

Distributed Ray Tracing

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Anti-Aliasing

- Graphics as signal processing
 - Scene description: continuous signal
 - Sample
 - digital representation
 - Reconstruction by monitor

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Anti-Aliasing

- Represent any function as sum of sinusoidals
- Sampling
 - Spatial: multiply function by comb function
 - Frequency: convolve function by comb function
- Nyquist limit
- Reconstruction
 - Spatial: convolve with filter
 - Frequency: multiply by filter

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Typical anti-aliasing

- Increase sampling frequency
 - Doesn't solve problem
 - Increases frequencies handled (Nyquist limit)
- Average values after sampling
 - Doesn't address problem
 - Blurs bad results

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Ideal sampling and reconstruction

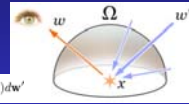
- Sample at greater than Nyquist frequency
- Reconstruct using sinc (box) filter
- Given sampling frequency, remove all frequencies higher than Nyquist limit
- Filter first, then sample
 - or do both at the same time

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Illumination is Integration

Outgoing intensity of reflected light at a point on a surface in a certain direction is

- the point's emission,
- and an integral over the hemisphere above the surface of an illumination function L and a bidirectional reflectance function.



$$L_o(x, w, \lambda, t) = L_e(x, w, \lambda, t) + \int_{\Omega} f_r(x, w', w, \lambda, t) L_i(x, w', \lambda, t) (-w' \cdot n) dw'$$

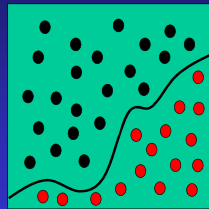
Usually referred to as "Kajia's Rendering Equation"

The shading function may be too complex to compute analytically

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Monte Carlo Integration

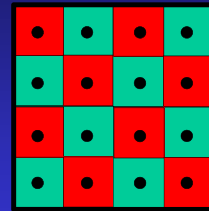
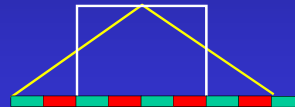
- Determine area under the curve
- Non analytic function so can't integrate
- Can tell if point is above or below curve
- Generate random samples
- Count fraction below curve
- Accurate in the limit



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Supersampling

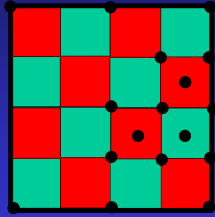
- Multiple samples per pixel
- Average together using uniform weights (box filter)
- Average together using a pyramid filter or a truncated Gaussian filter



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Adaptive Supersampling

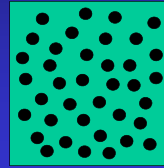
- Trace rays at corner of pixels: initial area
- Trace ray (sample) at center of area
- If center is 'different' from corners,
 - Subdivide area into 4 sub-areas
 - Recurse on sub-areas



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Poisson Distribution

- Similar to distribution of vision receptors
- Random with minimum distance between samples

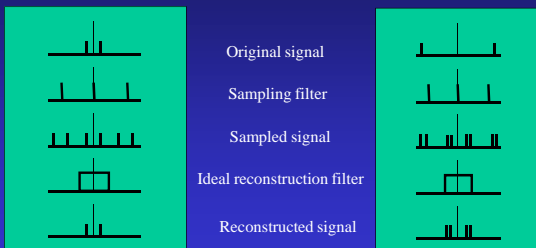


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Spectrum analysis of regular sampling

low frequency signal

high frequency signal

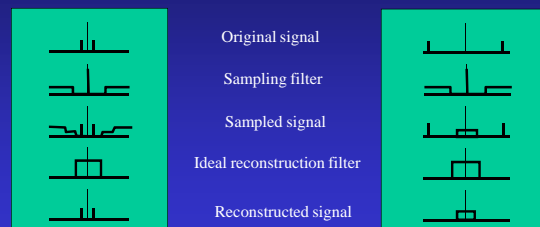


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Spectrum analysis of regular sampling

low frequency signal

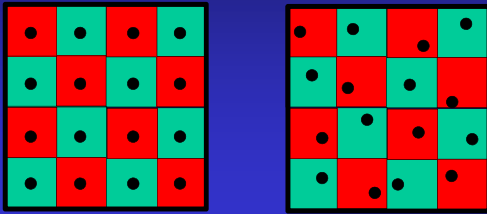
high frequency signal



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Jittered Sampling

Frequencies above Nyquist limit are converted to noise instead of incorrect patterns



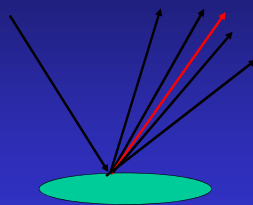
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Gloss

- Mirror reflections calculated by tracing rays in the direction of reflection
- Gloss is calculated by distributing these rays about the mirror direction
 - The distribution is weighted according to the same distribution function that determines highlights.

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Gloss



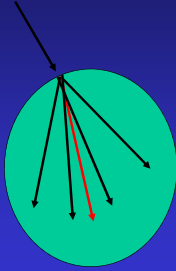
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Translucency

- Analogous to the problem of gloss
- Distribute the secondary rays about the main direction of the transmitted rays
 - The distribution of transmitted rays is defined by a specular transmittance function

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Translucency



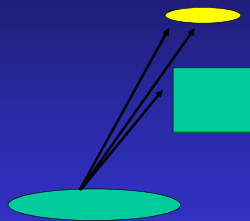
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Penumbras

- Consider the light source to be an area, not a point
- Trace rays to random areas on the surface of the light source
- distribute rays according to areas of varying intensity of light source (if any)
- Use the fraction of the light intensity equal to the fraction of rays which indicate an unobscured light source

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Penumbras



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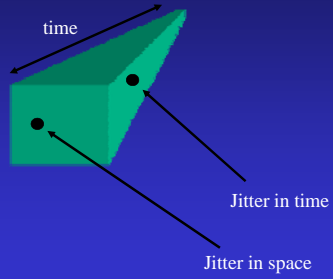
Motion Blur

Post-process blurring can get some effects, but consider:

- Two objects moving so that one always obscures the other
 - Can't render and blur objects separately
- A spinning top with texture blurred but highlights sharp
 - Can't post-process blur a rendered object
- The blades of a fan creating a blurred shadow
 - Must consider the movement of other objects

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Temporal Jittered Sampling



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Temporal Jittered Sampling

7	11	3	14
4	15	13	9
16	1	8	12
6	10	5	2

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Importance Sampling

- Sample uniformly and average samples according to distribution function

OR

- Sample according to distribution function and average samples uniformly

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Pinhole Camera

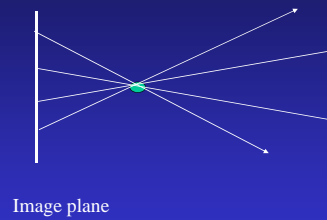
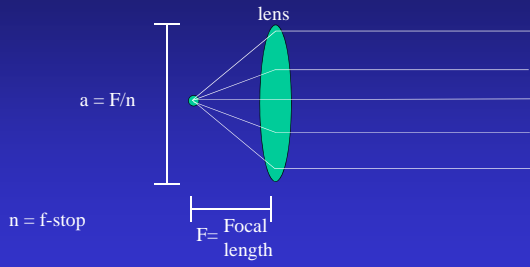


Image plane

Perfect focus - low light

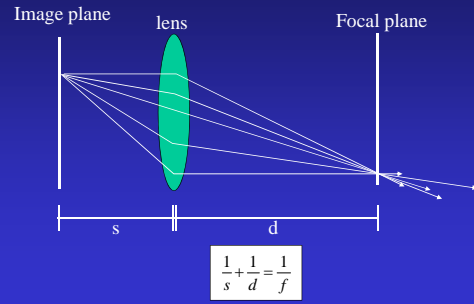
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Use of lens - more light



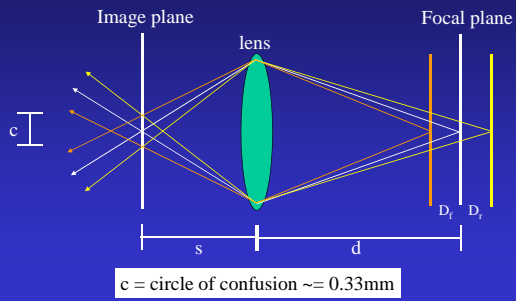
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Use of lens - more light



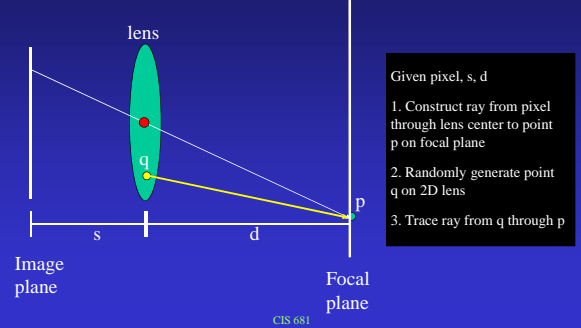
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Circle of Confusion



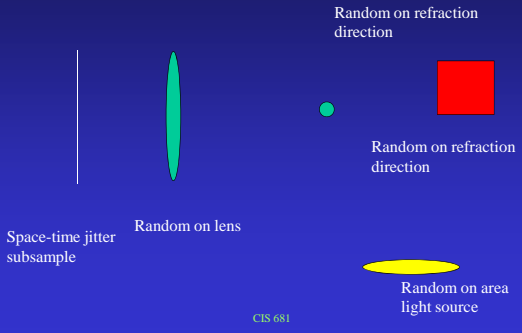
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Depth of Field



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Summary



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