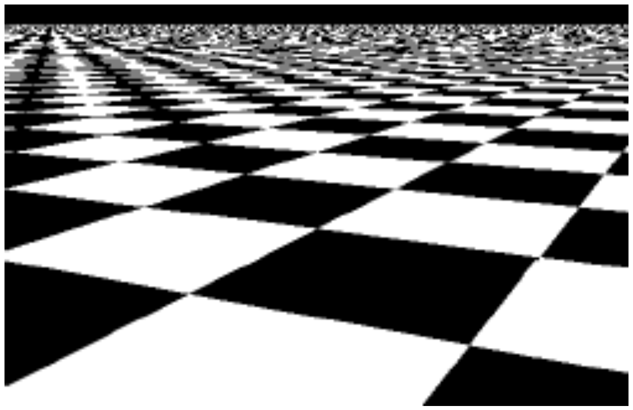
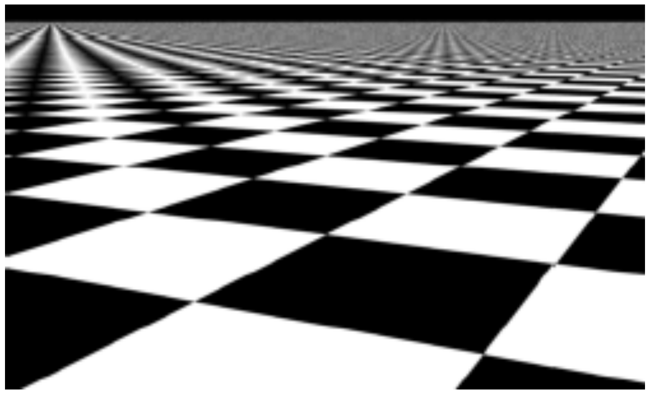
Antialiasing

CSE 781

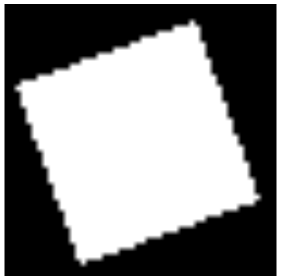


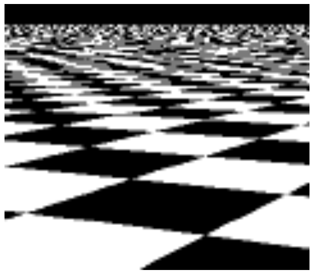


Han-Wei Shen

What is alias?

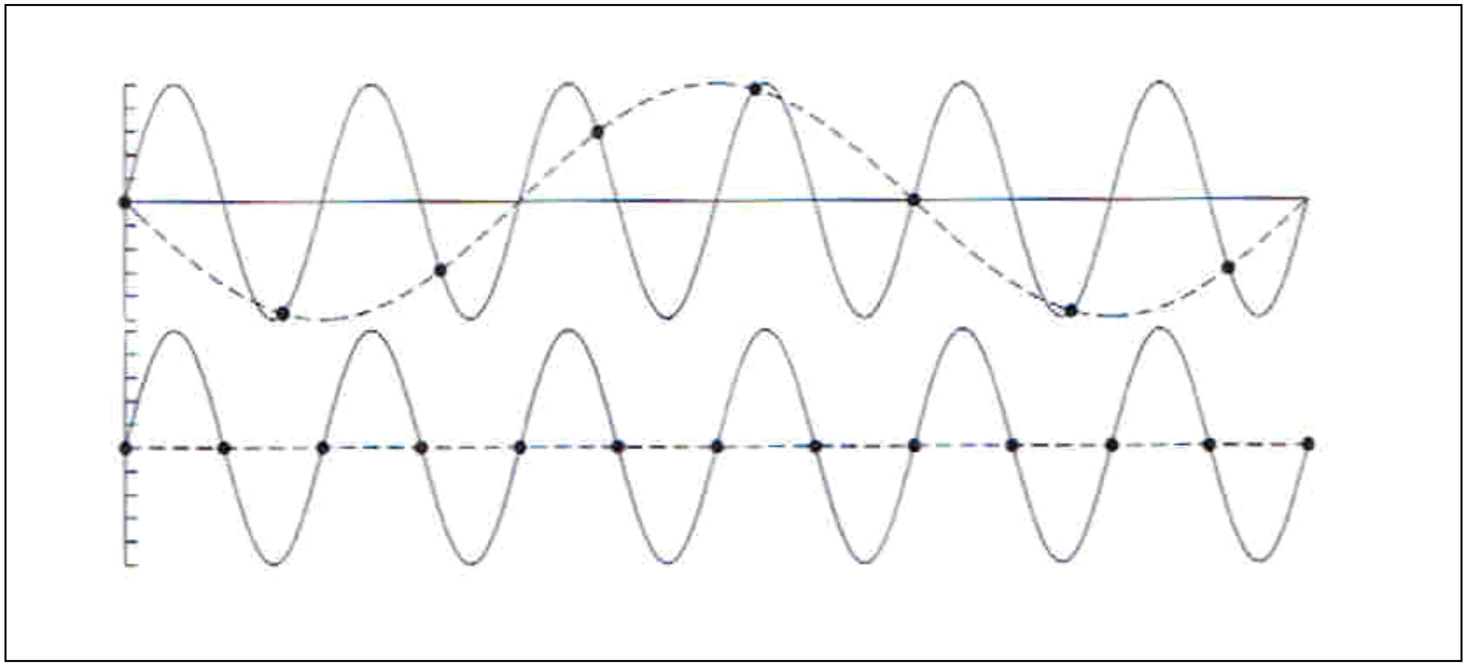
- Alias - A false signal in telecommunication links from beats between signal frequency and sampling frequency (from dictionary.com)
  - Not just telecommunication, alias is everywhere in computer graphics because rendering is essentially a sampling process
  - Examples:
    - Jagged edges
    - False texture patterns





Alias caused by under-sampling

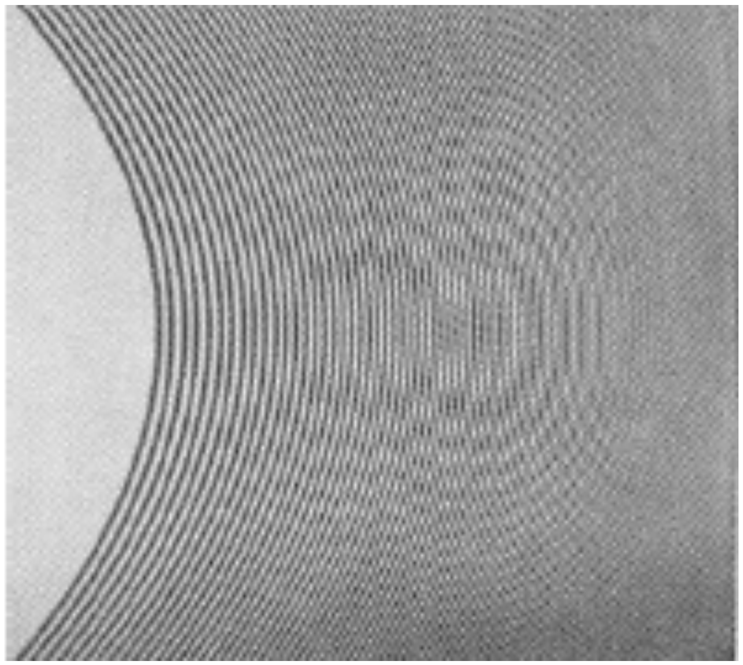
- 1D signal sampling example



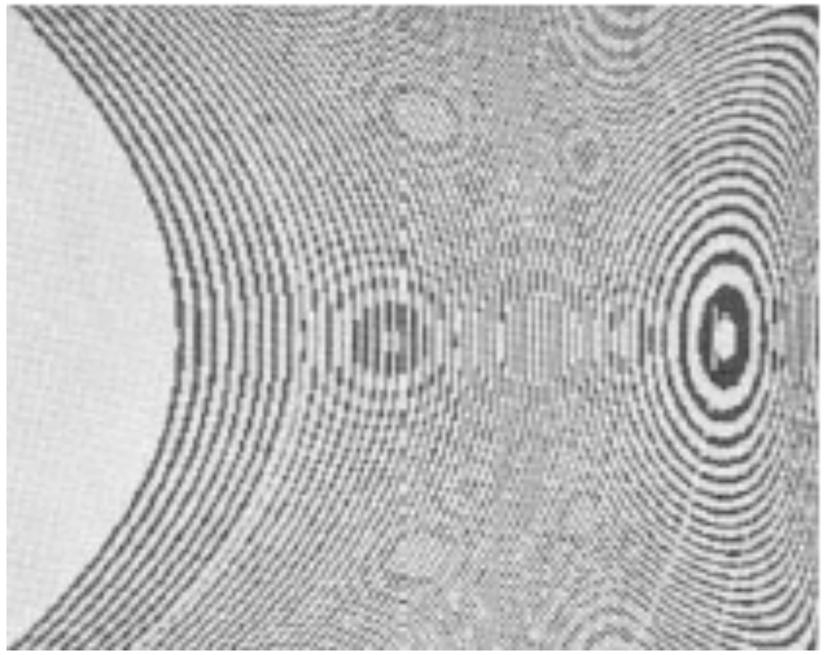
—————— Actual signal
-------------- Sampled signal

Alias caused by under-sampling

- 2D texture display example



Minor aliasing

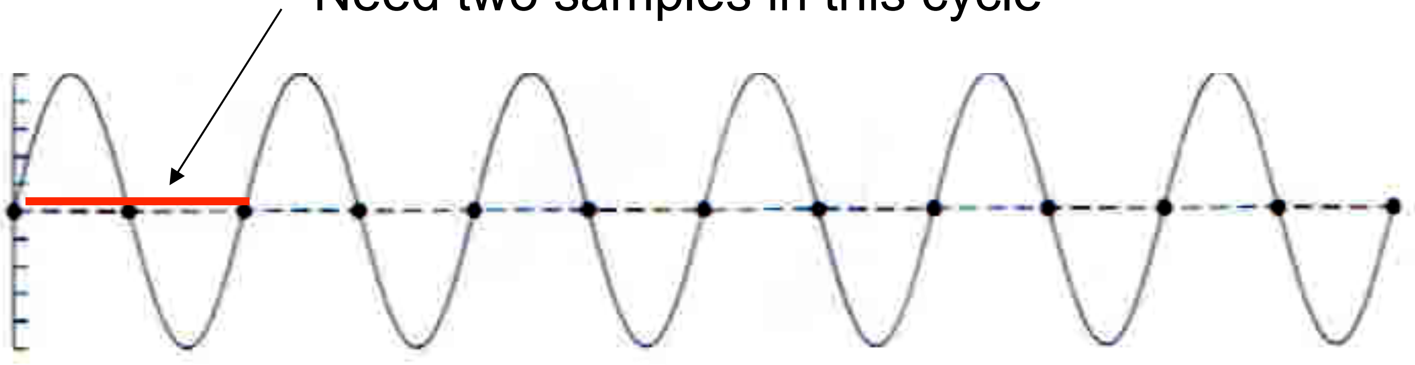


worse aliasing

How often is enough?

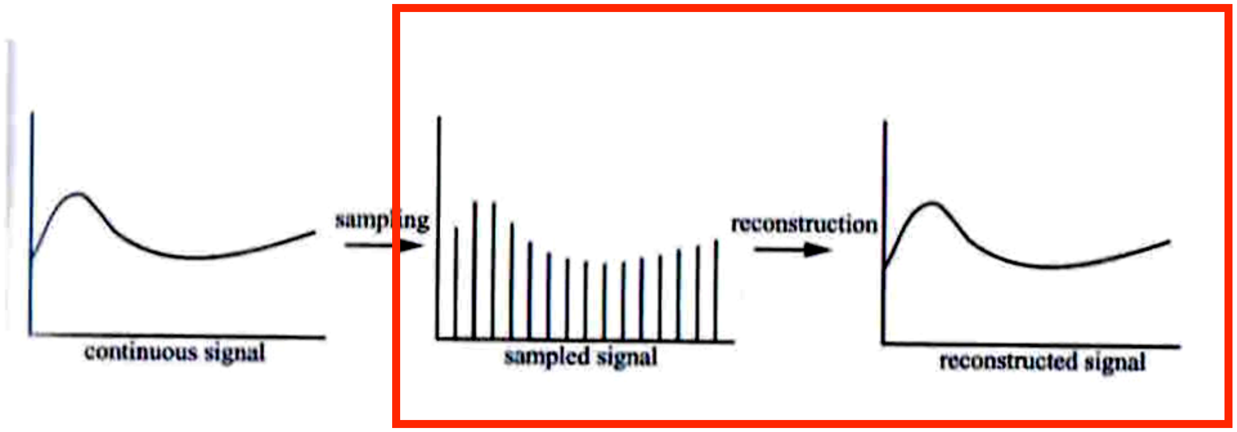
- What is the right sampling frequency?
- Sampling theorem (or Nyquist limit) - the sampling frequency has to be at least twice the *maximum* frequency of the signal to be sampled

Need two samples in this cycle



Reconstruction

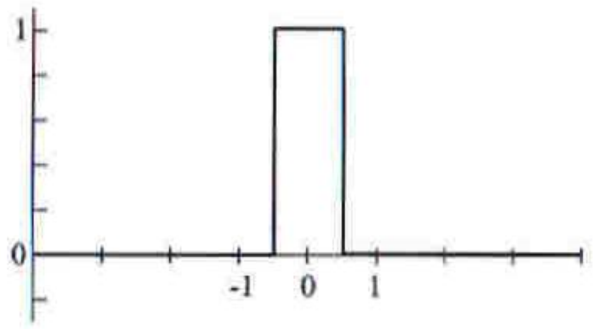
- After the (ideal) sampling is done, we need to reconstruct back the original continuous signal
- The reconstruction is done by reconstruction filter



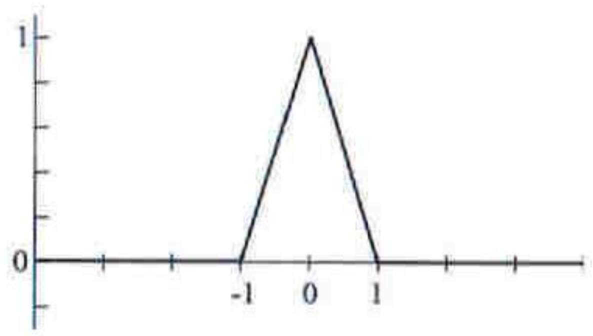
Reconstruction Filters

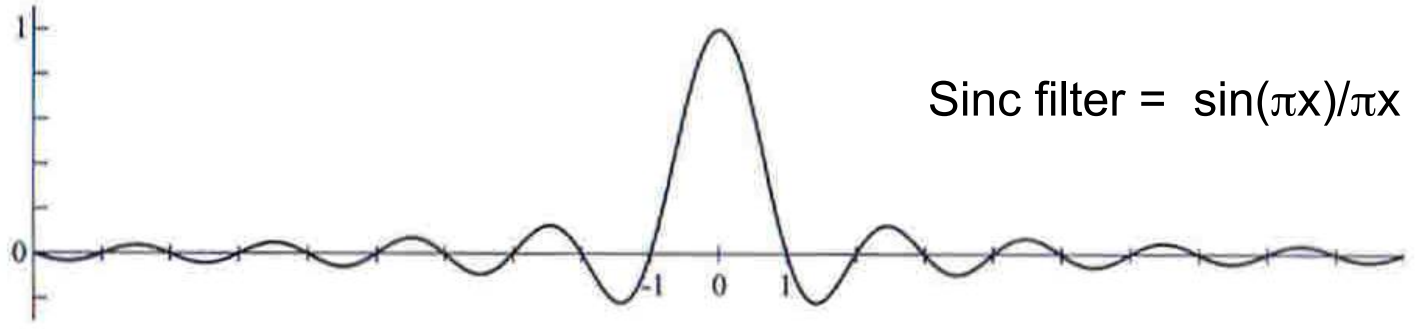
- Common reconstruction filters:

Box filter



Tent filter

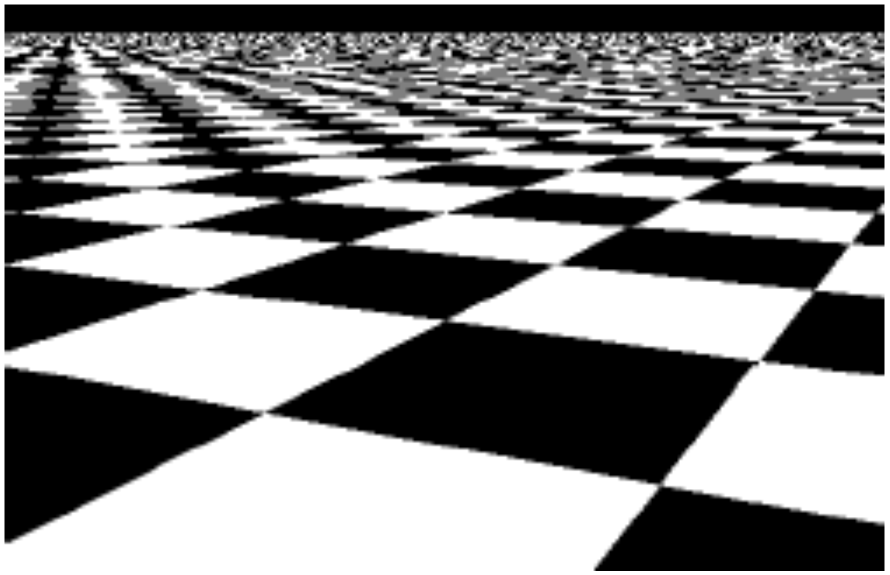




Sinc filter = $\sin(\pi x)/\pi x$

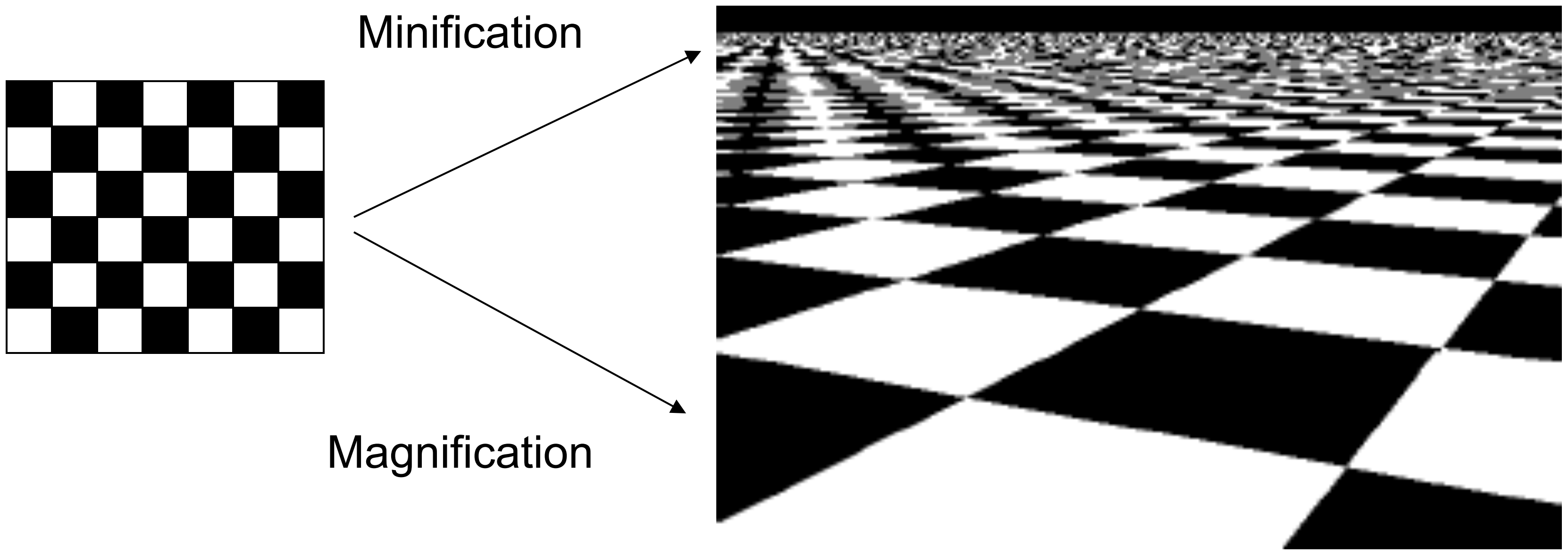
Anti-aliased texture mapping

- Two problems to address –
  - Magnification
  - Minification



Re-sampling

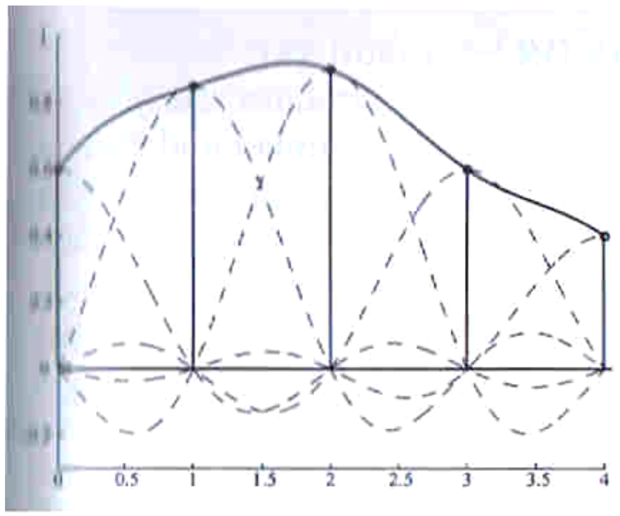
- Minification and Magnification – resample the signal to a different resolution

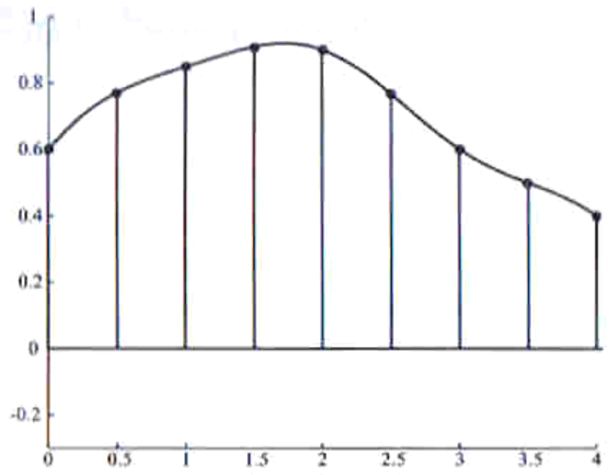


(note the minification is done badly here)

Magnification

- Simpler to handle, just resample the reconstructed signal

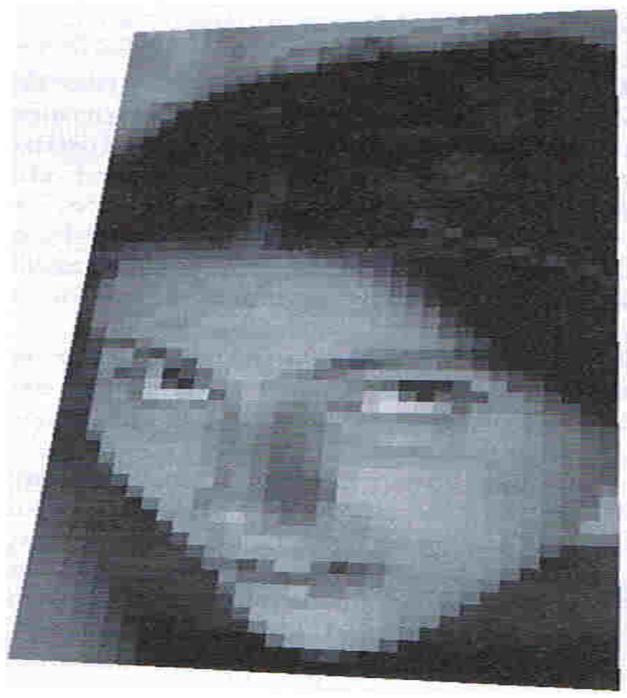




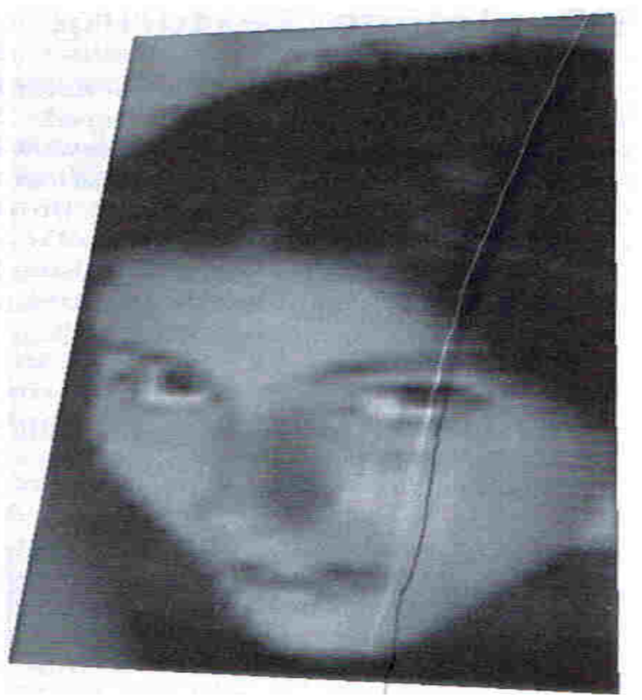
Reconstructed signal Resample the reconstructed signal

Magnification

- Common methods: nearest neighbor (box filter) or linear interpolation (tent filter)

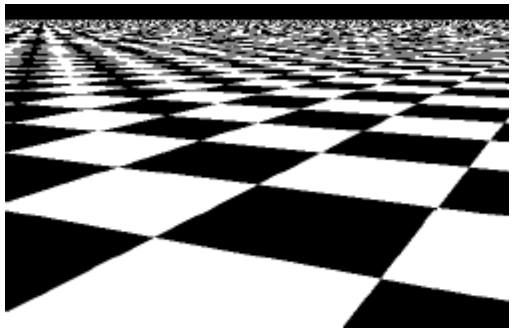


Nearest neighbor



bilinear interpolation

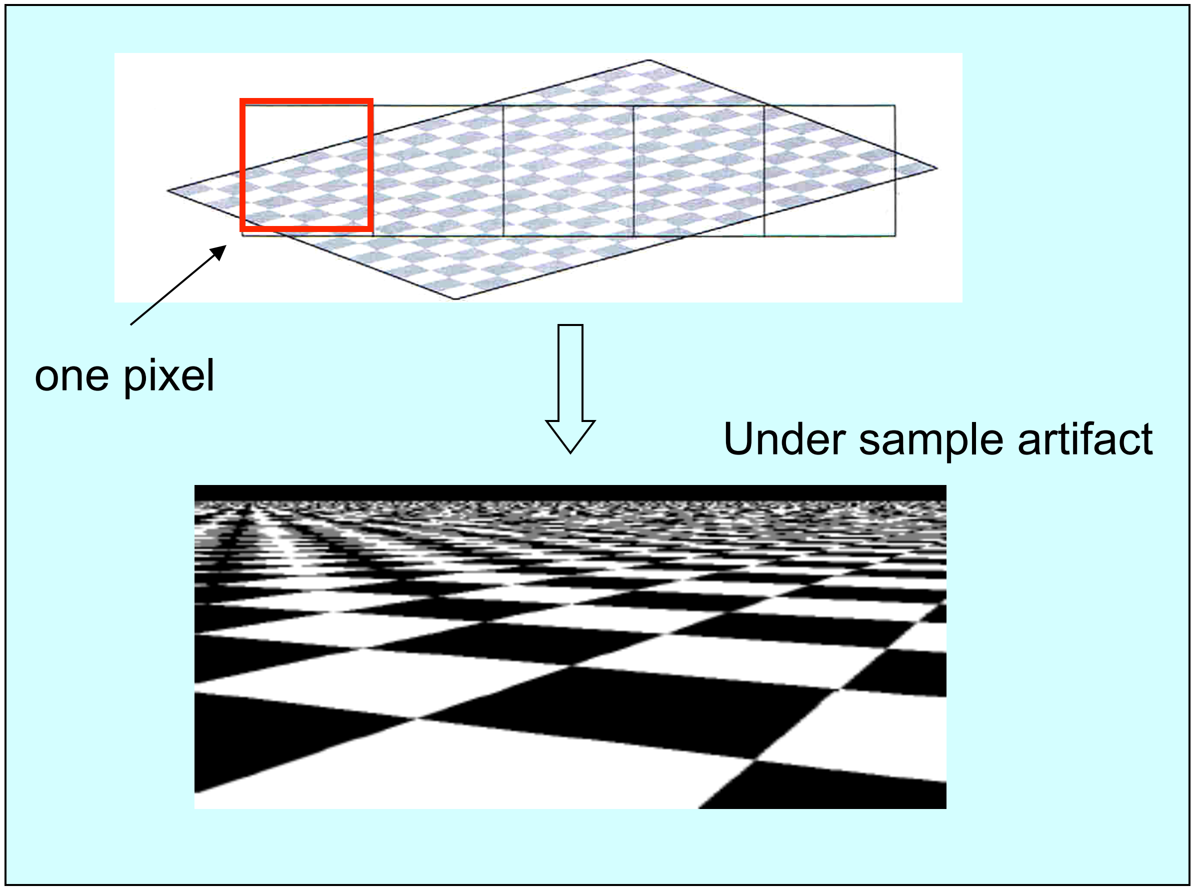
Minification



- Harder to handle
- The signal's frequency is too high to avoid aliasing
- A possible solution:
  - Increase the low pass filter width of the ideal sinc filter – this effectively blur the image
  - Blur the image first (using any method), and then sample it

Minification

- Several texels cover one pixel (under sampling happens)



Solution:

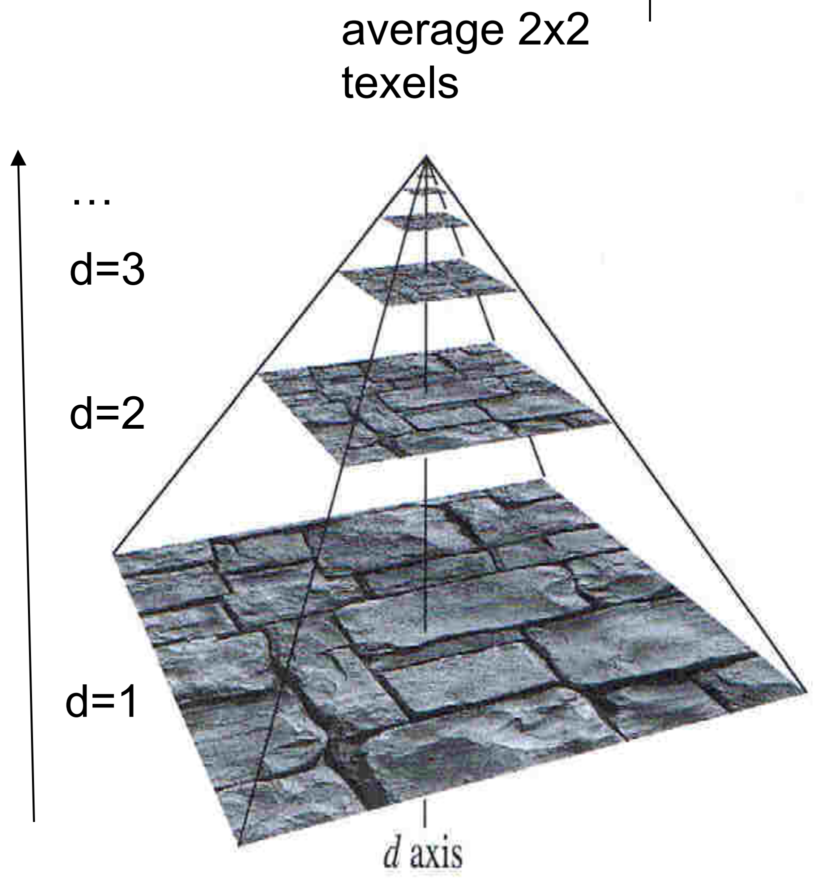
Either increase sampling rate or reduce the texture Frequency

We will discuss:

1. Mip-mapping
2. Rip-mapping
3. Sum Area Table

Mip-mapping

- By Lance Williams (SIGGRAPH ’83)
- Mip – many things in a small place
- The original texture is augmented with a set of low resolution textures
- Which resolution to use depends on the screen projection size – try to maintain pixel to texel ration close to 1

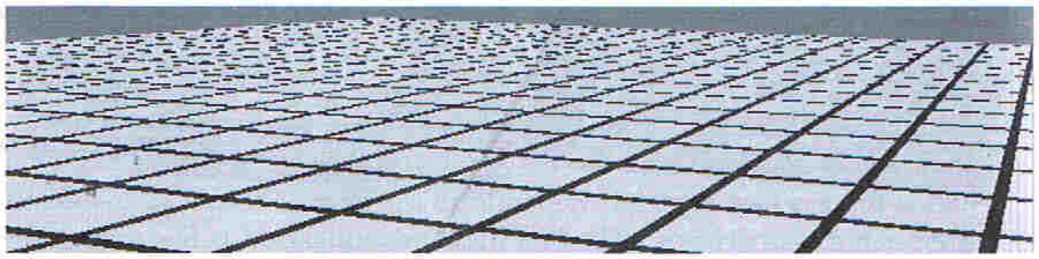


Mipmapping

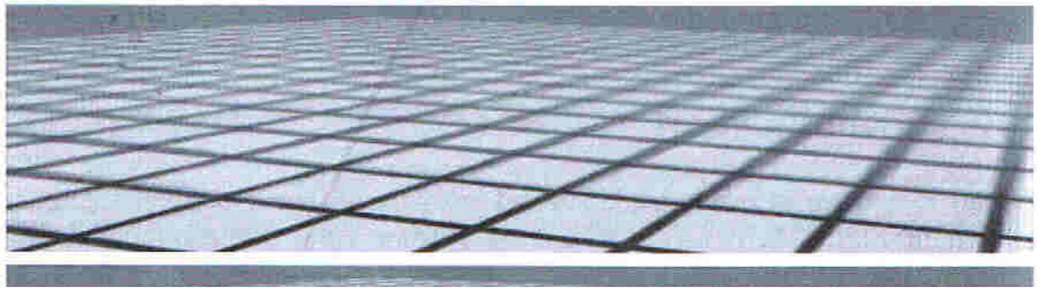
- Two common measures are used to compute *d*.
  - Use the longer edge of the quadrilateral
  - Use the largest absolute value of the four differentials ($\partial u/\partial x$, $\partial v/\partial x$, $\partial u/\partial y$, $\partial v/\partial y$)
- Interpolate between levels

Mipmapping problem

- Overblurring! – When a pixel covers many u texels but few v texels, we always choose the largest pixel coverage to decide the level



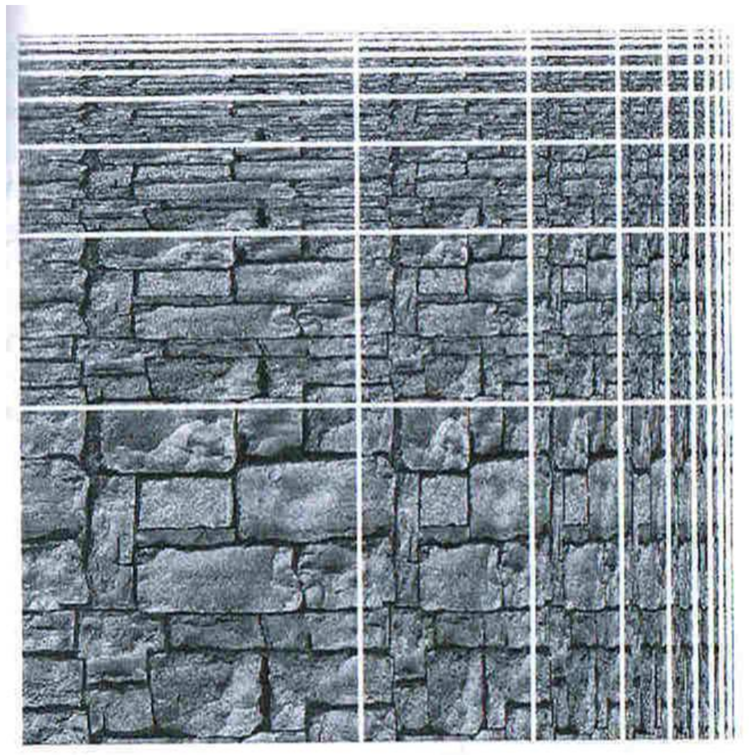
Non mipmapping



mipmapping

Ripmapping

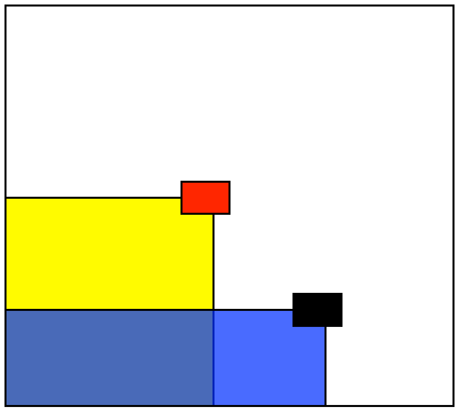
- Correct the over-blurring problem of mipmapping – separating x and y filtering



- Scale by half by x across a row.
- Scale by half in y going down a column.
- The diagonal has the equivalent mip-map.
- Four times the amount of storage is required.
- Four different texel values to average

Summed Area Table

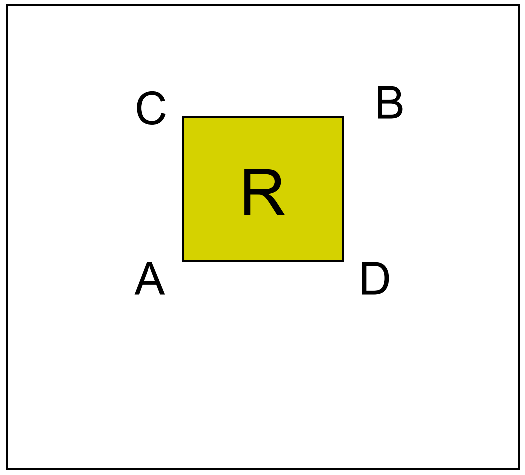
- Another way to perform anisotropic filtering - can be used to compute the average color for any arbitrary rectangular region in the texture space at a constant speed
- A two dimensional array that has the same size as the texture



Every pixel stores the sum of all the texel colors in the lower left corner

Summed Area Table (SAT)

- How to calculate the sum of texels in the area between A and B?



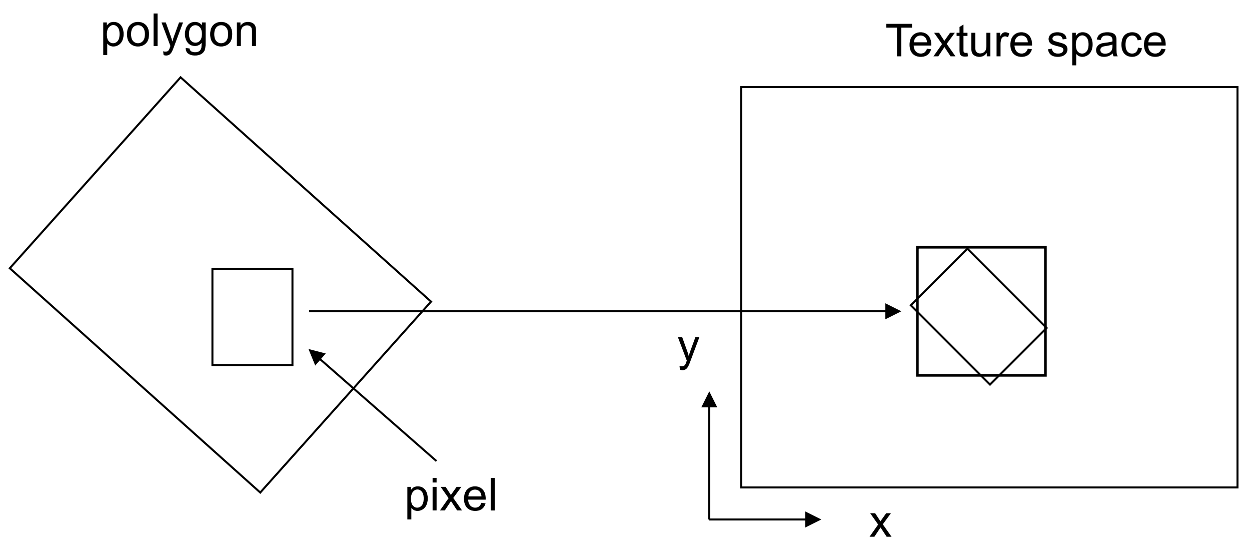
R = SAT[B] – SAT[C] – SAT[D] + SAT[A]

The average value can be computed by

R / num of texels in R

Summed Area Table (SAT)

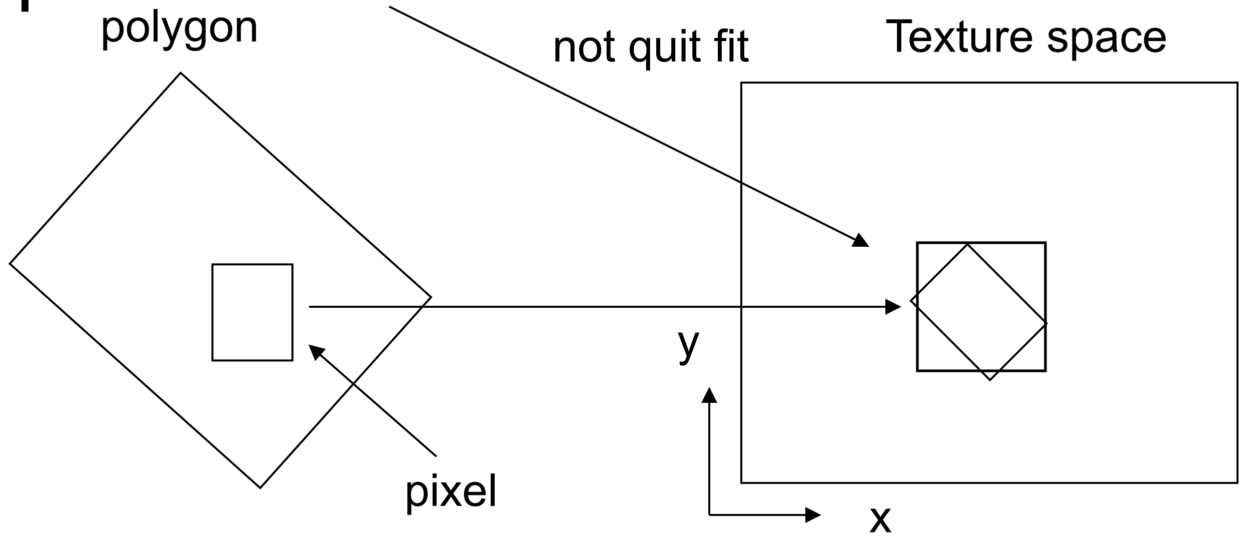
- is used to filter the texture



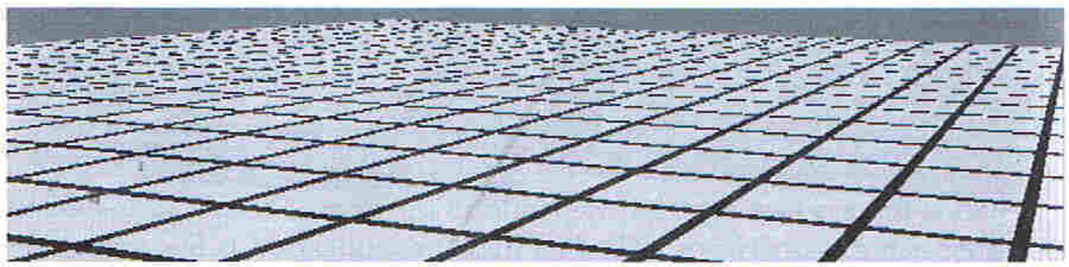
Compute the rectangular bounding box of the pixel area in the texture and then use summed area table to compute the average color (i.e., filter the texels when magnification takes place)

Summed Area Table

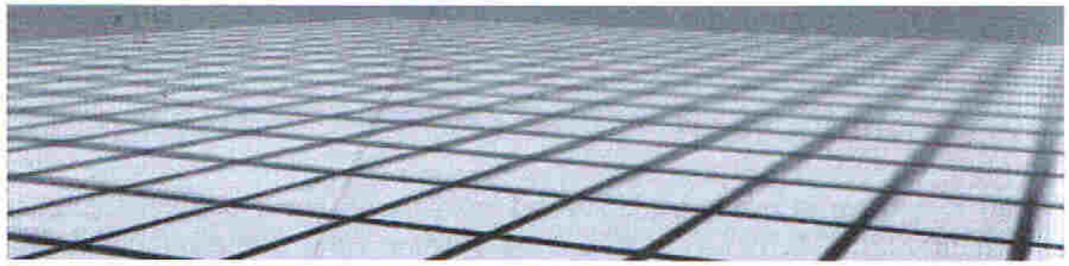
- Less blurry than Mipmapping
- Still blurry when the texture is viewed along its diagonal – this is because the bounding box of the pixel area is larger than the actual pixel area



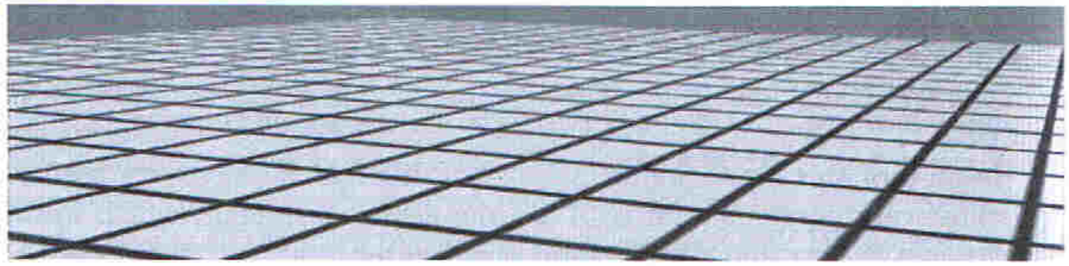
Comparison



Non filtering



Mipmapping



Summed area table

Note that only mipmap is implemented by hardware and supported by OpenGL