CS4620/5620: Lecture 24

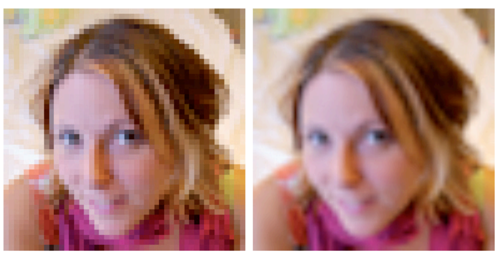
Texture Mapping

Announcements

- HW 3 out
  - Barycentric coordinates for Problem 1

Texture mapping from 0 to infinity

- When you go close...

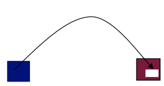


When viewed from a distance

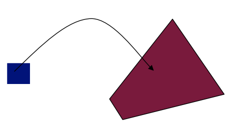
- Aliasing!

How does area map over distance?

- At optimal viewing distance:
  - One-to-one mapping between pixel area and texel area
- When closer
  - Each pixel is a small part of the texel

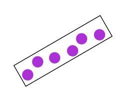


- When farther
  - Each pixel could include many texels



Minification: Theoretical Solution

- Find the area of pixel in texture space
- "Filter" the area to compute "average" texture color
  - Filtering eliminates high frequency artifacts
  - How to filter?
    - Analytically compute area
    - Super-sample
    - But too expensive

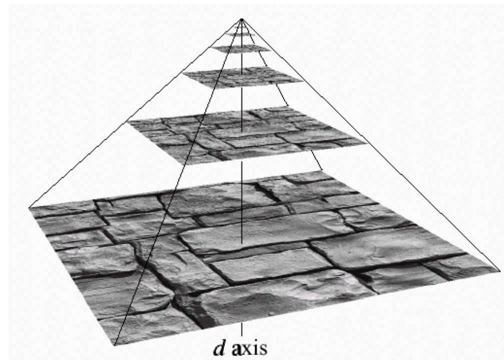


MIP Maps

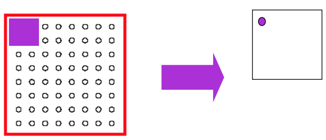
- MIP Maps
  - Multum in Parvo: Much in little
  - Proposed by Lance Williams
- Stores pre-filtered/averaged versions of texture
- Supports very fast lookup

- Assumptions:
  — Can't really precompute every possible required area
  — But can precompute some areas

Image Pyramid



Filtering by Averaging



- Each pixel in a level corresponds to 4 pixels in lower level
  - Average
  - Gaussian filtering (more on this next lecture)

Using the MIP Map

- Find the MIP Map level where the pixel has a 1-to-1 mapping

- How?
  - Find largest side of pixel footprint in texture space
    - Pick level where that side corresponds to a texel
  - Compute derivatives to find pixel footprint

Given derivatives: what is level?

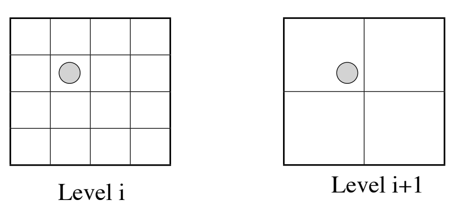
$$level = log[max(\frac{du}{dx}, \frac{dv}{dx}, \frac{du}{dy}, \frac{dv}{dy})]$$

$$level = log\sqrt{(\frac{du}{dx})^2 + (\frac{dv}{dx})^2 + (\frac{du}{dy})^2 + (\frac{dv}{dy})^2}$$

- Gradients
  - Available in pixel shader

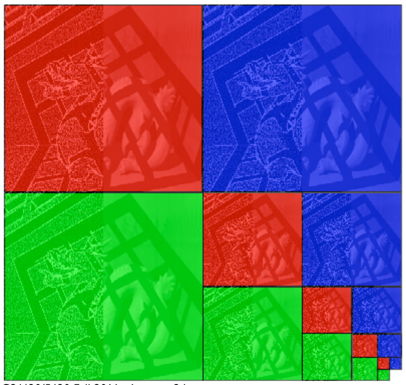
Using the MIP Map

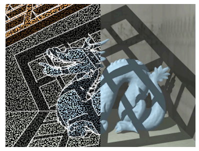
- In level, find texel and
  - Return the texture value: point sampling
  - Bilinear interpolation
  - Trilinear interpolation



Memory Usage

- What happens to size of texture?

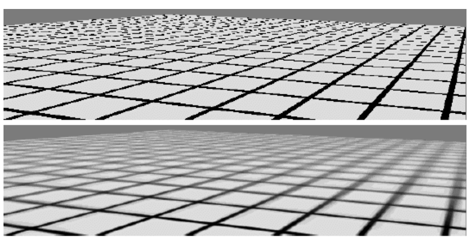




MIPMAP

- Multi-resolution image pyramid
  - Pre-sampled computation of MIPMAP
  - 1/3 more memory
- Bilinear or Trilinear interpolation

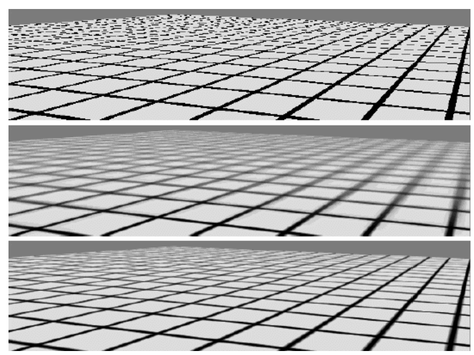
Filtered Texturing



point sampled

mipmapped

Filtered Texturing



point sampled

mipmapped

summed area tables

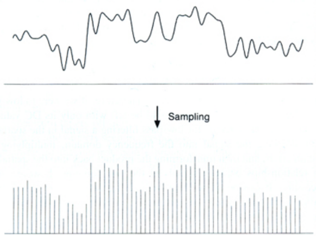
Some basic assumptions

- Assume that the pixel only maps to squares in texture space
- In fact, assume it maps to squares at particular locations

Sampling and Antialiasing

Sampled representations

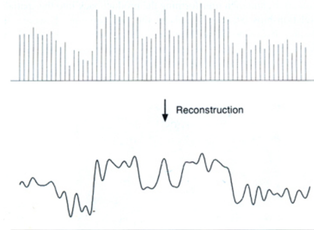
- How to store and compute with continuous functions?
- Common scheme for representation: samples
  - write down the function's values at many points



[FvDFH fig.14.14b / Wolberg]

Reconstruction

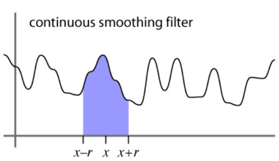
- Making samples back into a continuous function
  - for output (need realizable method)
  - for analysis or processing (need mathematical method)
  - amounts to "guessing" what the function did in between

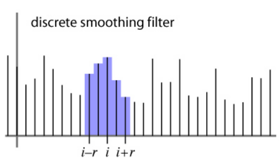


[FvDFH fig.14.14b / Wolberg]

Filtering

- Processing done on a function
  - can be executed in continuous form (e.g. analog circuit)
  - but can also be executed using sampled representation
- Simple example: smoothing by averaging



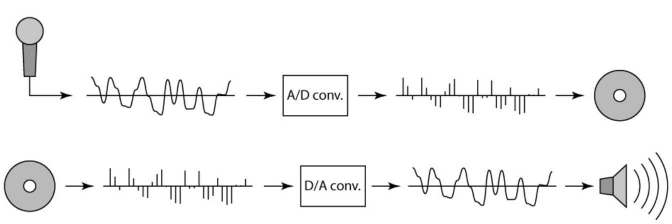


Roots of sampling

- Nyquist 1928; Shannon 1949
  - famous results in information theory
- 1940s: first practical uses in telecommunications
- 1960s: first digital audio systems
- 1970s: commercialization of digital audio
- 1982: introduction of the Compact Disc
  - the first high-profile consumer application
- This is why all the terminology has a communications or audio "flavor"
  - early applications are 1D; for us 2D (images) is important

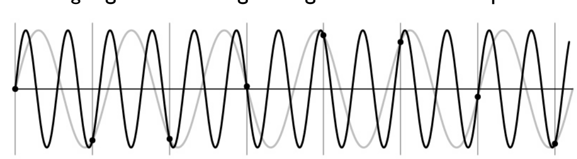
Sampling in digital audio

- Recording: sound to analog to samples to disc
- Playback: disc to samples to analog to sound again
  - how can we be sure we are filling in the gaps correctly?



Undersampling

- What if we "missed" things between the samples?
- Simple example: undersampling a sine wave
  - unsurprising result: information is lost
  - surprising result: indistinguishable from lower frequency
  - also was always indistinguishable from higher frequencies
  - *aliasing*: signals "traveling in disguise" as other frequencies



Preventing aliasing

- Introduce lowpass filters:
  - remove high frequencies leaving only safe, low frequencies
  - choose lowest frequency in reconstruction (disambiguate)