COMPSCI 715 Part 2

Lecture 7 - Advanced Ray Tracing

Advanced Ray Tracing

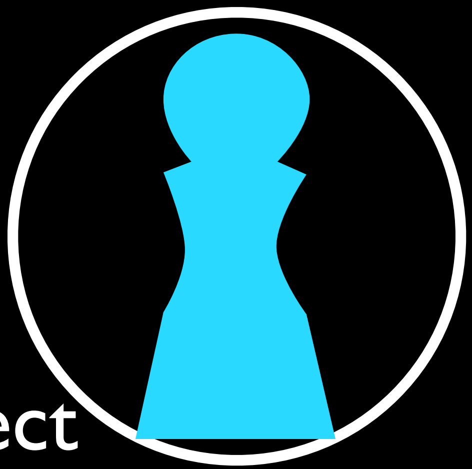
- Acceleration methods
- Distributed Ray Tracing

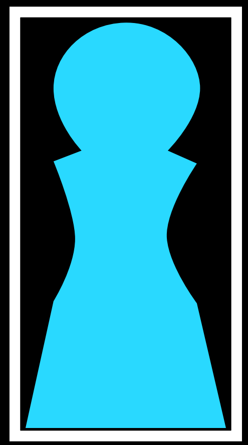
Acceleration Methods

- Suppose 100,000 objects and 1000x1000 output
  - 10^6 per ray tests -> 10^{11} per image
  - Plus reflections, shadow tests etc
  - Need to reduce ray tests
- Methods:
  - Bounding Volumes
  - Vista buffers
  - Space subdivision

Bounding Volumes

- Idea:
  - Find box/sphere that encompasses object
  - Test ray against bounds
  - If hit: test underlying geometry
- Can use hierarchical volumes
- Marginal cost increase



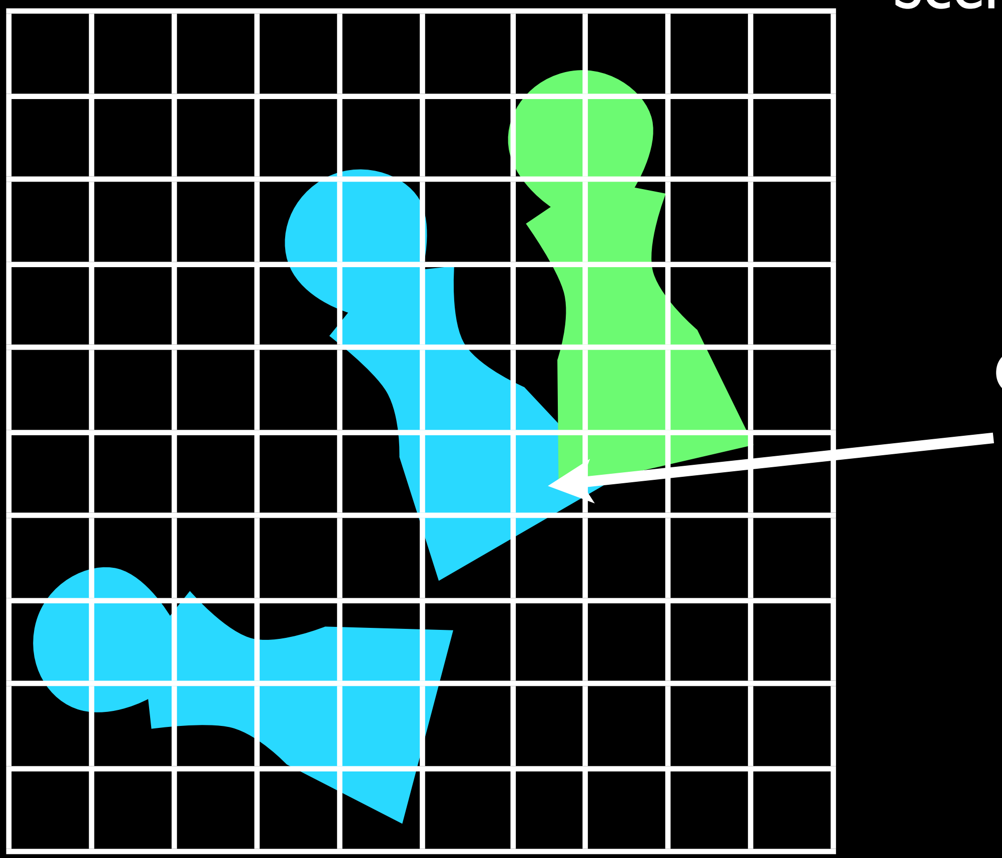


Vista Buffer

- Idea:
  - Do initial projection of scene onto viewplane
  - List objects which cover each pixel
  - Do primary ray intersection with those objects only
- Doesn’t speed up reflection / shadow rays

Vista Buffer

Scene projected onto view plane

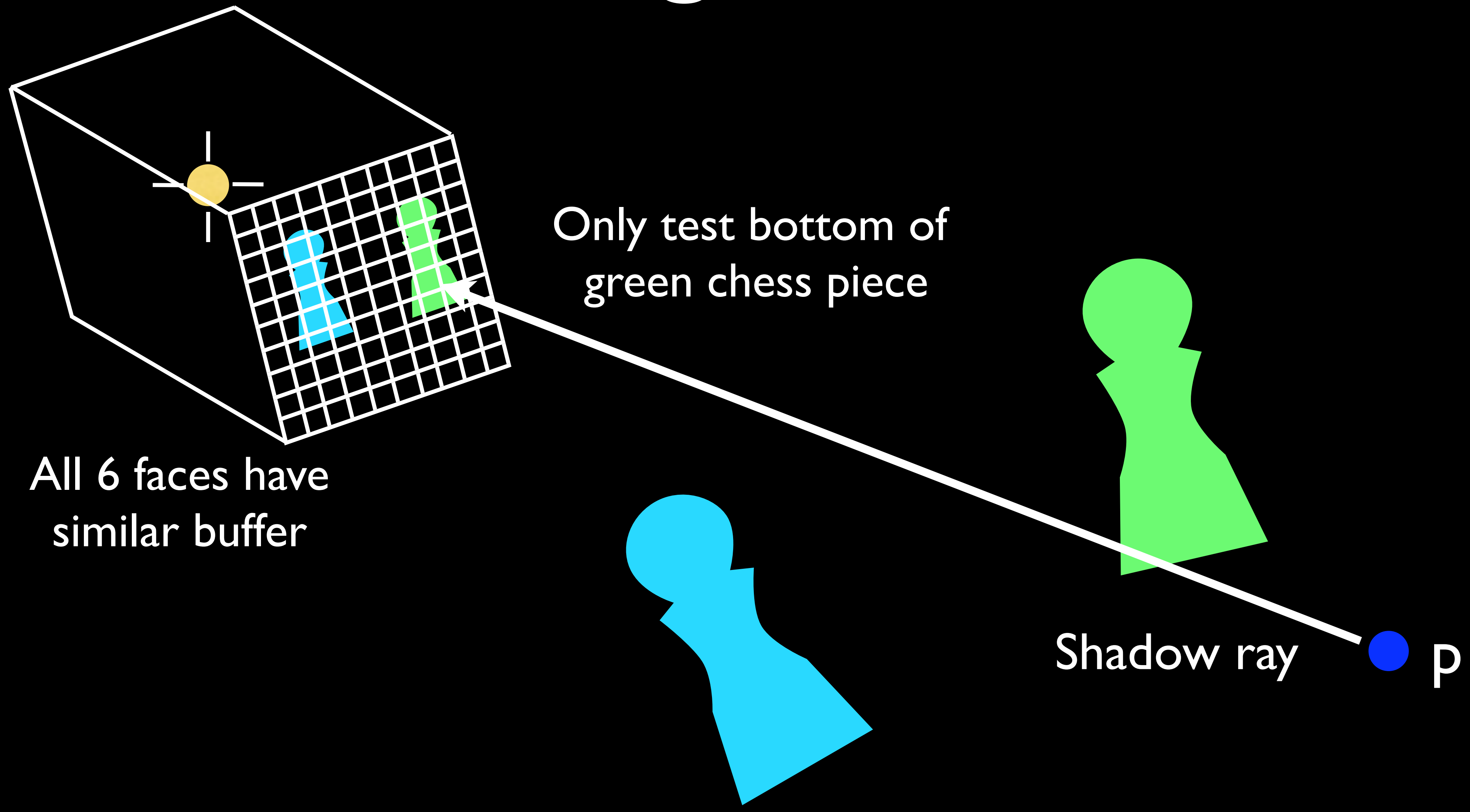


Only check against the two possible chess pieces

Light Buffer

- Shadow rays are costly (can be 90% of time)
- Light Buffer:
  - Build box around each light
  - Project scene onto each face of box
  - Determine which face / pixel of projection shadow ray passes through
  - Only interesection test against possible objects

Light Buffer

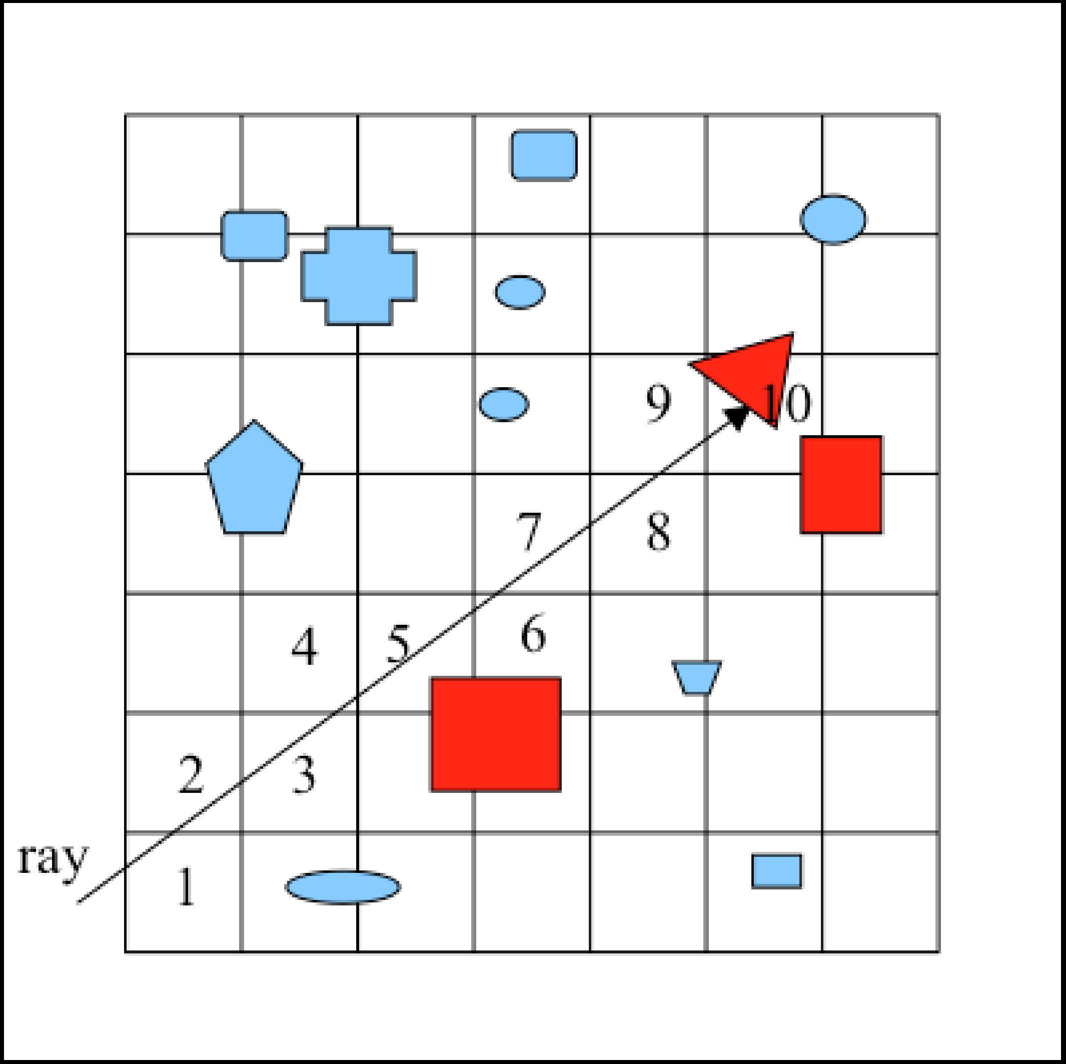


Space Subdivision

- Idea:
  - Subdivide scene in some way
  - Determine which objects intersect each region
  - Trace ray through each relevant region
    - Only test against member objects
- Methods:
  - Regular grid
  - Octree
  - BSP-Tree

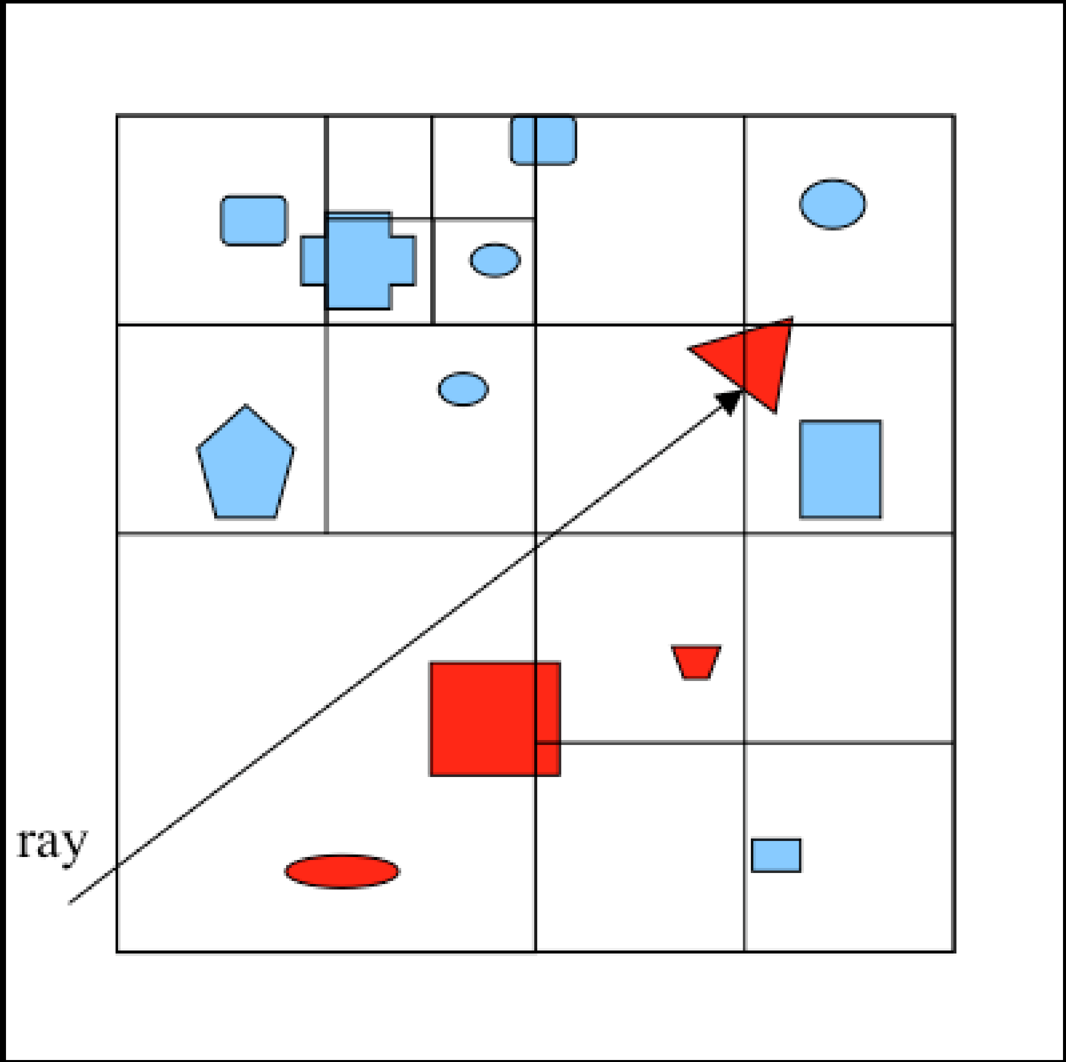
Regular grid

- Create regular grid of scene
- Each grid store list of child objects
- Trace ray inside each grid it passes



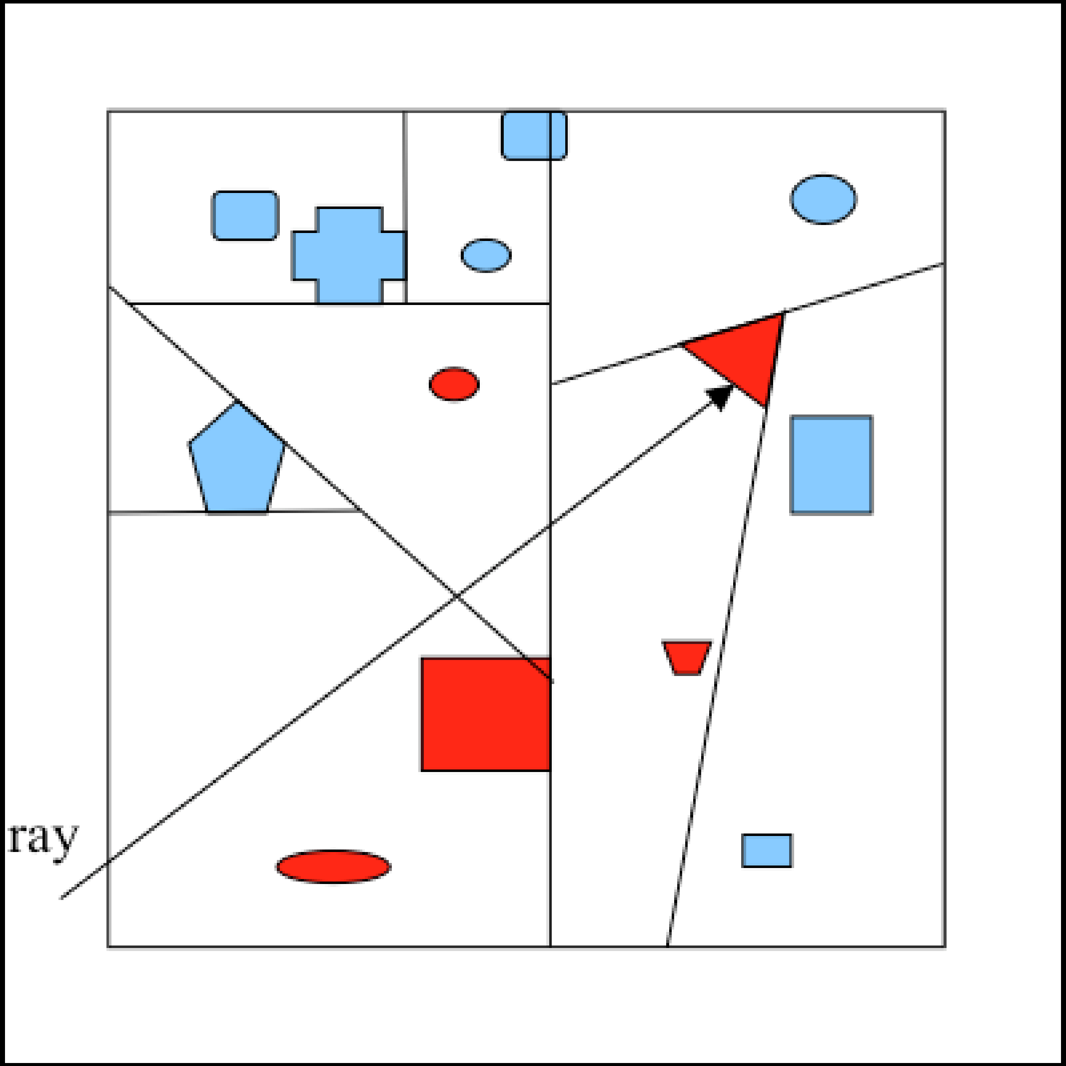
Octree

- Recursively subdivide space into 8 cubes
- Continue till at max (x) objects in each cell
- Steps faster but trickier algorithm



BSP-Tree

- Subdivide space using planes
- Choose planes intelligently
- Simple traversal but difficult subdivision



Problem with Ray Tracing

- Standard ray tracing
  - Point sample of colour
    - Should be average of area!
  - Point sample of shadow
    - Lights aren't just points!
  - Point sample of reflection
    - No such thing as a perfect mirror!

Distributed Ray Tracing

- Refers to distribution of samples, not distribution of computation
- Allows for anti-aliasing and motion blur

Aliasing

- Aliasing is where high frequency phenomena appear as low frequency due to point sampling
- Often seen as ‘*jaggies*’ on edges and ‘*Moiré patterns*’ in textures
- Sampling Theorem:

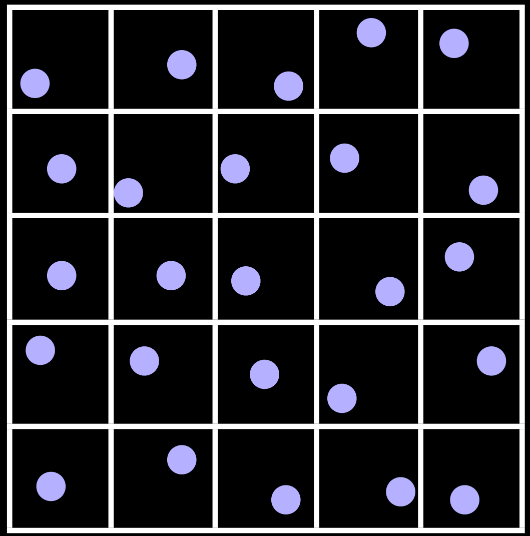
    If you want to be able to unambiguously reconstruct a signal from its samples, the sample frequency must be at least twice the highest frequency present in the signal.

Averaging Colour

- Use Monte-Carlo Integration / Stochastic Sampling
  - Distribute ‘randomly’ over filter region
  - Usually subdivide and take one ray from each sub-region
- Why randomly?

Stochastic Sampling with Box Filter

- Idea:
  - Break region into grid
  - Take one sample from each sub-region
- Good for jaggies, not so good for Moiré patterns

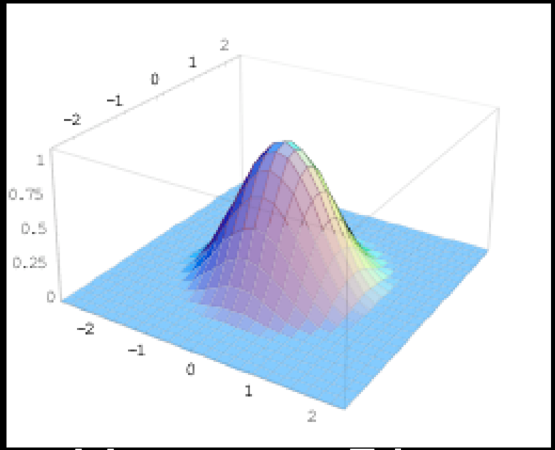


Stochastic Sampling with a weighted filter

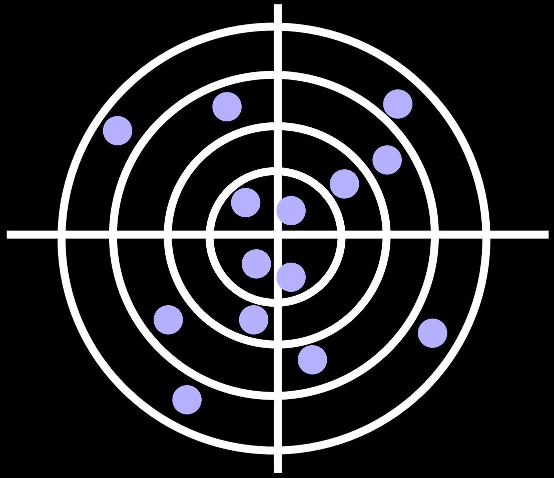
- Assign greater weight to samples closer to the center
- ‘Importance Sampling’
  - Break area into regions of equal weighting
  - Take one sample from each region
  - Average samples (weighting already done)

Stochastic Sampling with a weighted filter

- Weighting function
  - Want to favour center
  - Hamming Filter
    - $w(r) = k(1+\cos(\pi r/r_{max}))$
- Breaking into areas
  - Random angle, random r is hard

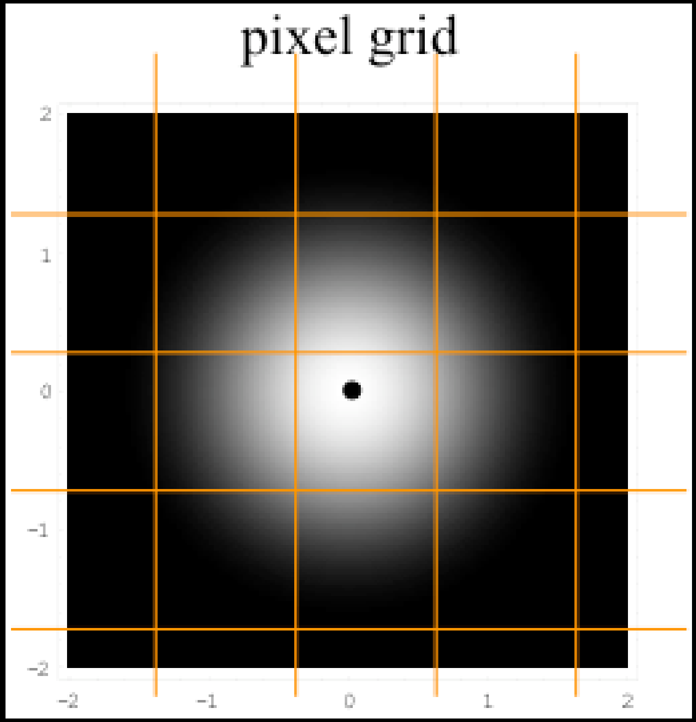


Hamming Filter


Weighting Areas

Stochastic Sampling with a weighted filter

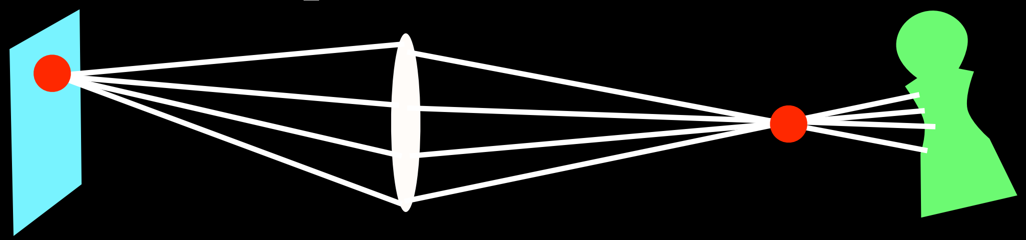
- Previous method can be very wasteful
- Better way: use a footprint
  - Use box filtering but with underlying weighting function
  - Can use across multiple pixels for better sampling



Temporal Antialiasing

- Moving objects and fixed time integrals can create appearance of jagged movement
  - Example: wagon wheel effect
- Can distribute samples in space as well as time
- Simple way:
  - For each super-sample ray also jitter in time (i.e. update positions)

Depth of Field



- Camera photos have ‘focal plane’ in which scene objects are in focus
- Focus is a function of the distance from this plane
- Can get depth of field from stochastic sampling:
  - Jitter super-sample points on a lens, through focal point

Sources

- Lobb, R (2003). Advanced Ray Tracing. COMPSCI 715 Lecture Notes