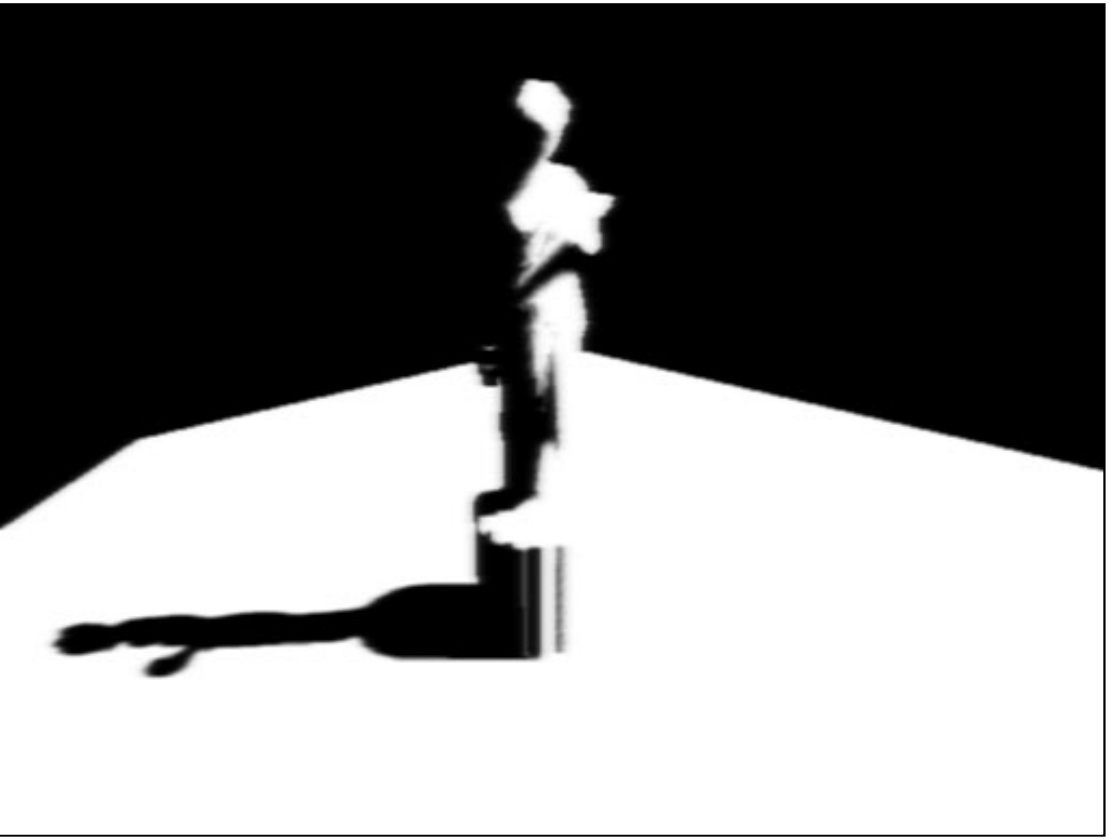
Soft Shadow

- Step 2: Rendering the shadowed scene into a buffer



Soft Shadow

- Step 3: Blurring the screen buffer



After first pass of Gaussian blur

After second pass of Gaussian blur

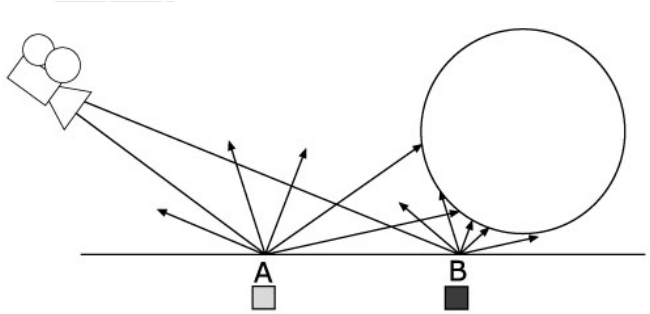
Soft Shadow

- **Step 4: Rendering the shadowed scene (with a spot light)**

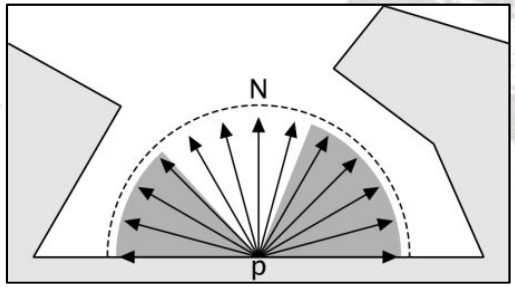
Soft Shadow

- Quality Comparison

Ambient Occlusion



- Calculate how each point is exposed in a scene to ambient lighting
- A cheap way to create more realistic ambient illumination



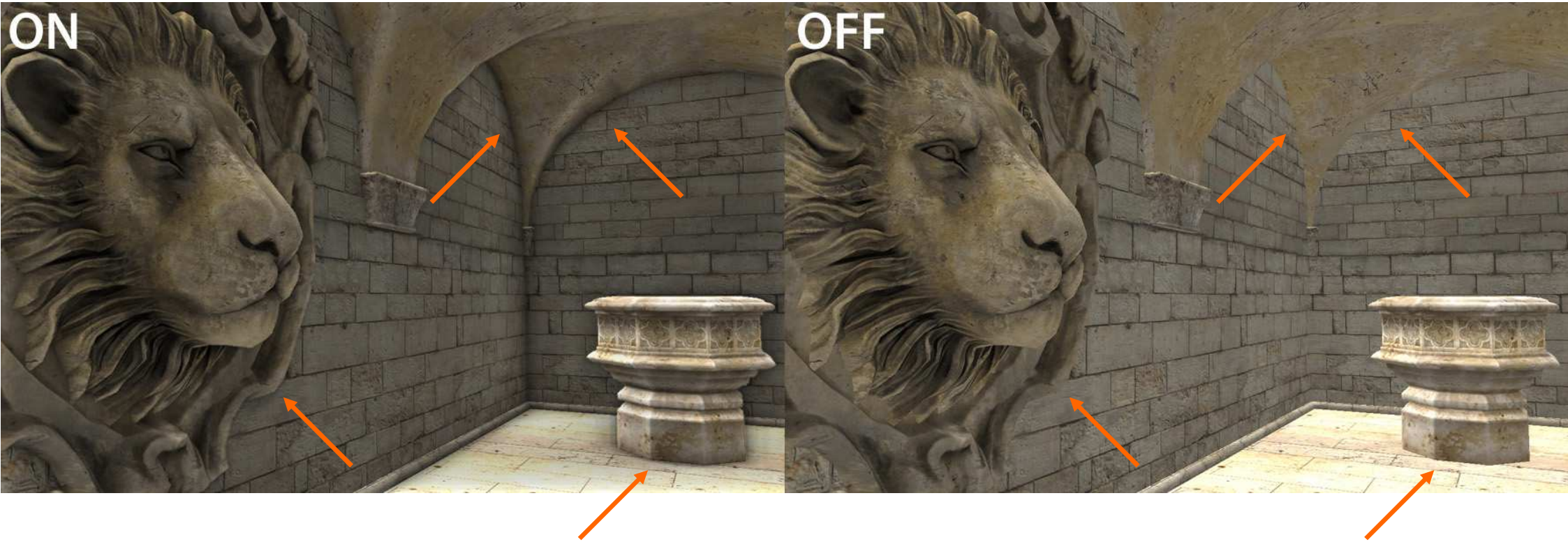
Diffuse Only

Ambient Occlusion

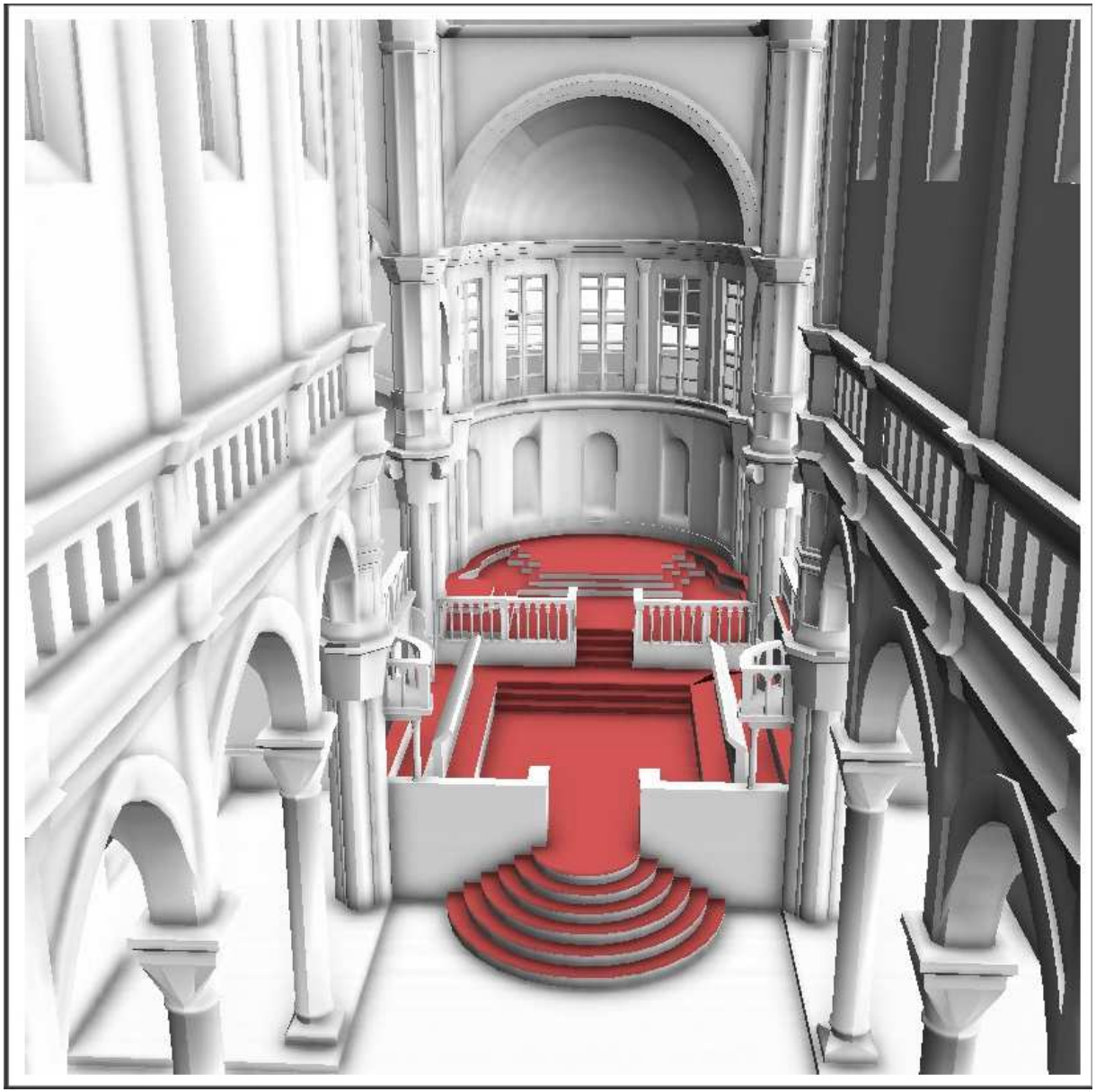
Combined

Ambient Occlusion

- Comparison



Ambient Occlusion



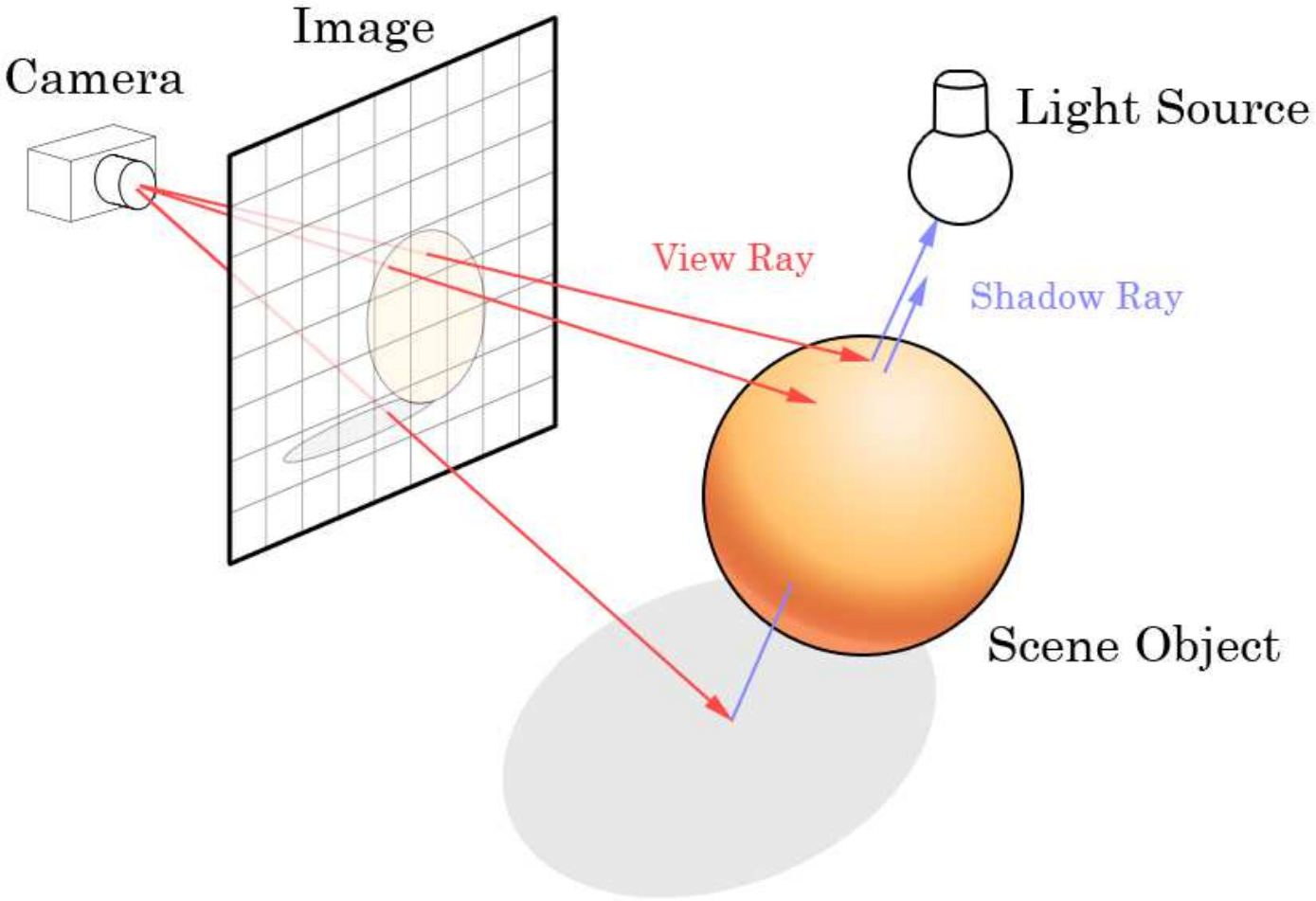
Gouraud + Ambient Occlusion

Ambient Occlusion

Gouraud + Ambient Occlusion

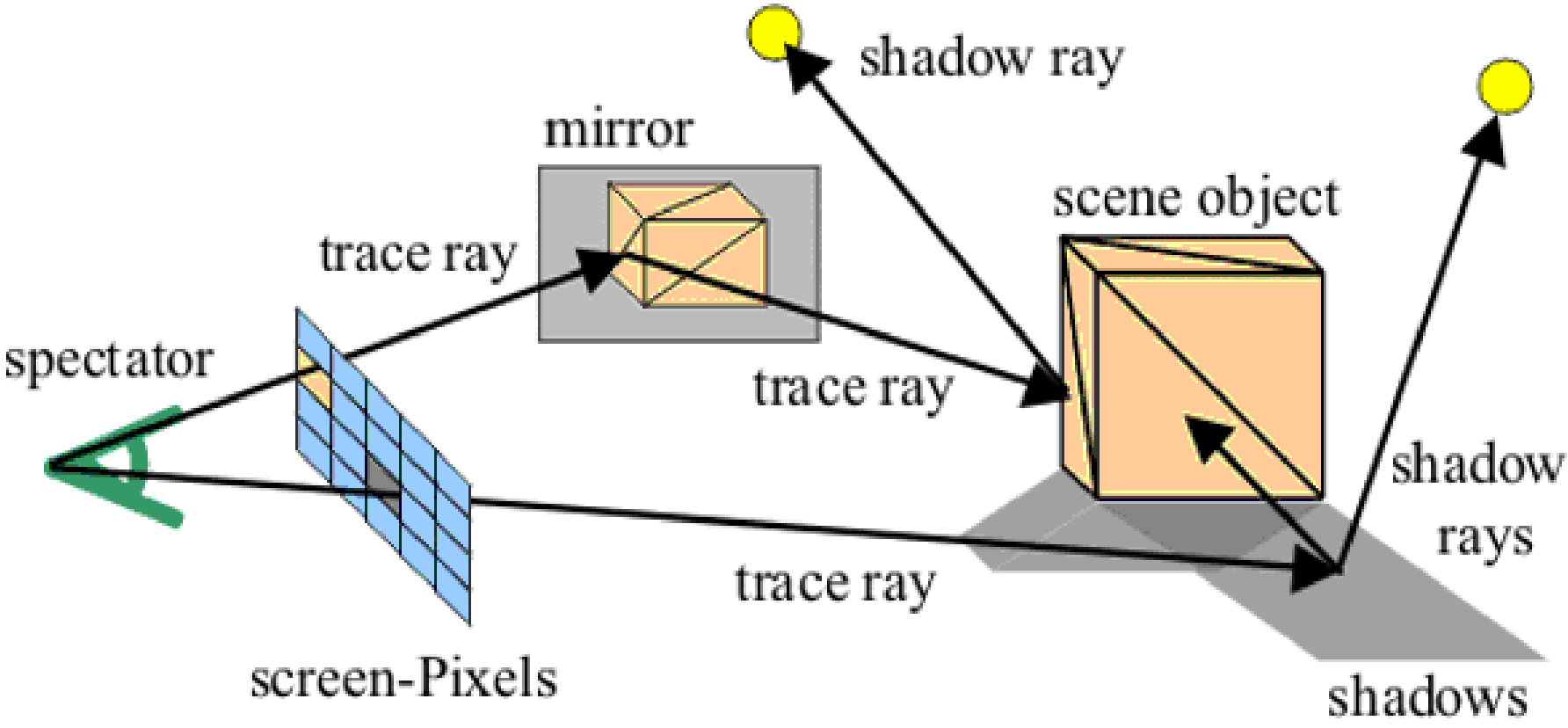
Shadows using Ray Tracing

- If the shadow ray is blocked by an object, then the pixel is in shadow



Shadows using Ray Tracing

- Multiple shadow rays with respect to multiple light sources



Q&A