Path tracing, Distributed ray tracing, Stochastic ray tracing, Monte Carlo ray tracing, Photon mapping, Bidirectional ray tracing, . . . OH MY!

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Trees vs. Paths

Recursive ray tracing

- **Fan-out** — More computation at deeper in tree
- Deeper segments contribute less to viewed pixel shades

![Diagram of a tree with a viewer, scene object, and light source showing recursive ray tracing concepts]
Trees vs. Paths

Recursive ray tracing

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Diagram:
- Light Source
- Fan-out
- Deeper segments contribute less to viewed pixel shades
- Scene Object
- Viewer
- Tree
Path tracing

- No fan-out — sampling rooted at the viewed pixel level
- Use *much* more (up to two orders of magnitude) sub-pixel sampling
- Need to be smart about:
  - Weighting samples
  - Picking direction to branch
Path tracing

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Ray Tracing Type Hierarchy

Ray Tracer

Recursive Ray Tracer

Stochastic Ray Tracer

a.k.a. Classic Ray Tracer

Distribution Ray Tracer

Path Tracer

Bidirectional Ray Tracing

Photon Tracer

a.k.a. Monte Carlo Ray Tracer

Photon Map
Ray Tracing Type Hierarchy

Ray Tracer

- Recursive Ray Tracer
  - a.k.a. Classic Ray Tracer
- Stochastic Ray Tracer
  - a.k.a. Monte Carlo Ray Tracer
  - Path Tracer
    - Bidirectional Ray Tracing
      - Photon Tracer
        - Photon Map

- Distribution Ray Tracer

- Oversample pixels
- Sample across: time, BRDF, lens area, etc.
- (Still a ray tree)
Ray Tracing Type Hierarchy

- Ray Tracer
  - Recursive Ray Tracer
    - a.k.a. Classic Ray Tracer
  - Stochastic Ray Tracer
    - a.k.a. Monte Carlo Ray Tracer
  - Distribution Ray Tracer
  - Path Tracer
    - Bidirectional Ray Tracing
    - Photon Tracer
    - Photon Map

- Don’t fan-out, trace a single path
Ray Tracing Type Hierarchy

- Ray Tracer
  - Recursive Ray Tracer
    - a.k.a. Classic Ray Tracer
  - Stochastic Ray Tracer
    - a.k.a. Monte Carlo Ray Tracer
  - Distribution Ray Tracer
  - Path Tracer
    - Bidirectional Ray Tracing
  - Photon Tracer
    - Photon Map

- Path trace from eye to scene
- Path trace from light sources to scene
- Intersect
Ray Tracing Type Hierarchy

- **Ray Tracer**
  - **Recursive Ray Tracer**
    - a.k.a. Classic Ray Tracer
  - **Stochastic Ray Tracer**
    - a.k.a. Monte Carlo Ray Tracer
    - **Distribution Ray Tracer**
    - **Path Tracer**
      - **Bidirectional Ray Tracing**
      - **Photon Tracer**
      - **Photon Map**

- Similar to bidirectional, but store results of light path tracing in photon map
- Related techniques:
  - Radiance cache
  - Irradiance gradients
The Crux(es) of Stochastic Ray Tracing

• When picking a stochastic ray, what is the distribution of the rays that works best? It is *not* the uniform distribution across the hemisphere!
  – “Importance sampling”

• When a sample is computed, how much does it weigh in the pixel’s total?

• How can one reuse results from earlier rays?
“With PRMan’s hybrid rendering algorithm there are no visibility rays, but ray tracing can be used to compute e.g. reflections, shadows, and ambient occlusion. Thanks to the use of ray differentials and multiresolution texture and tessellation caches, very complex scenes can be ray-traced....”