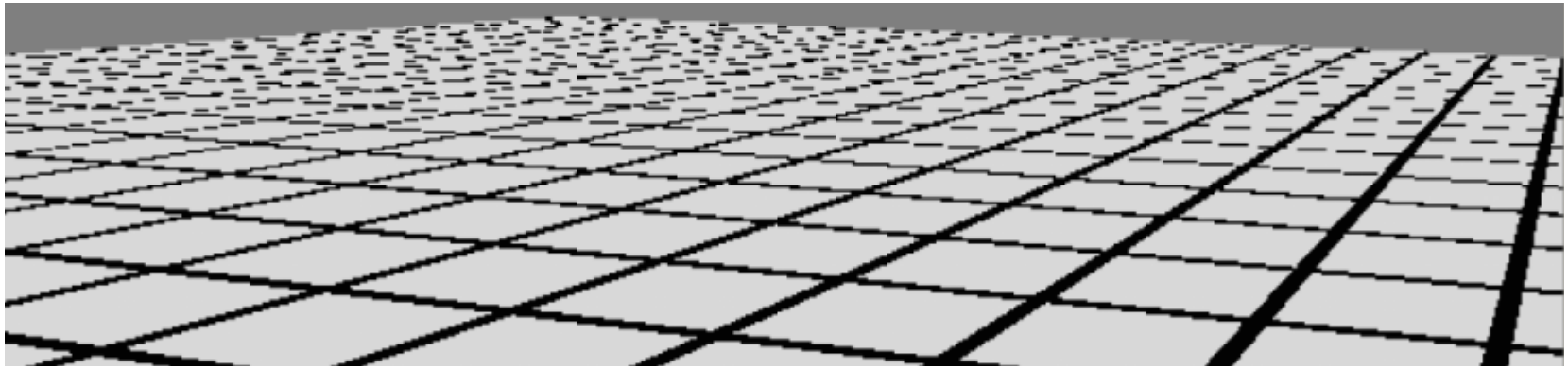
Antialiasing

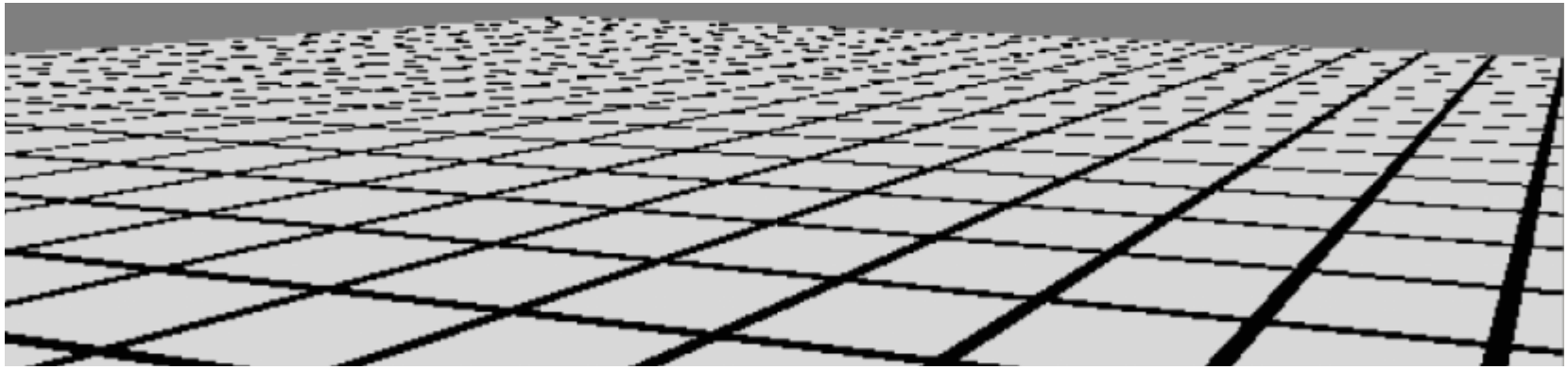
Example: Alien Isolation (2014)

https://youtu.be/Js-Az06kGl8?t=12

What is Aliasing?

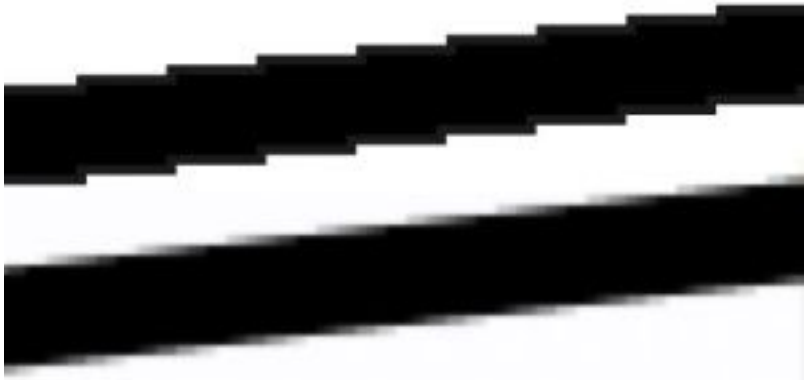


What is Aliasing?



- A signal-processing problem!
- Reconstruction from sampling distorted from original signal
- Called “jaggies” in graphics

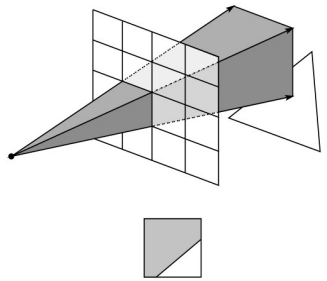
Sampling Problem

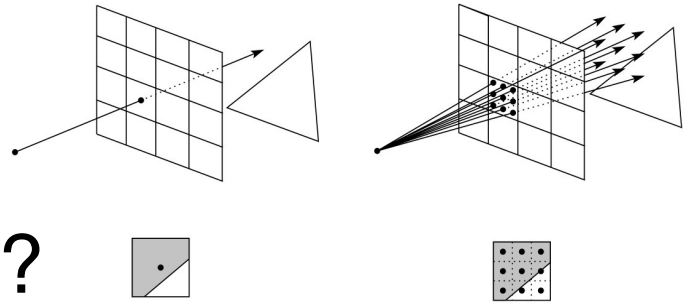


- No correlation of pixel and texel size
- Too many texels per pixel
- Can solve by super-sampling (Nyquist–Shannon sampling theorem)

Antialiasing in a Ray Tracer

- One ray per pixel likely to have artifacts
- Cast multiple rays and average result





What's the problem with this?

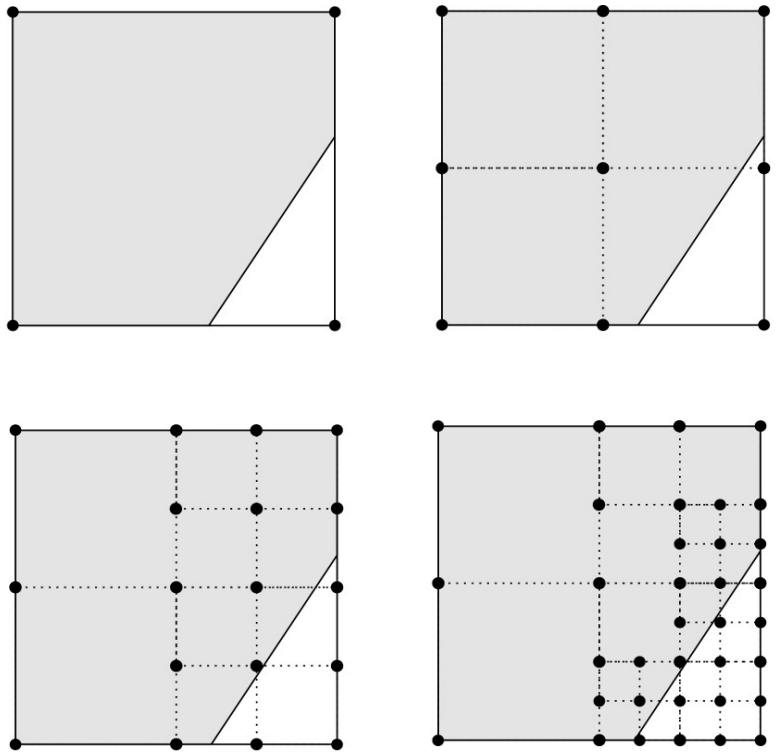
Expensive!

- Many of these super samples are unnecessary
  - Only required in areas with rapid change in intensity

Adaptive Sampling

Cast more rays in a particular area

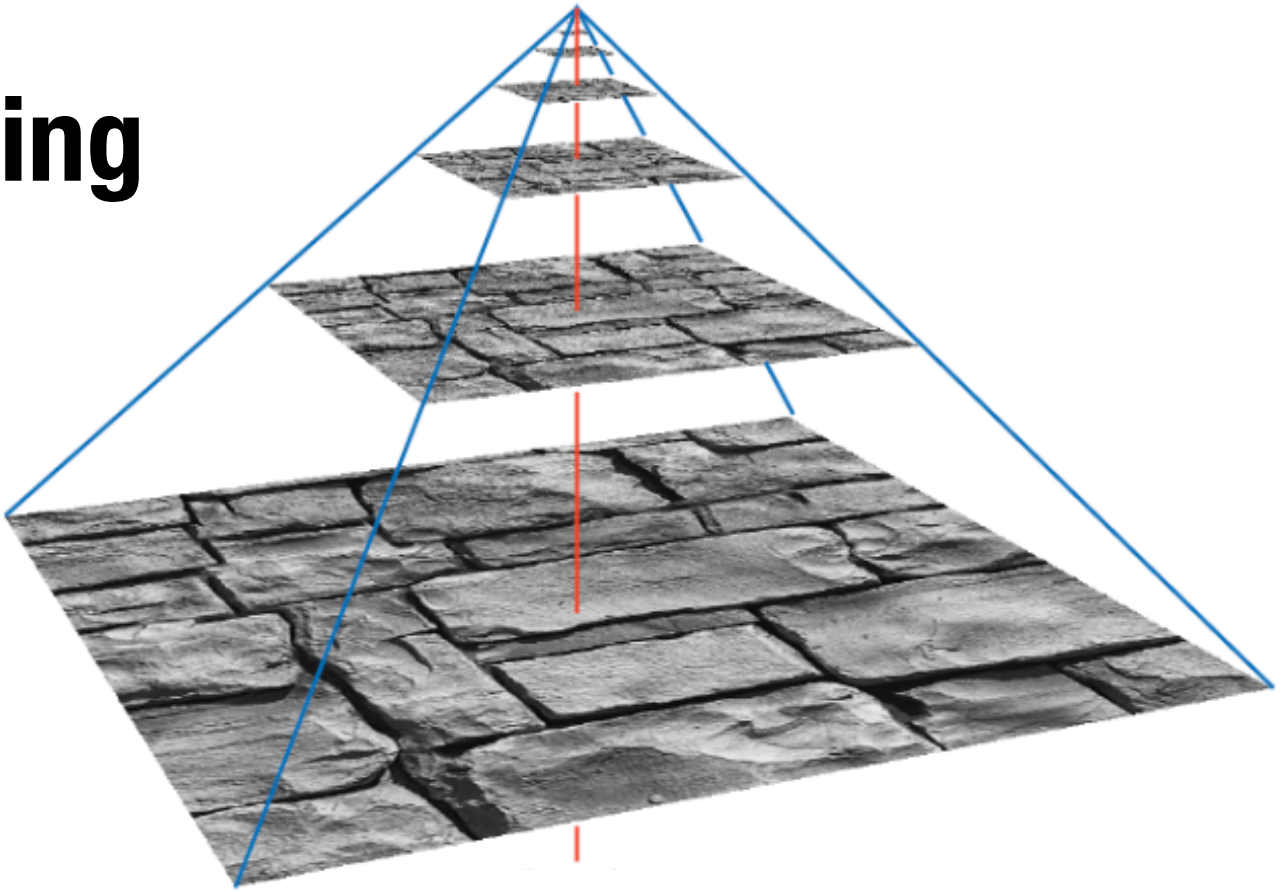
Where should we sample more?



Level of Detail

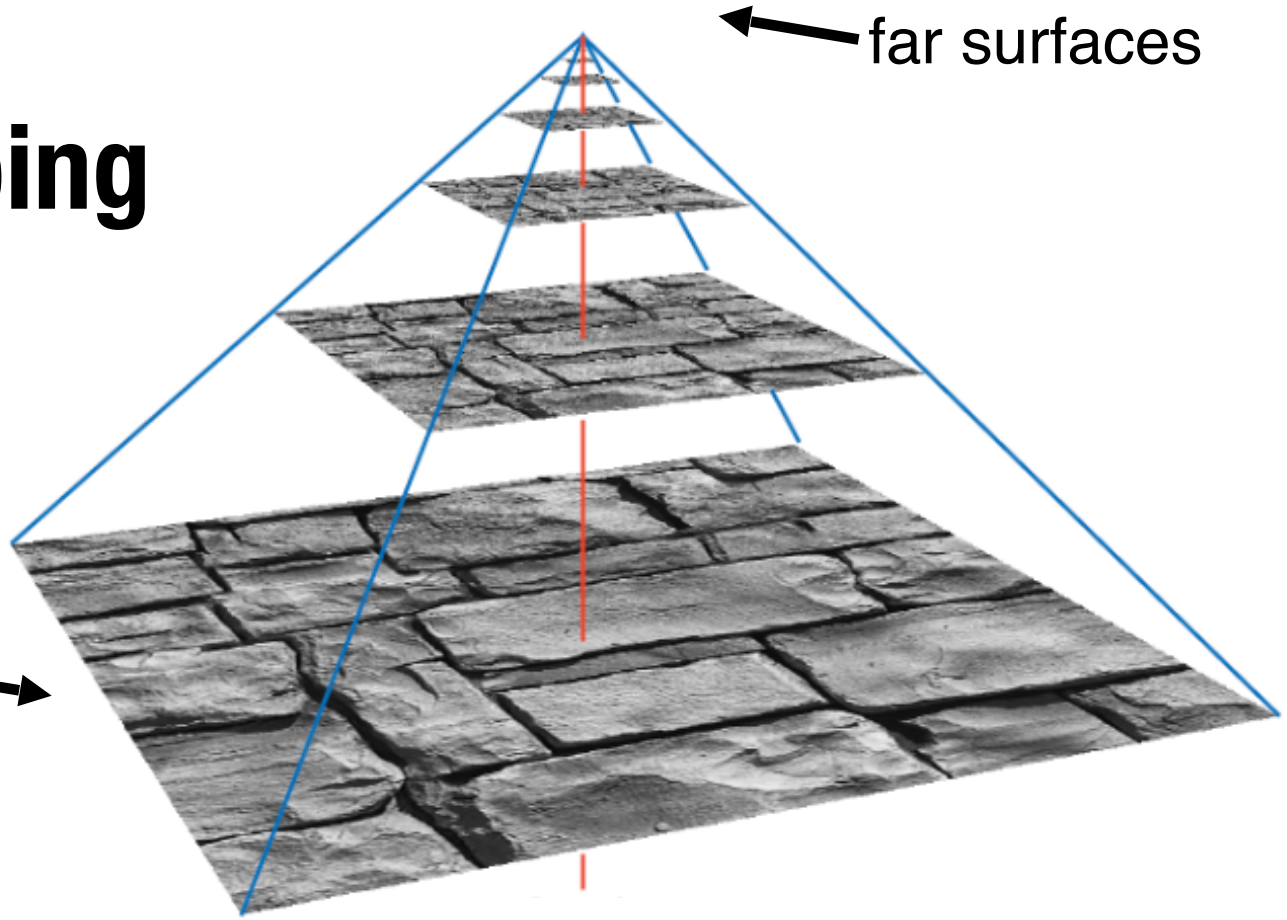
- Decreases complexity based on distance from the camera
- Often used for geometric complexity
  - But can apply to textures and shaders
- Correlates texel and pixel size thus helping with jaggies

Mipmapping



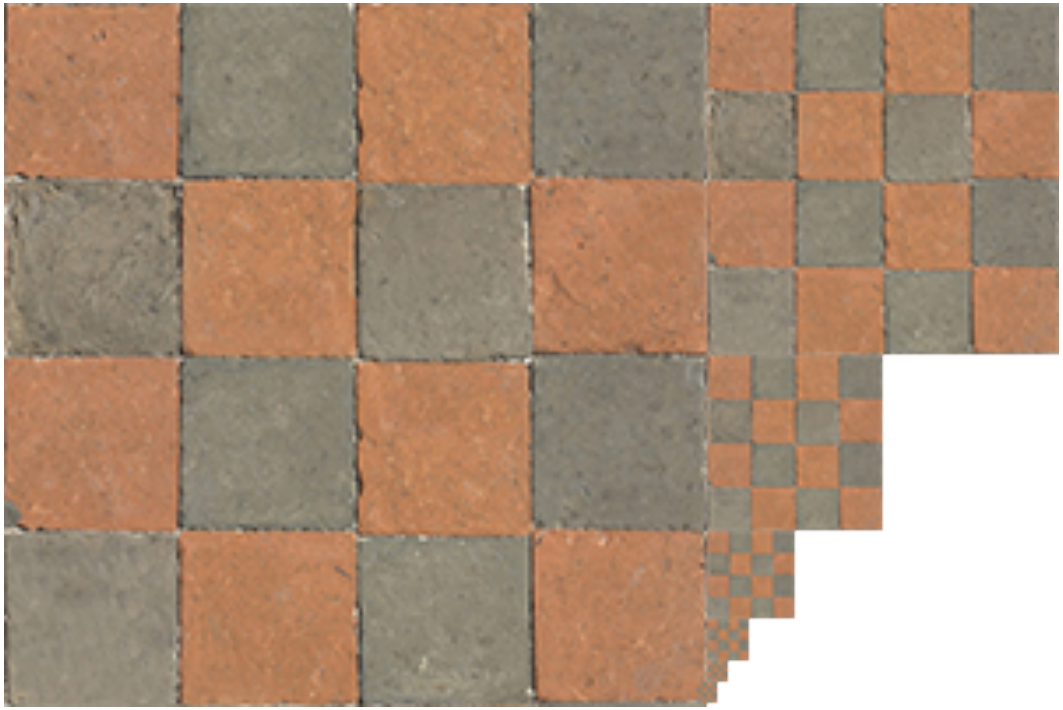
Main idea: store hierarchy of subsampled textures

Mipmapping



How much memory does this take?

Mipmapping



~50% more memory consumed

Applying Textures

What if (u,v) is out of range for the number of pixels?

repeat

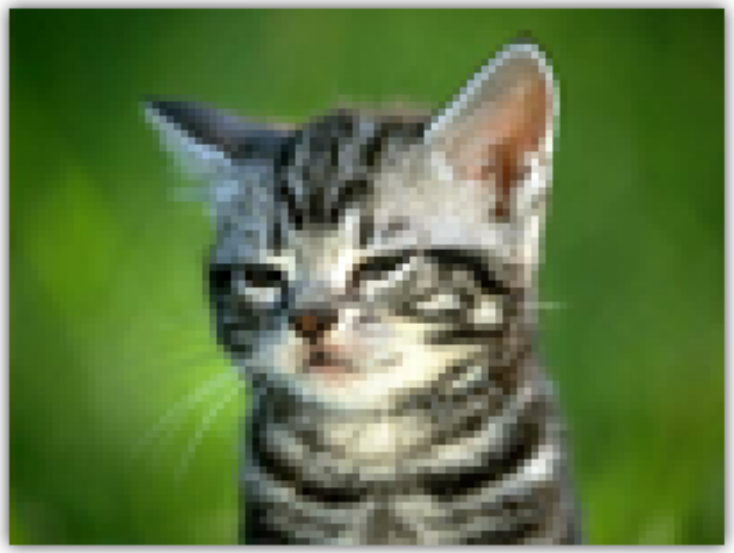
mirror

clamp

background

Apply Textures

What if (u,v) isn't an integer?



snap to nearest texel

linearly interpolate color

Linear Interpolation

Remember linear interpolation using parameter t?

$p(t) = p0(1-t) + p1(t)$

Can also calculate point along line using (x,y) ratios

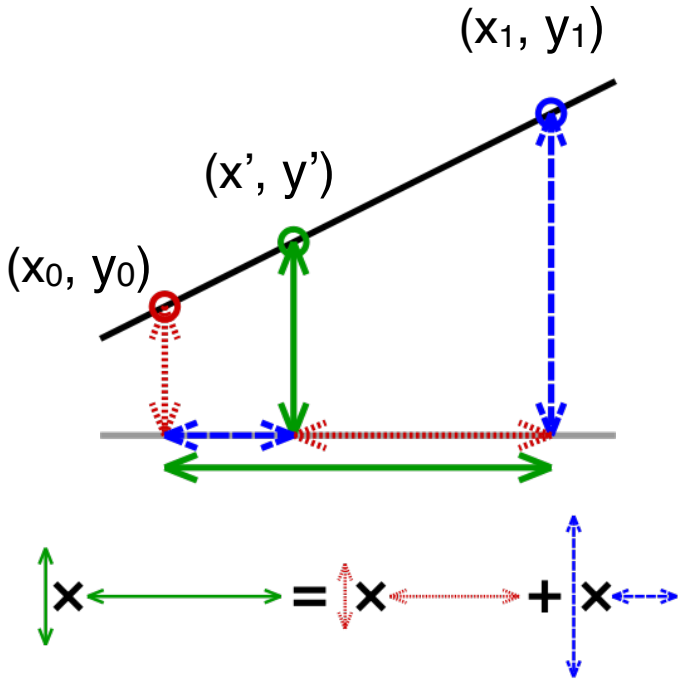
Linear Interpolation

Given known points (x_0, y_0) and (x_1, y_1), we can calculate any y' at x':

$$\frac{y' - y_0}{x' - x_0} = \frac{y_1 - y_0}{x_1 - x_0}$$

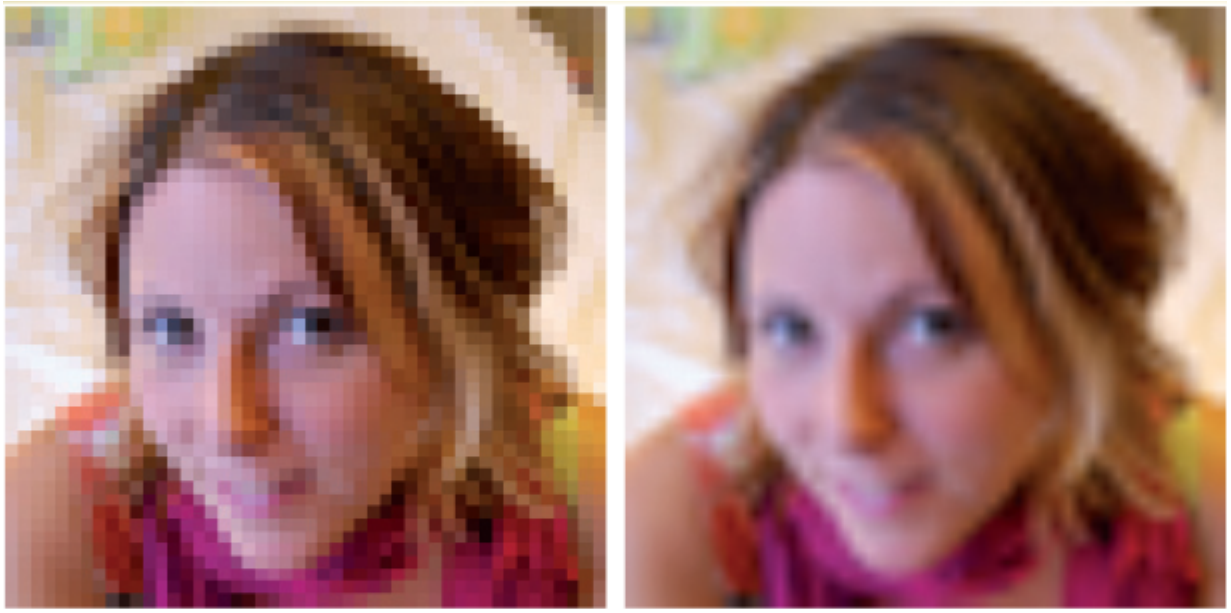
$$y' = y_0 + (x' - x_0)\frac{y_1 - y_0}{x_1 - x_0}$$

$$y' = \frac{y_0(x_1 - x')}{x_1 - x_0} + \frac{y_1(x' - x_0)}{x_1 - x_0}$$



Bilinear Filtering

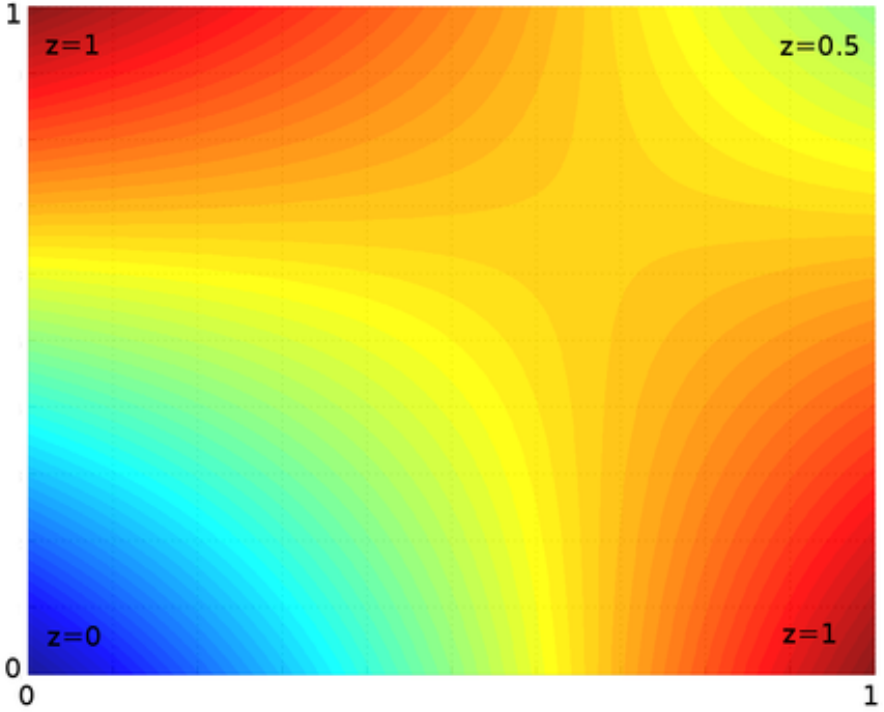
Average four nearest texels



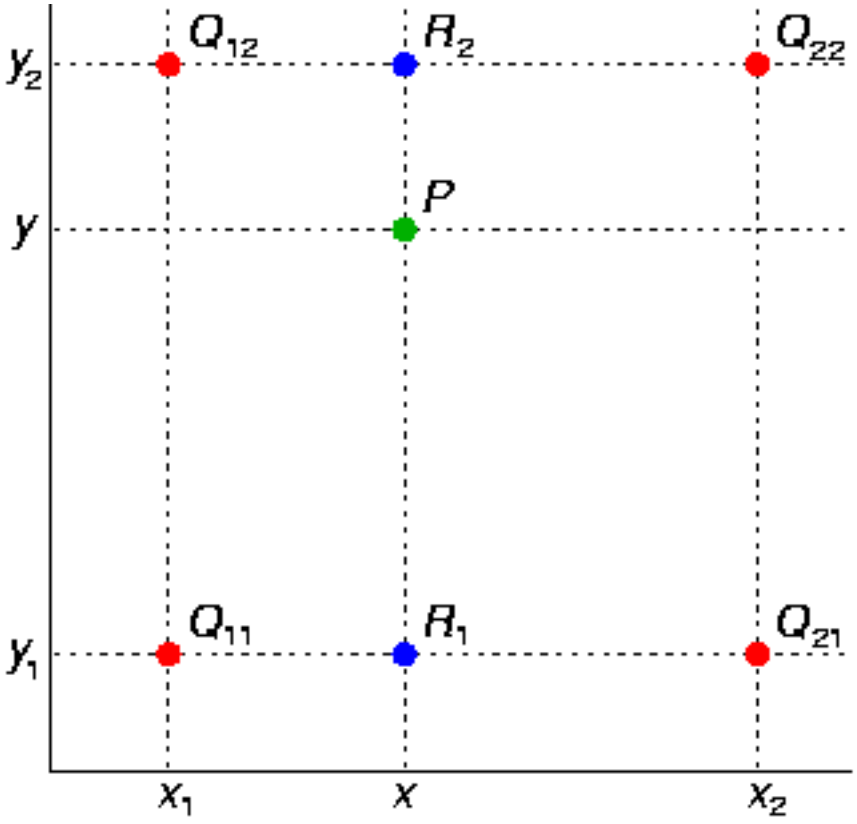
Eliminates “blockiness”/pixellation

Bilinear Interpolation

- Three linear interpolations to calculate a position on a 2D grid
- Provides weighted average between all four points



How to Perform Bilinear Interpolation?

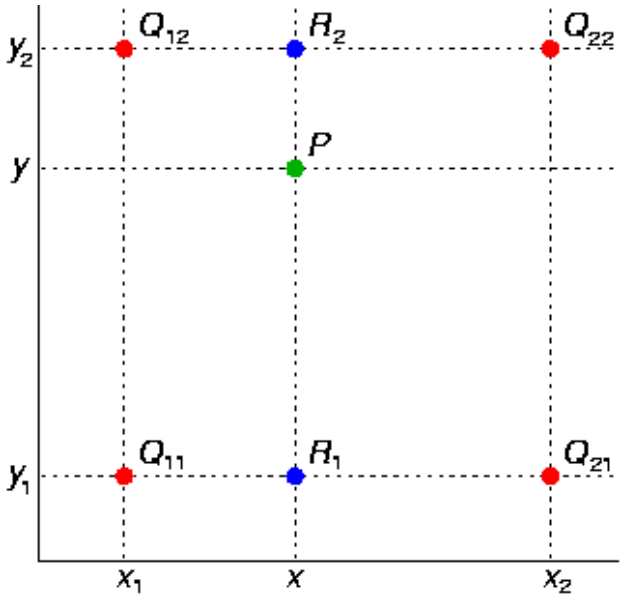


R1 = linear interpolation between Q11 and Q21

R2 = linear interpolation between Q12 and Q22

P = linear interpolation between R1 and R2

Bilinear Interpolation



$$R1 = Q11(\frac{x_2 - x}{x_2 - x_1}) + Q21(\frac{x - x_1}{x_2 - x_1})$$

$$R2 = Q12(\frac{x_2 - x}{x_2 - x_1}) + Q22(\frac{x - x_1}{x_2 - x_1})$$

$$P = R1(\frac{y_2 - y}{y_2 - y_1}) + R2(\frac{y - y_1}{y_2 - y_1})$$

Trilinear Filtering

Classic problem in games: popping

Trilinear Filtering

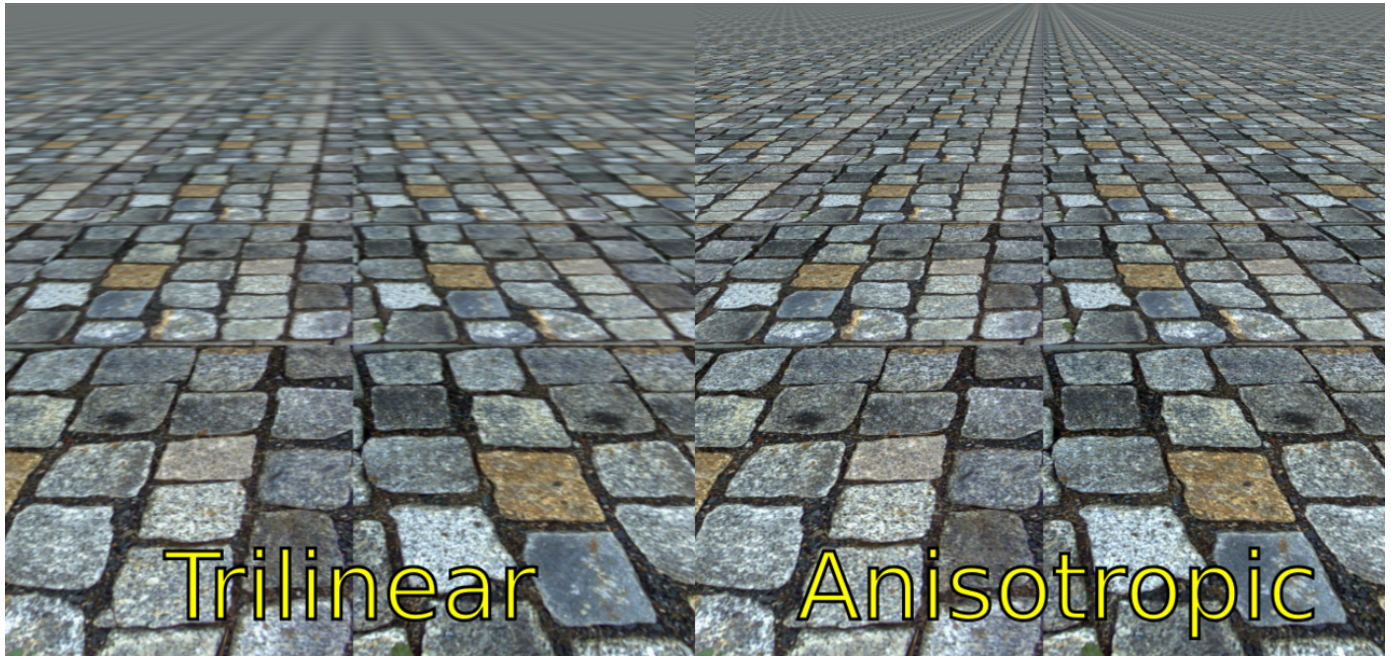
Classic problem in games: popping

Can fix by averaging neighboring levels:

Bilinear interpolation on each level then linearly interpolate

Anisotropic Filtering

Use non-square pyramid levels



Compute them on the fly

Anisotropic Mipmaps

Modern Anti-Aliasing

- Aliasing is still an active area of research!
- Many techniques exist to reduce its effects in real-time applications
  - MSAA (multisample anti-aliasing)
  - TXAA (temporal anti-aliasing)
  - DLSS (deep learning super sampling)
- Efficiency of AA techniques relate to screen resolution (the jump from 2k to 4k requires different approaches)

Example: Control (2019)

https://youtu.be/YWIKzRhYZm4?t=43