

# Real-Time High Quality Rendering

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## Lecture 8: Real-Time Global Illumination (screen space)



# Announcements

- Homework 2 has been released!
- Homework 3 will be about Screen Space Reflection (SSR)
- GAMES101 homework submission
  - Still recruiting graders!
  - Now do not need to have taken GAMES101 before

# Last Lecture

- Precomputed Radiance Transfer (cont.)
  - SH for glossy transport
  - Wavelet
- Real-Time Global Illumination (in 3D)
  - Reflective Shadow Maps (RSM)
  - Light Propagation Volumes (LPV)
  - Voxel Global Illumination (VXGI)

# Today

- Finishing up
  - Light Propagation Volumes (LPV)
  - Voxel Global Illumination (VXGI)
- Real-Time Global Illumination (screen space)
  - Screen Space Ambient Occlusion (SSAO)
  - Screen Space Directional Occlusion (SSDO)
  - Screen Space Reflection (SSR)

# Light Propagation Volumes (LPV)

光传播体积

# Light Propagation Volumes (LPV)

- First introduced in CryEngine 3
  - Fast performance and good quality



# Light Propagation Volumes (LPV)

- Key problem

- Query the radiance from any direction at any shading point

查询任意点上任意方向的 radiance

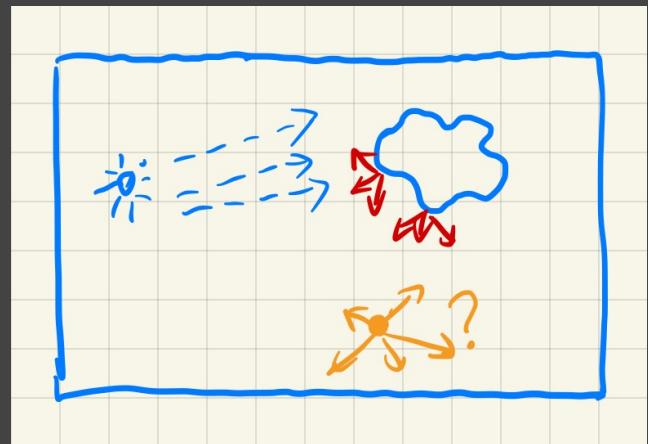
- Key idea

- Radiance travels in a straight line and does not change

\* radiance 在传播过程中是不变的.

- Key solution

- Use a 3D grid to propagate radiance from directly illuminated surfaces to anywhere else



将区域划分为3D网格

将辐射 radiance 从直接照明的 surface  
传播到其他任何位置.

# Light Propagation Volumes (LPV)

- Steps

四点行为源点光源，接受到直接光

1. Generation of radiance point set scene representation
2. Injection of point cloud of virtual light sources into radiance volume 将虚拟光源的点云注入到辐射体中
3. Volumetric radiance propagation 体积 radiance 传播
4. Scene lighting with final light propagation volume 具有最终光传播体积的场景照明（渲染）

# Light Propagation Volumes (LPV)

- Step 1: Generation
  - This is to find directly lit surfaces 找到直接照明的表面
  - Simply applying RSM would suffice!
  - May use a reduced set of diffuse surface patches (virtual light sources)  
可使用一组减少的漫反射表面 patches  
«采样» <虚拟光源>

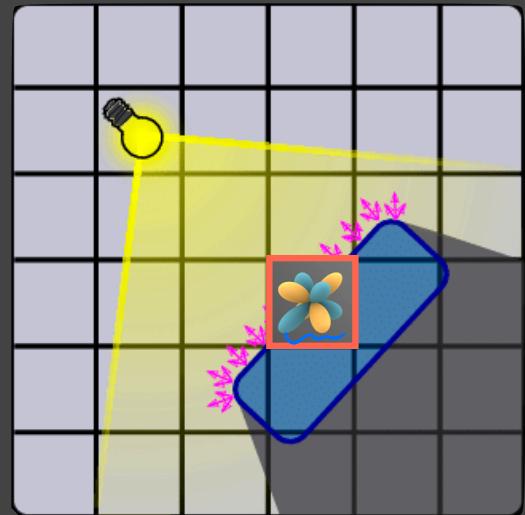


# Light Propagation Volumes (LPV)

- Step 2: Injection

将场景预先划分为3D网格

- Pre-subdivide the scene into a 3D grid
- 对每个网格单元，查找包围的虚拟光源  
For each grid cell, find enclosed virtual light sources
- 对它们的定向辐射度分布求和  
Sum up their directional radiance distribution
- Project to first 2 orders of SHs  
(4 in total)



# Light Propagation Volumes (LPV)

- Step 3: Propagation

对于每个网格单元，收集从其6个面中每

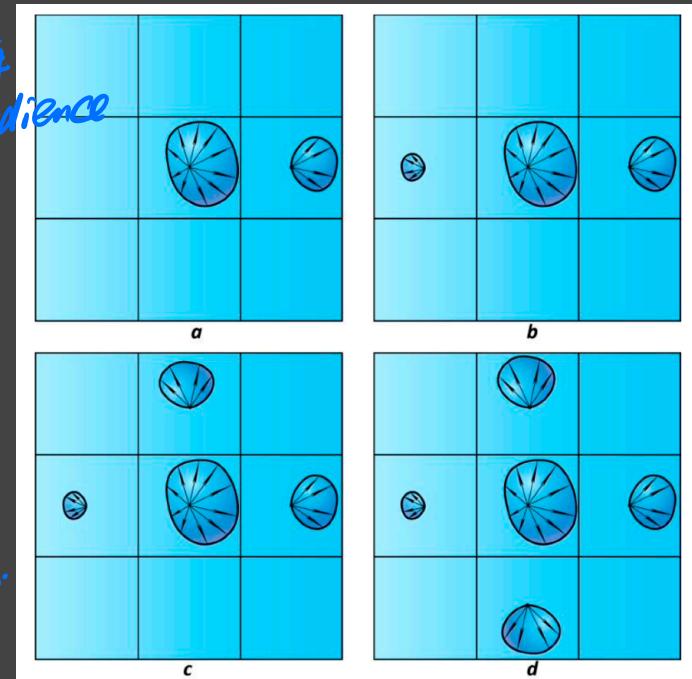
- For each grid cell, collect the radiance received from each of its 6 faces

重新用SH重新表示。

- Sum up, and again use SH to represent

- Repeat this propagation several times till the volume becomes stable

重复传播多次，直到体积变得稳定。



# Light Propagation Volumes (LPV)

- Step 4: Rendering

对于任一待着色点，查找它所在网格单元

- For any shading point, find the grid cell it is located in

获取网格单元中入射辐射  $\langle \text{从所有方向} \rangle$

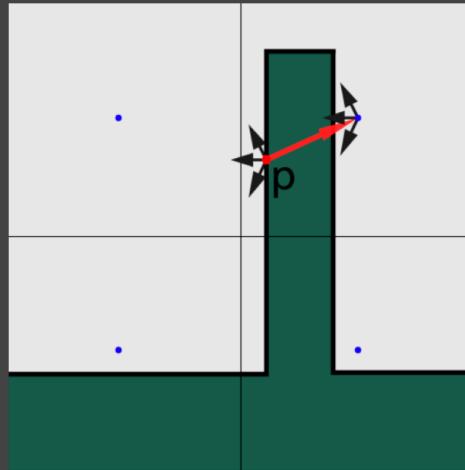
- Grab the incident radiance in the grid cell (from all directions)

- Shade

- Any problems? *Light leaking*

- Hint: look at point p

网格比例还要小。



# Light Propagation Volumes (LPV)

- Light leaking



LPV

Reference

# Light Propagation Volumes (LPV)

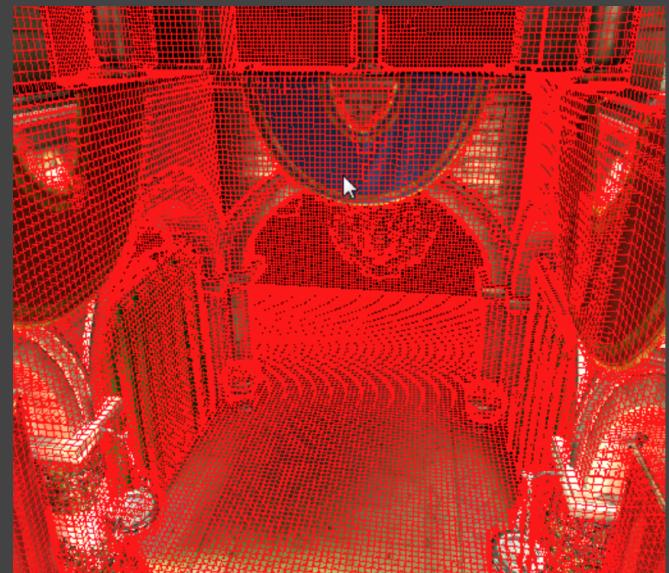


# Questions?

# Voxel Global Illumination (VXGI)

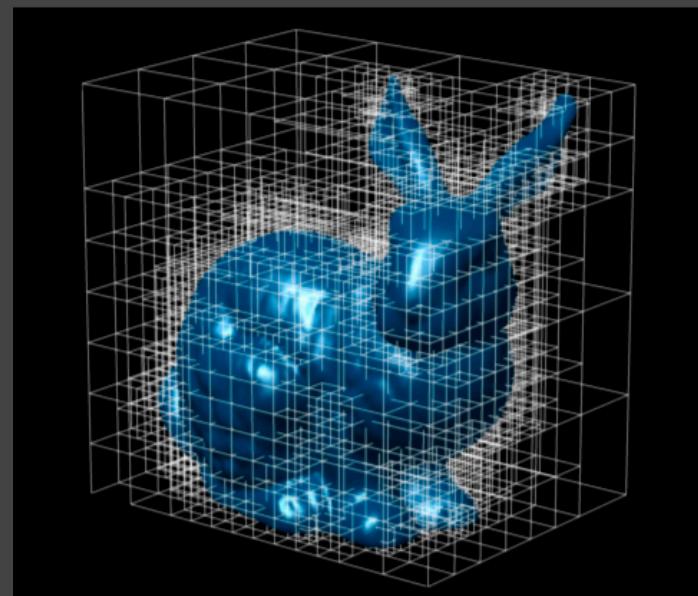
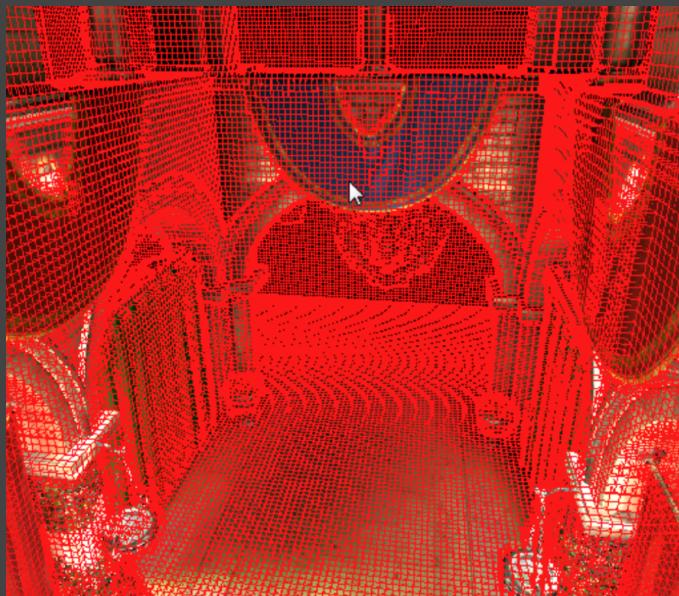
# VXGI

- Still a two-pass algorithm
- Two main differences with RSM
  - ① 直接照明要素 → (层次) 体素
    - Directly illuminated pixels -> (hierarchical) voxels
    - Sampling on RSM -> tracing reflected cones in 3D  
(Note the inaccuracy in sampling RSM)
  - ② RSM采样  
→ 3D追踪反射锥体



# VXGI

- Voxelize the entire scene 对整个场景体素化处理.
- Build a hierarchy 建立一个层级结构



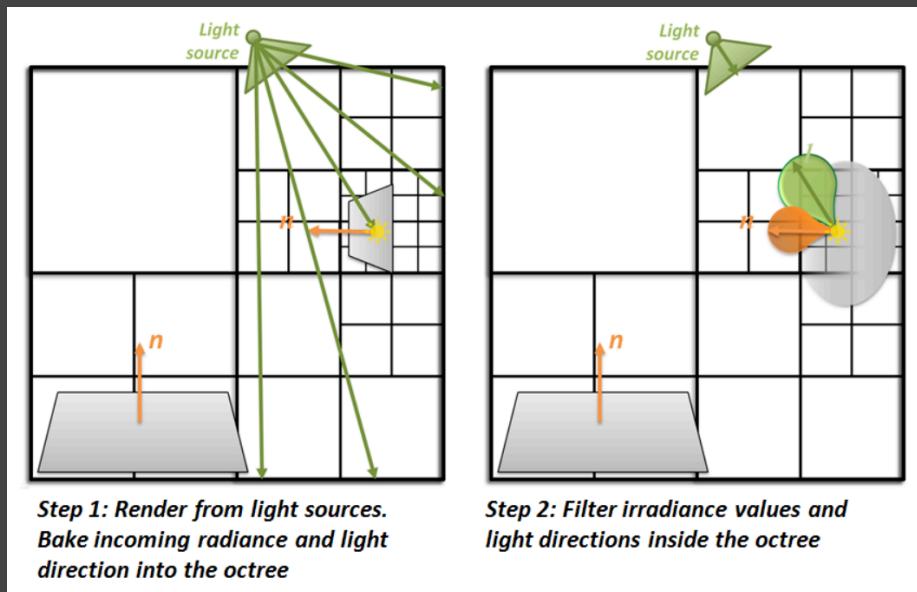
# VXGI

光源

- Pass 1 from the light

每个体素中有输入的光分布，光线分布。

- Store the incident and normal distributions in each voxel
- Update on the hierarchy 层次结构的更新。



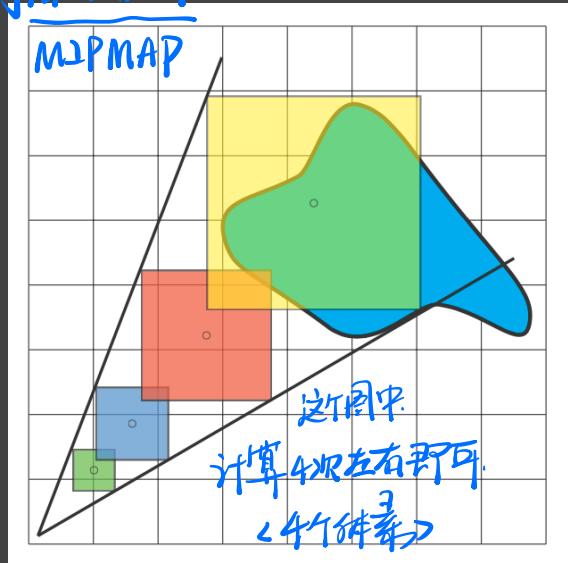
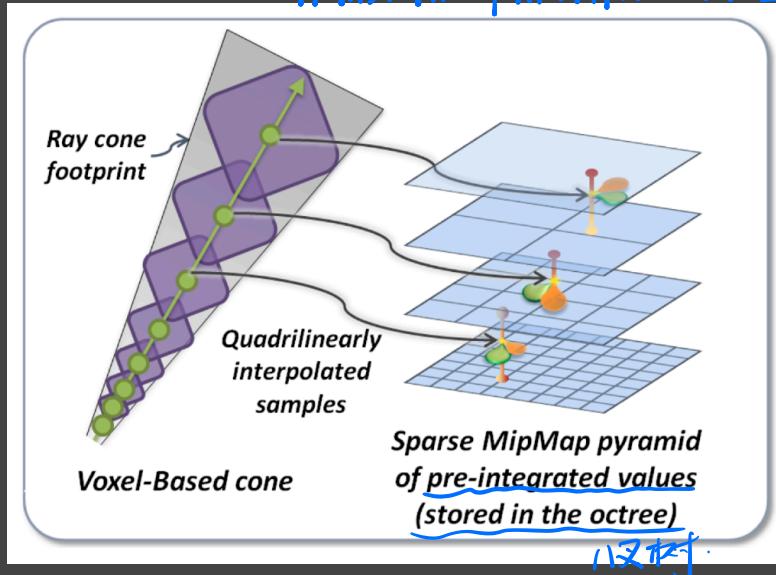
# VXGI

从 camera

- Pass 2 from the camera

- 对于 glossy 表面，向反射方向指向一个 cone (圆锥体)
  - For glossy surfaces, trace 1 cone toward the reflected direction
  - Query the hierarchy based on the (growing) size of the cone

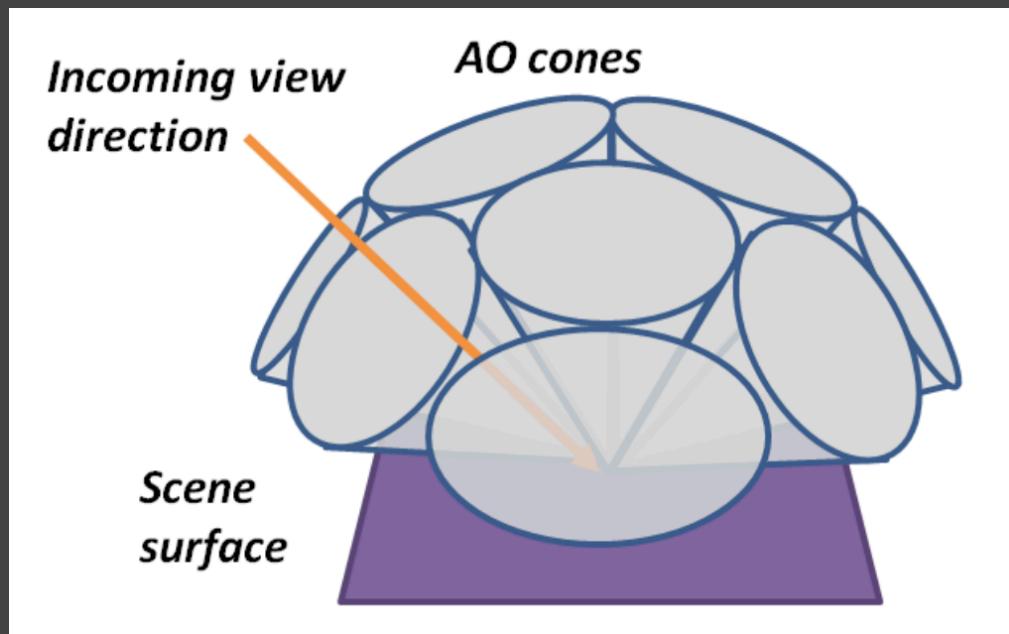
根据圆锥体的(增长)大小查询层级结构



# VXGI

对于漫反射 追踪八个圆锥体

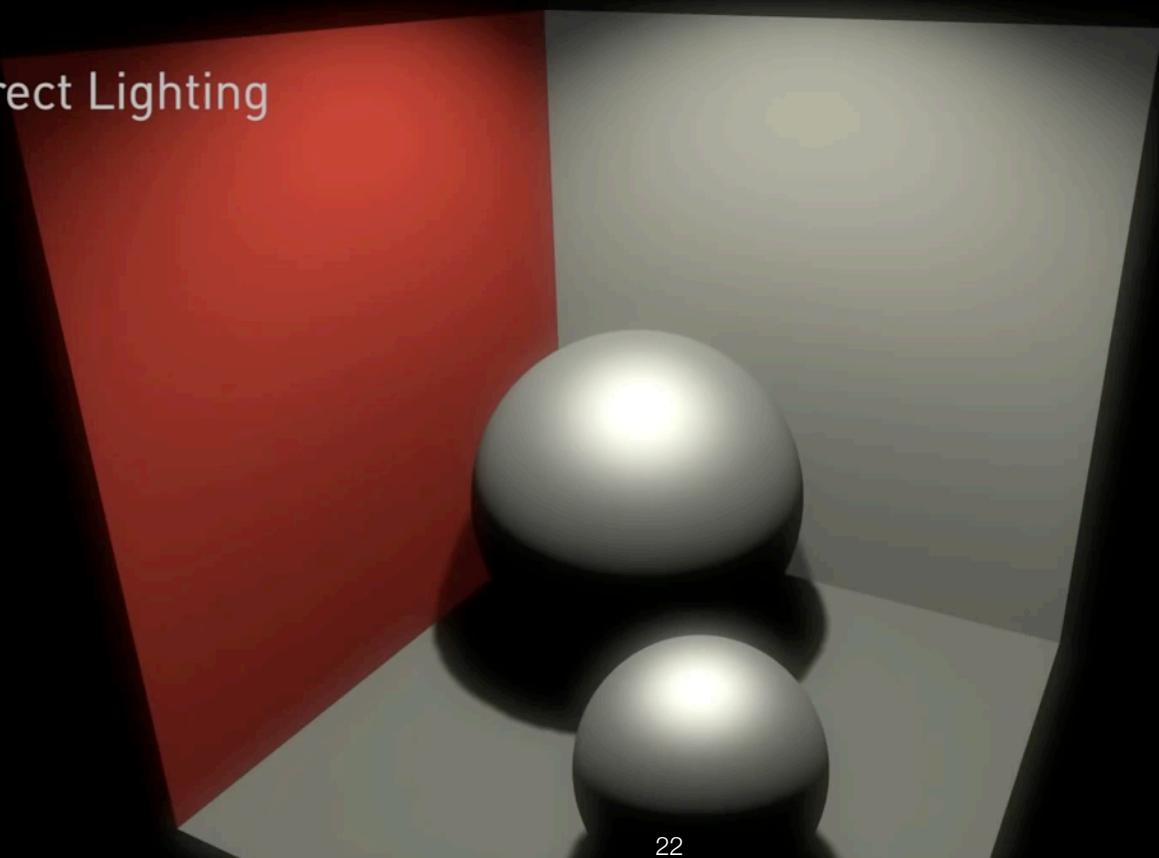
- For diffuse, trace several cones (e.g. 8)



# VXGI

- Pretty good results, close to ray tracing

Direct Lighting

A 3D rendering of two spheres in a scene with direct lighting. The spheres are white and black, positioned in front of a large red plane and a light gray wall. The lighting is dramatic, casting strong shadows and highlights on the spheres and the surrounding surfaces.

# Questions?

# Today

- Finishing up
  - Light Propagation Volumes (LPV)
  - Voxel Global Illumination (VXGI)
- Real-Time Global Illumination (**screen space**)
  - Screen Space Ambient Occlusion (SSAO)
  - Screen Space Directional Occlusion (SSDO)
  - Screen Space Reflection (SSR)

# GI in Screen Space

- What is “screen space”?
  - Using information only from “the screen” 只使用来自“屏幕”信息
  - In other words, **post processing** on existing renderings  
对现有渲染进行后处理



[Xin et al. Lightweight Bilateral Convolutional Neural Networks for Interactive Single bounce Diffuse Indirect Illumination]