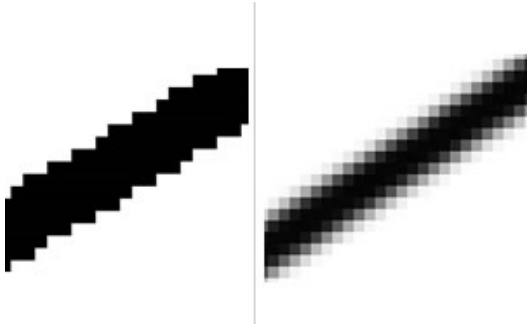
28 – SAMPLING. ALIASING AND ANTI-ALIASING

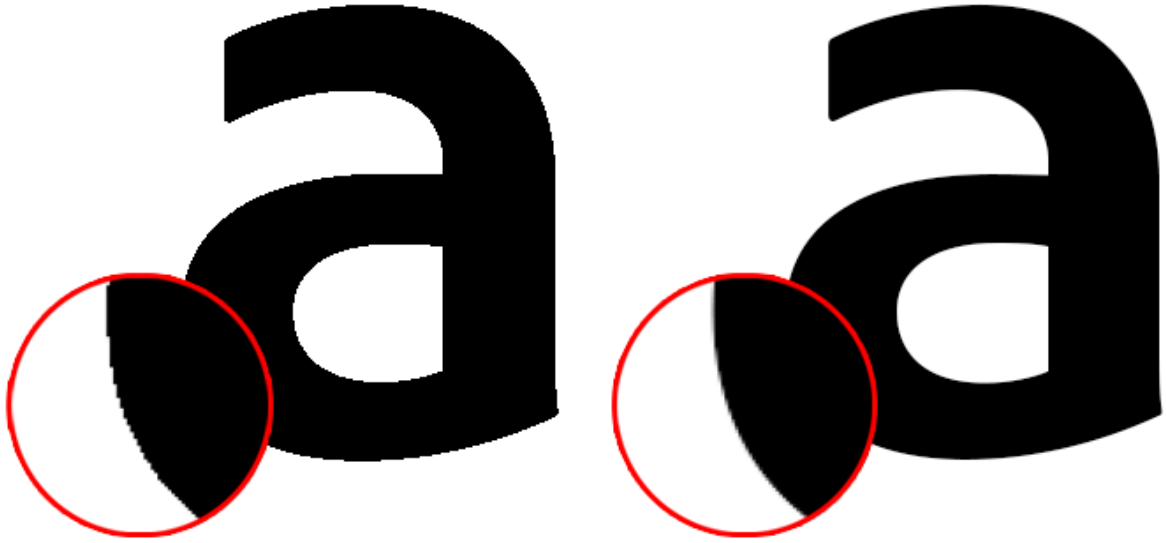
Textbook: 16



UGRAD.CS.UBC.CA/~CS314

Alla Sheffer, 2016

ALIASING & ANTI-ALIASING



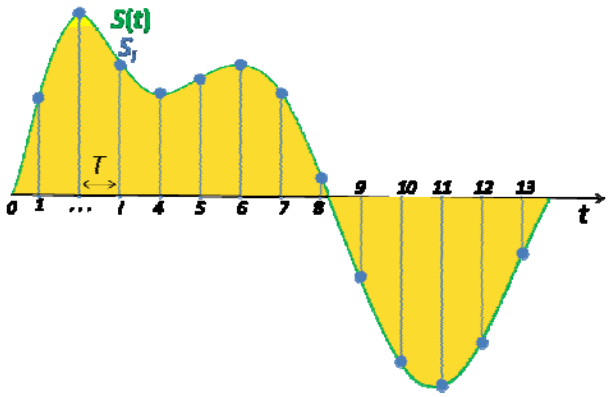
TWO VIEWS OF IMAGES

- A *continuous image*, $I(x_w, y_w)$, is a bivariate function.
  - range is a linear color space.
- A *discrete image* I[i][j] is a two dimensional array of color values.
- We associate each pair of integers i, j, with the continuous image coordinates $x_w = i$ and $y_w = j$

3

CONTINUOUS VS. DISCRETE

- Continuous -> Discrete: ***Sampling***
- Discrete -> Continuous: ***Reconstruction/Interpolation***



SAMPLING

- The simplest and most obvious method to go from a continuous to a discrete image is by *point sampling*.
- To obtain the value of a pixel i, j, we sample the continuous image function at a single integer valued domain location:

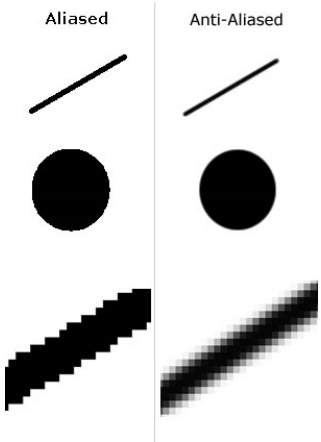
$$I[i][j] \leftarrow I(i, j)$$

- This can result in unwanted artifacts.

5

ALIASING

- Scene made up of black and white triangles: jaggies at boundaries
  - Jaggies will crawl during motion
- If triangles are small enough then we get random values or weird patterns.
  - Jaggies will crawl during motion

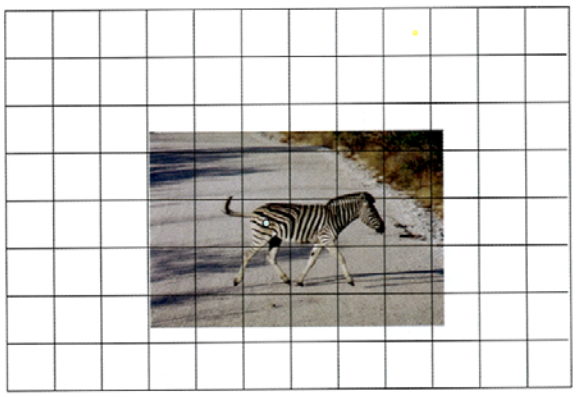


6

ALIASING CAN HAPPEN IN DISCRETE TO DISCRETE DOWN/UP SAMPLING

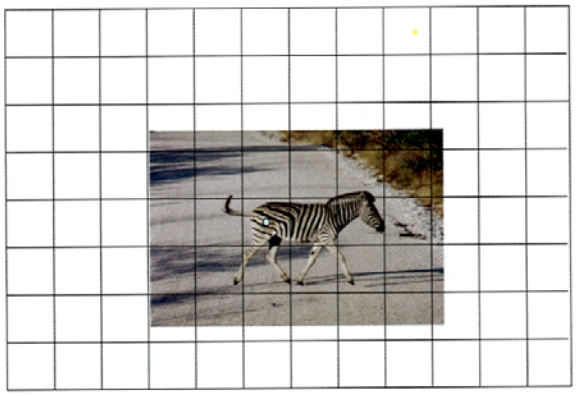
ALIASING

- Aliasing happens when hi-res image is drawn on low-res media



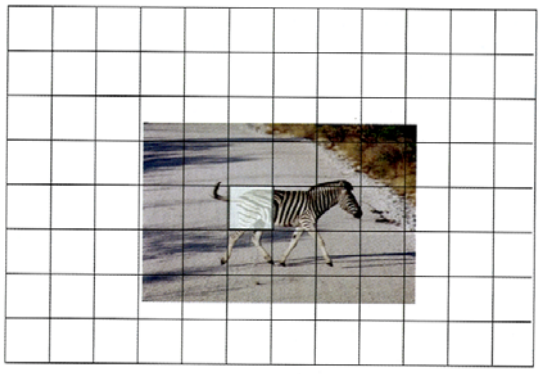
ALIASING

- Aliasing happens when hi-res image is drawn on low-res media
- The heart of the problem:
  too much information in one pixel



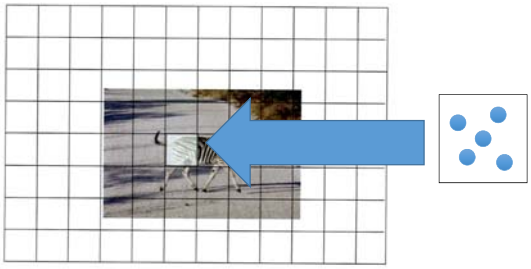
ANTI-ALIASING

- Intuitively:
  - single sample is a bad value
  - should use some kind of average value over some appropriate region.
- In the above examples, perhaps some gray value.



OVER-SAMPLING

- The renderer first produces a "high resolution" color and z-buffer "image",
  - where we will use the term *sample* to refer to each of these high resolution pixels.
- Then, once rasterization is complete, groups of these samples are averaged together, to create the final lower resolution



11

SUPER-SAMPLING

- If the sample locations for the high resolution image form a regular, high resolution grid, then this is called *super sampling*.
- We can also choose other sampling patterns for the high resolution "image"

12

FASTER: MULTI-SAMPLING

- Sample per pixel/per triangle - fragment shader called **only once per final resolution pixel.**
  - This color data is shared between all of the samples hit by the triangle in a single (final resolution) pixel.
- *During the rasterization* of each triangle, "coverage" and z-values are computed at this sample level
  - One triangle on the pixel, coverage is 1
  - 3 triangles on the pixel, coverage is 3
- Once rasterization is complete, groups of these high resolution samples are averaged together.

13

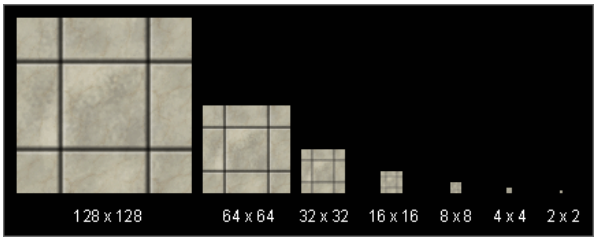
MULTI-SAMPLING

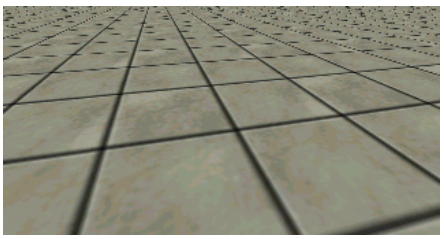
- Why is MS effective?
- Colors tend to vary quite slowly over each triangle
  - => no need to be computed at high spatial resolution
  - not true for textures
- For textures: pre-process the texture image itself
  - Our mipmaps!

14

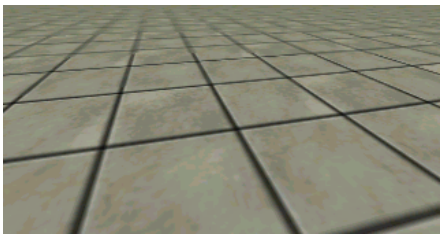
MIPMAPPING

use “image pyramid” to precompute averaged versions of the texture



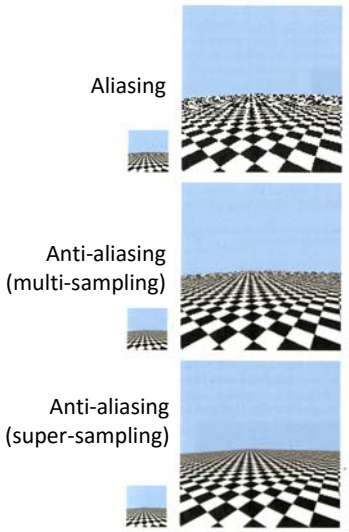


Without MIP-mapping



With MIP-mapping

ALIASING AND ANTI-ALIASING



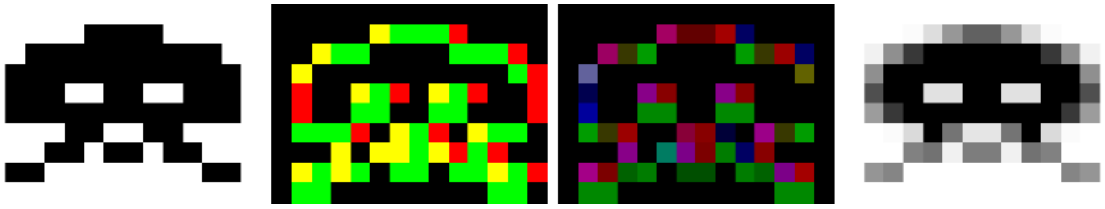
16

REAL TIME ANTI ALIASING PROBLEMS

- Supersampling requires rendering 2x/4x/8x/16x the # of pixels
- Multi-sampling incompatible with rendering techniques
  - Only at geometry *edges* - multisampling will not anti-alias a specular highlight
  - Mip-mapping requires the data being interpolated to be linear (color)
    - Cannot mip-map normals, shader data, specularity, etc.
- Game industry relies on “tricks”

MORPHOLOGICAL ANTI-ALIASING

- Detect patterns of “jagged” edges using color/depth information
- Look for specific patterns along borders
- Blend pixels along borders intelligently using their pattern type and position in the pattern – not real anti-aliasing but good enough



TEMPORAL STRATEGIES

- The previous frame is pretty close to this frame
- Find out "how close" by analyzing motion of last frame compared to this frame
- Use sample from previous frame (where possible) to 'fake' super-sampling

TEMPORAL STRATEGIES CAN FAIL

- No robust way of doing this (yet!)
- Good, fast, realtime antialiasing is still an open problem for games