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CS 563 Advanced Topics in Computer Graphics

Sampling Light Sources and Volume Scattering

Introduction

- Motivation
  - It is useful to be able to determine a subset space for relevant rays
  - Rays should represent paths of illumination with non-zero values
  - BSDF's distribution may be inefficient for sampling
  - Consider instead sampling the area in which the light is visible from the point being sampled
- This will be accomplished using Monte Carlo techniques
- Sampling Interface
  - Light::Sample_L()
  - Light::Pdf()

Point lights

- Lights with Singularities are relatively simple to sample...

- Sampling method towards light:
  - Refers to the sampling method from the PointLight object
  - Generates a vector pointing from the point to the light
  - Sampling distribution is always 1; there is only one ray

Point lights (cont.)

- Sampling method away from light:
  - A point light can potentially hit an entire sphere
  - The sphere is sampled uniformly
  - Sampling distribution is the same as the sphere
- PDF:
  - The light source is infinitesimal
  - You cannot sample something smaller than a point
  - Always returns 0

Spotlights

- Sampling method towards light and PDF:
  - Only one way to get to the light from any point
  - Only one possible ray can be generated
  - Uses the same implementations as point lights
- Sampling method away from light:
  - Uses a cone to model illumination
  - Samples from a uniform distribution over the directions encompassed by the cone

Directional lights

- Sampling method towards light:
  - Like the point light, sample is handled by the light object
- Sampling method away from light:
  - The direction of the ray is predefined
  - Consider the bounding sphere for the scene
  - Constructs a disk with the same radius as the sphere
  - Sample this disk using ConcentricSampleDisk()
  - Ensure that origin is outside of the bounding sphere

Directional lights (cont.)

- PDF:
  - The light has no area
  - Must return 0, since its impossible to sample
- Projection and Goniophotometric lights
  - Projection lights are analogous to spotlights
  - Goniophotometric lights are analogous to point lights

Area lights

- Area lights are closely tied to the shapes representing their areas
- Methods should generate samples on those shapes
- Shape Interface
  - Sampling method
  - Distribution function

Sampling Area lights

- Sampling method towards light:
  - Gets a point on the light by sampling the relevant shape
  - Generates ray to this point
  - Calculates radiance emitted at that point
- Sampling method away from light:
  - Gets a point on the light
  - Samples uniformly from a hemisphere of directions
  - Flips the direction based on the surface normal
- PDF:
  - Returns the value of the shape’s distribution

Sampling Shapes

- Disks
  - Uses ConcentricSampleDisk()
  - Scales based on radius
  - Shifts Z position based on height
  - How to handle partial disks? Discuss later.
- Triangles
  - Uses UniformSampleTriangle()
  - This method returns barycentric coordinates
  - These coordinates are then converted to a Point object

Sampling Shapes (cont.)

- Cylinders
  - Considered trivial; its basically a rectangle
- Spheres
  - Default sampling method uses UniformSampleSphere()
  - Improvement: Given a point being illuminated...
    - Sample the sphere along the visible solid angle
    - Sets a new coordinate system
    - Different cases for sampling points within sphere or outside of it
  - Sampling Distribution
    - Uniform sampling of the sphere from within
    - Uniform sampling of a cone from without

Shapesets

- Useful when a “shape” actually requires many shapes to be sampled
- Still implements the Shape interface
- Still needs a needs sampling method that is uniform over its surface
- Solution: Sample each shape according to a weighted CDF
  - Shapes are weighted proportionally to surface area
  - First, a random shape is chosen
  - Then, a uniform sample from that shape is returned

Infinite Area lights

- Represented by a sphere surrounding the entire scene
- Sampling method towards light:
  - Uniform sampling (as for the interior of a Sphere light) is used when no surface normal is provided
  - Otherwise, cosine-weighted distribution is used
  - Normal is used to construct an appropriate coordinate system
    - Z vector is based on the normal itself
    - X and Y vectors are arbitrarily constructed
    - They are perpendicular to Z and to each other

Infinite Area lights (cont.)

- Sampling method away from light:
  - Problem: How do we ensure that points and ray directions are distributed normally without a finite area?
  - Given: “uniformly distributed lines through the volume enclosed by a sphere can be generated by connecting two uniformely chosen points on [its] surface” (p. 710)
  - Solution:
    - Pick any two points from the surface of the bounding sphere of the scene
    - Connect these two points
    - Weight the ray according to a cosine distribution

Volume Scattering