

Anti-Aliasing

CMSC 161: Interactive Computer Graphics

2nd Semester 2014-2015

Institute of Computer Science

University of the Philippines – Los Baños

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x: 0, y: 0

x: 1, y: 0



x: 0, y: 1

x: 1, y: 1



Aliasing

Distortion of data caused by reduction of
analog data to a discrete data

The method of reduction is called **sampling**

Aliasing

Spatial Aliasing for spatial data

Temporal Aliasing for time related data

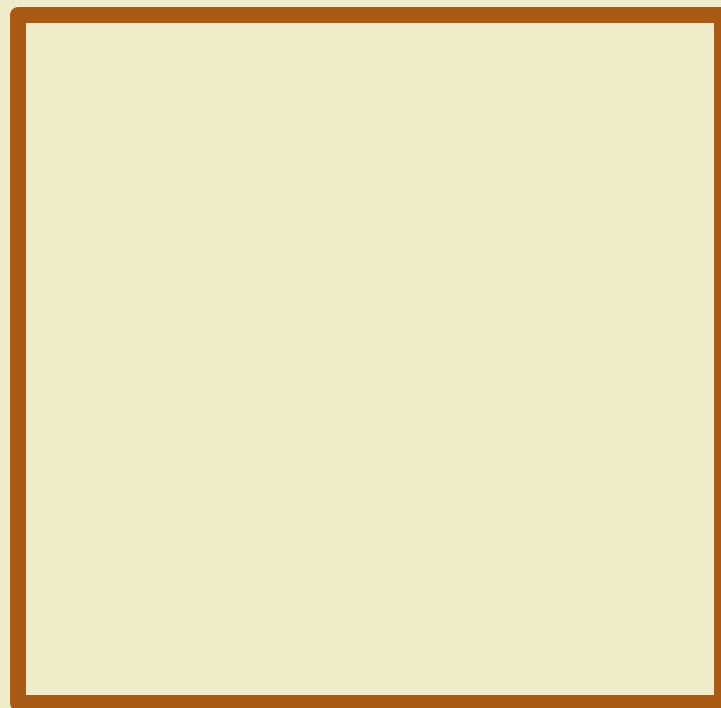
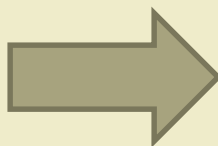
Spatial aliasing

A type of visual artifact that looks like
stair-steps

Spatial aliasing

Consequence of **rasterization**

Occurs when there is an **insufficient sampling of data**



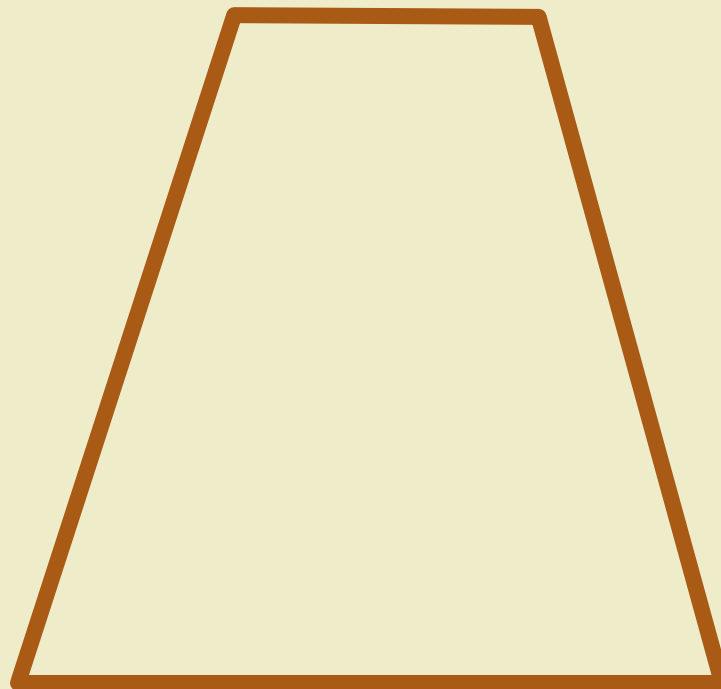
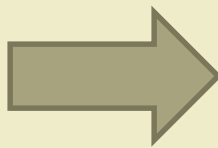
x: 0, y: 0

x: 1, y: 0



x: 0, y: 1

x: 1, y: 1



$x: 0, y: 0$

$x: 1, y: 0$

WebGL

$x: 0, y: 1$

$x: 1, y: 1$

$x: 0, y: 0$

$x: 1, y: 0$

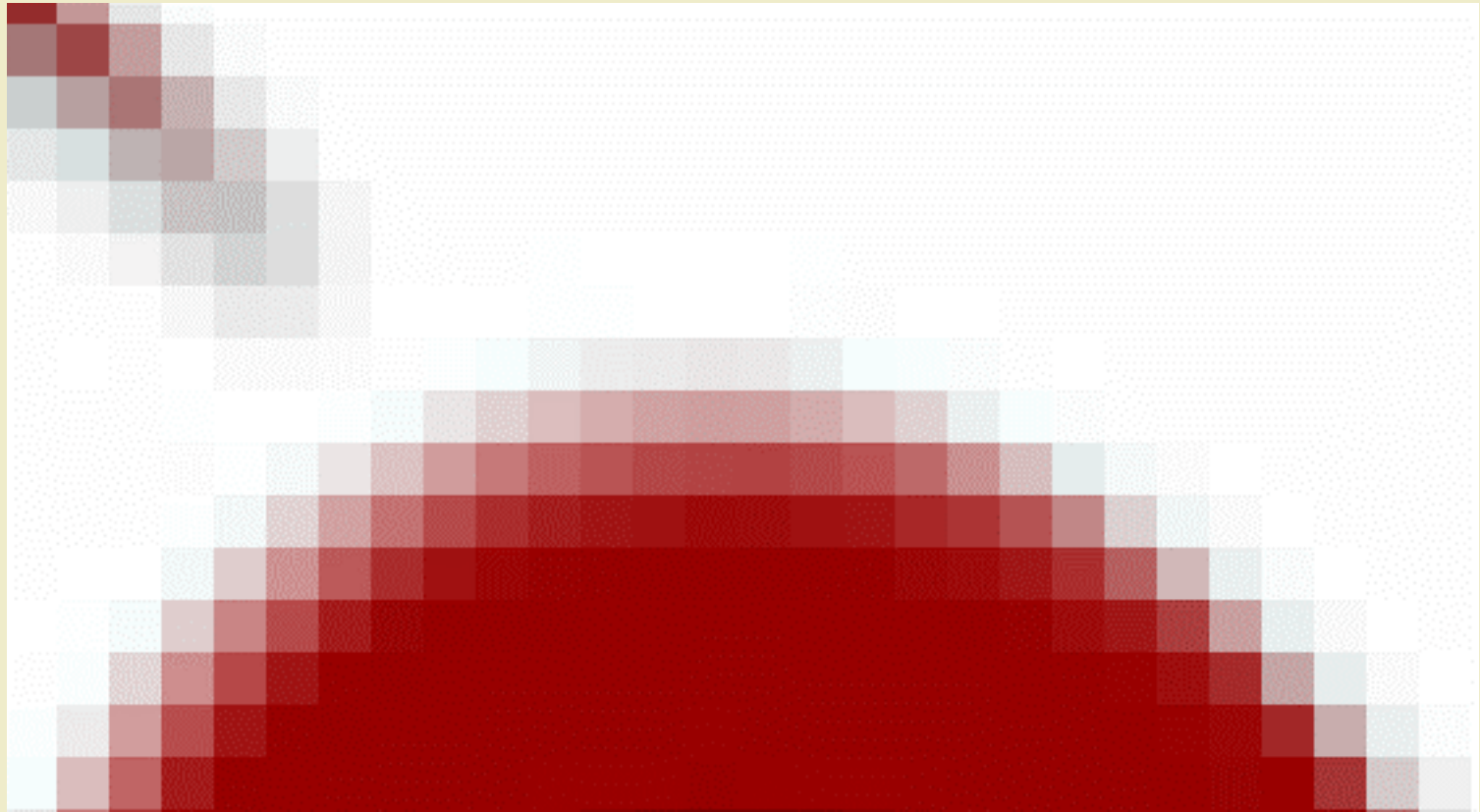


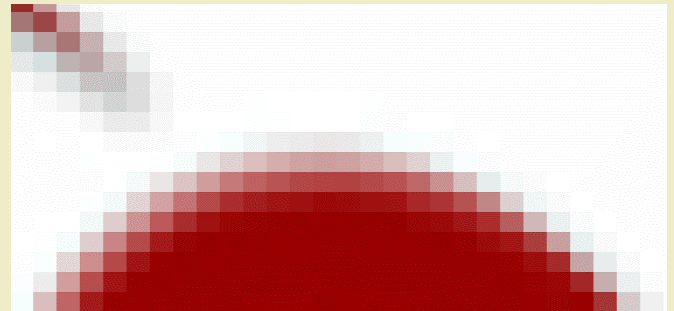
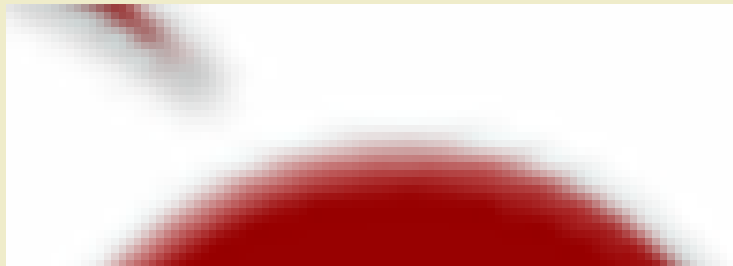
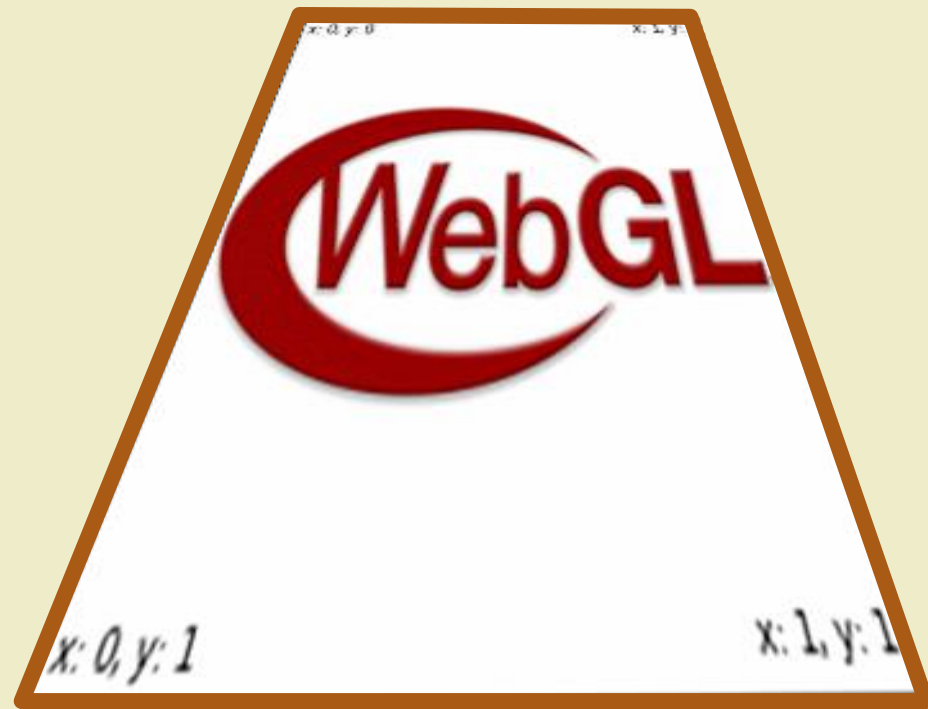
WebGL

$x: 0, y: 1$

$x: 1, y: 1$





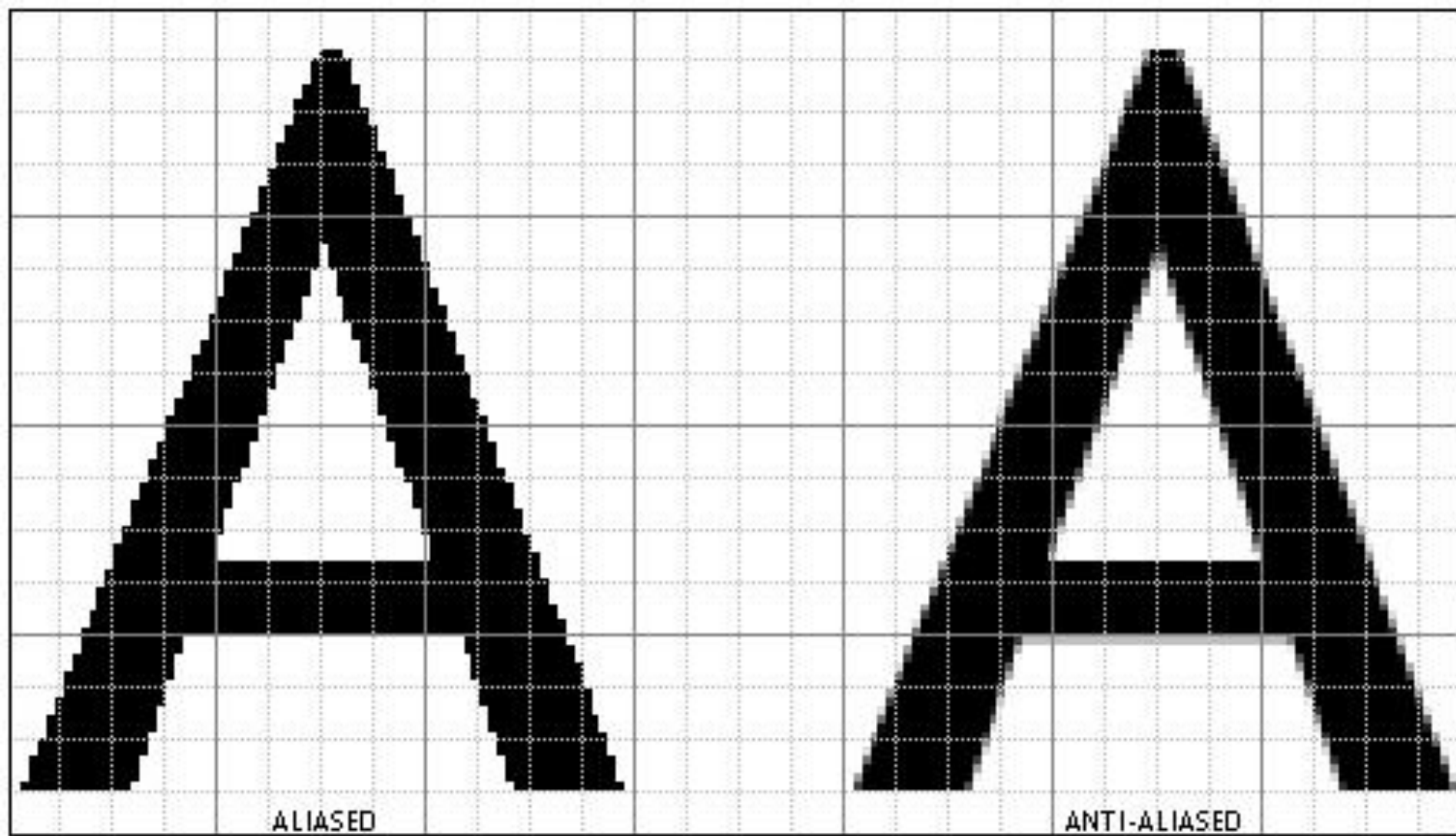


Spatial **Anti**-aliasing

Technique used to minimize the prevalence of
aliasing

Spatial **Anti**-aliasing

Blends the edges of shapes using color to
make them less harsh



Spatial Anti-aliasing

Done using

Sampling algorithms

Or

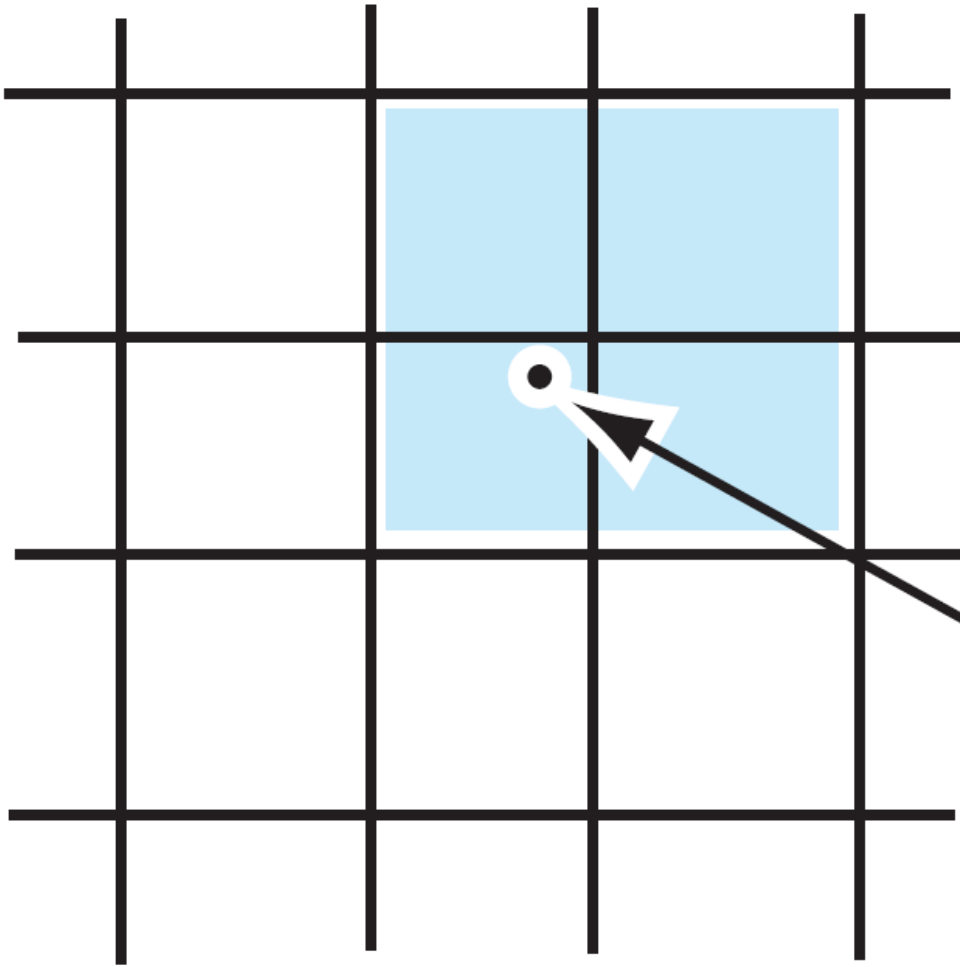
Filtering algorithms

Spatial Anti-aliasing

Filtering for textures

Sampling for objects (general)

FILTERING ALGORITHMS

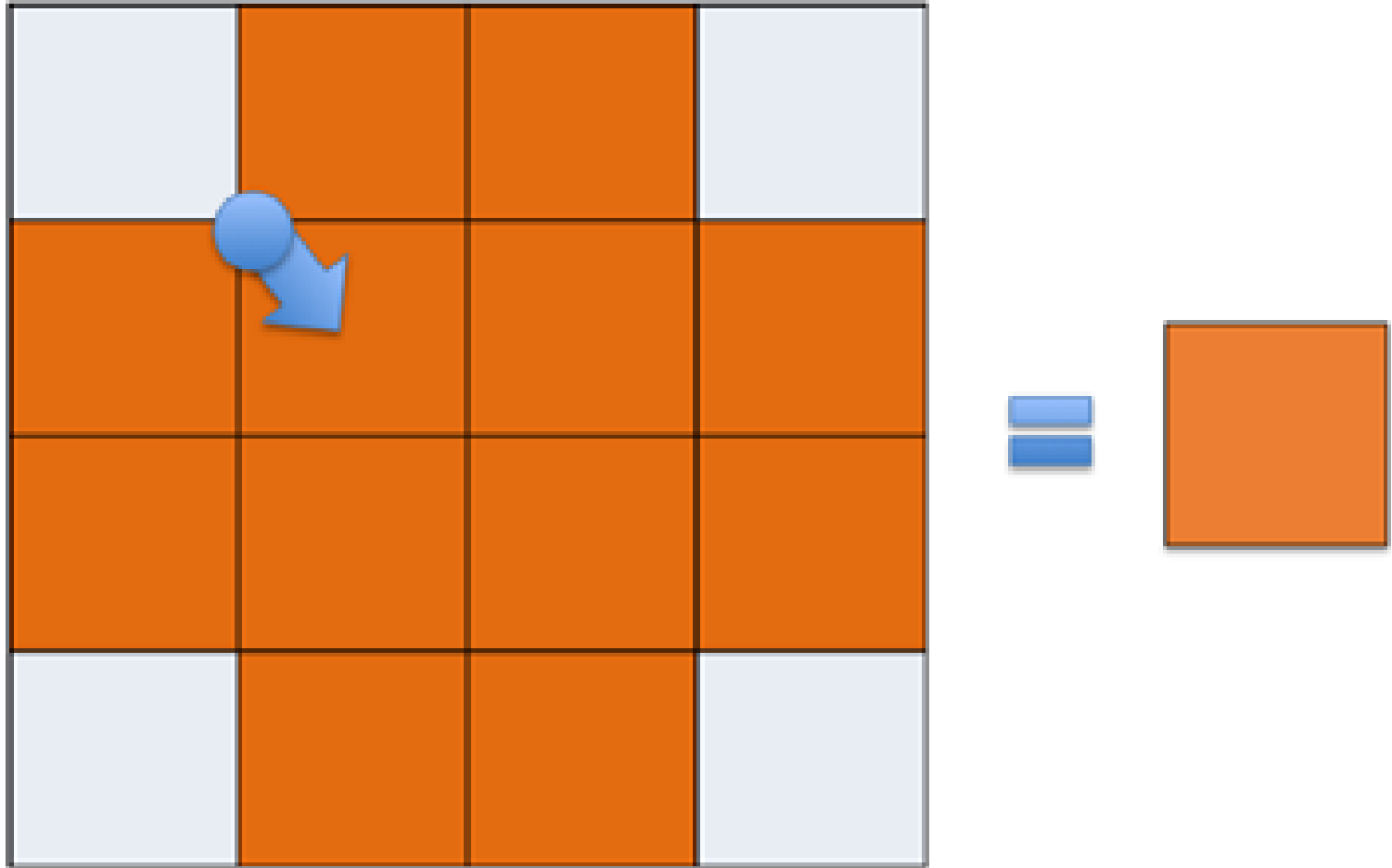


point sample

Nearest Neighbor Filtering

Select the texel that is **nearest** to the
pixel/fragment

Nearest Neighbor Filtering

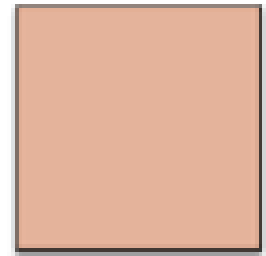
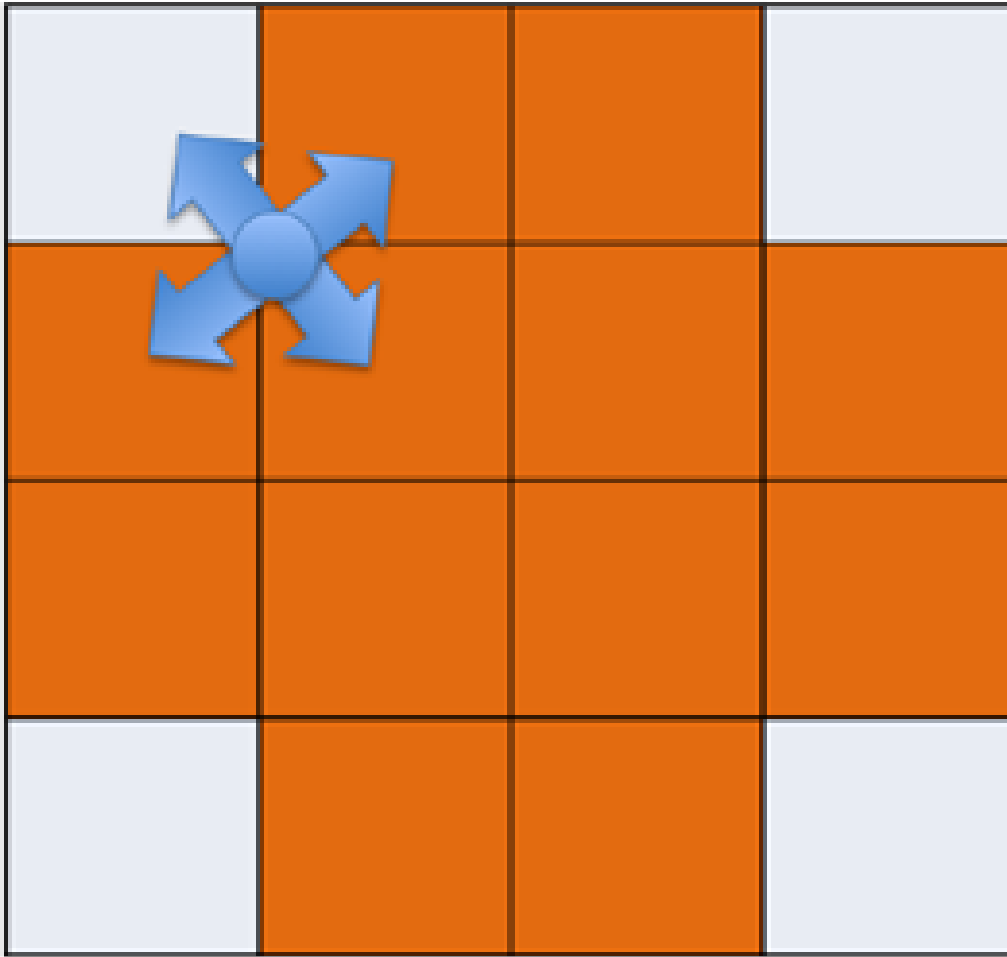


gl.NEAREST

Linear Filtering

Select the **nearest four texels** to the pixel/fragment and average its values

Linear Filtering



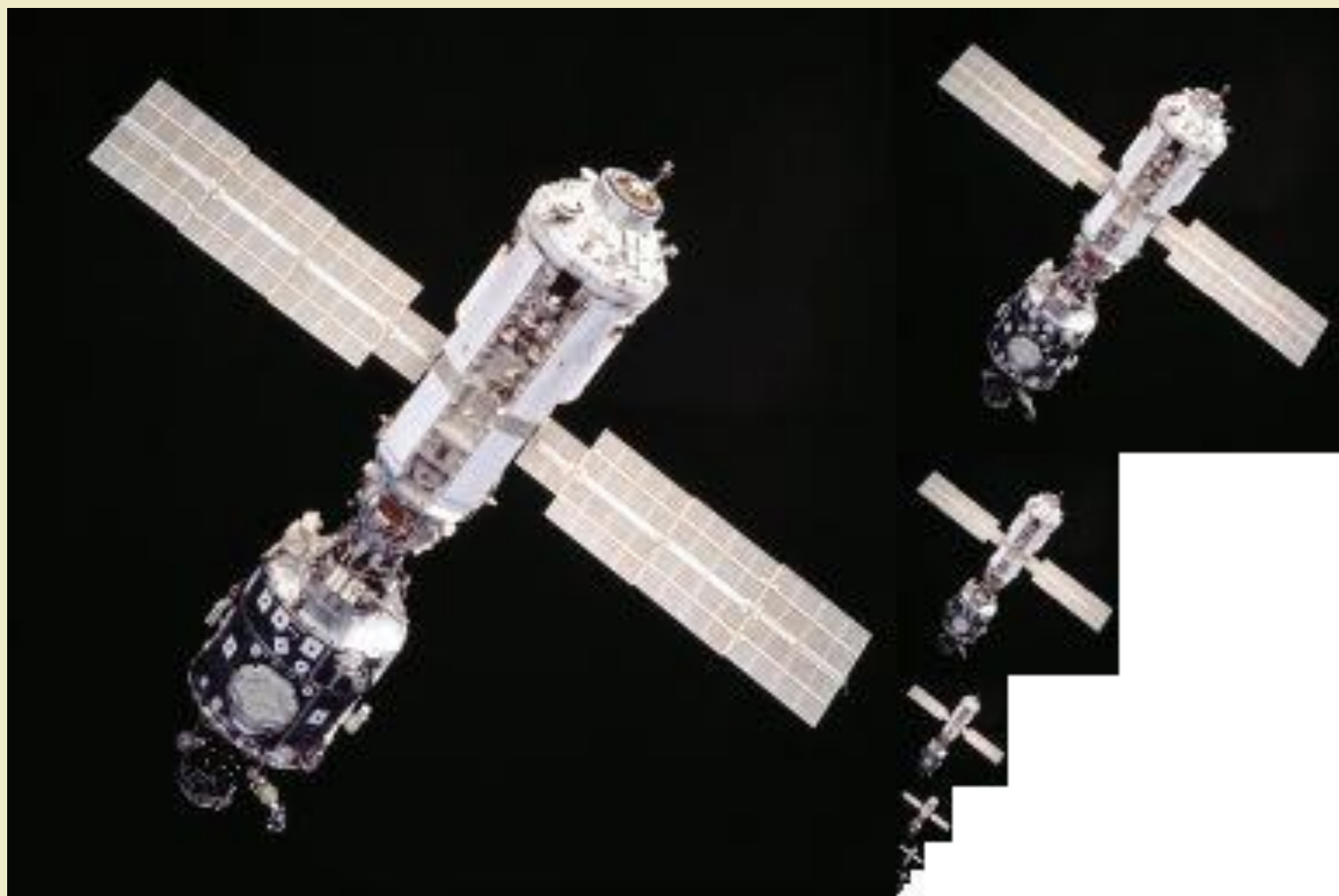
gl.LINEAR

Linear Filtering

Maybe used with or without MipMaps

Mipmapping





Bilinear filtering

Linear filtering that uses MipMaps

Bilinear filtering

Perform **linear filtering** on the selected
MipMap level

Magnify or minify the selected mipmap level when necessary

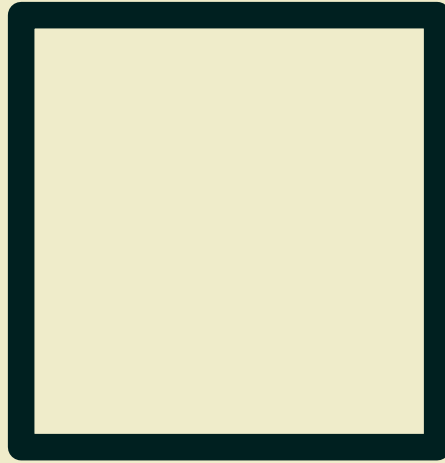
Bilinear filtering

Select the **nearest Mipmap level** that is
closest to the size of the object

perform linear filtering

Magnify or minify the selected mipmap level when necessary

Bilinear filtering



Bilinear filtering



Trilinear Filtering

Improvement of Bilinear Filtering

Bilinear + 1

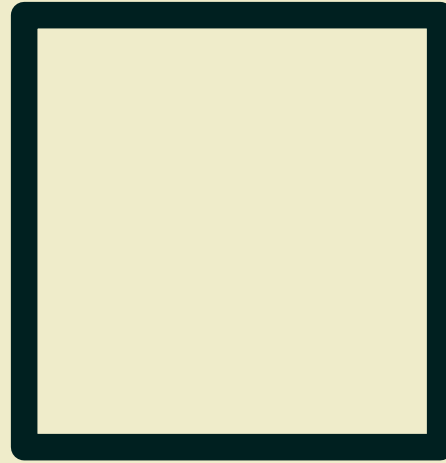
Trilinear Filtering

Select the **two nearest Mipmap level** that is closest to the size of the object then perform linear filtering

Trilinear Filtering

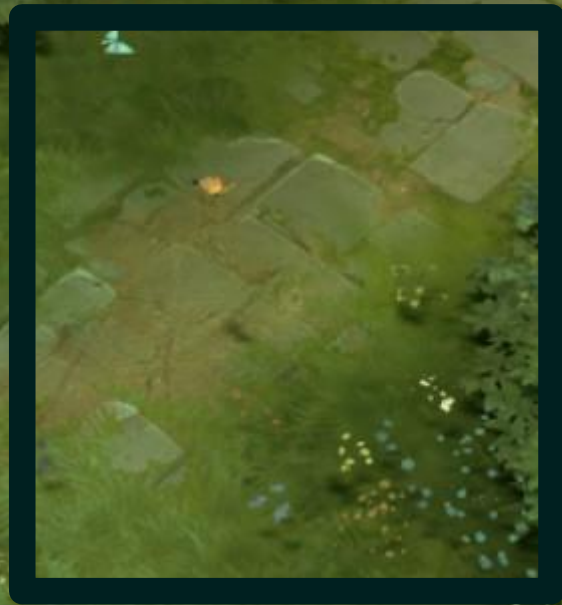
Average the result from two mipmap levels

Trilinear Filtering



Trilinear Filtering





568



LEVEL UP +1



Juxti (Tidehunter) resumed the game.



LEVEL UP +1

TIDEHUNTER

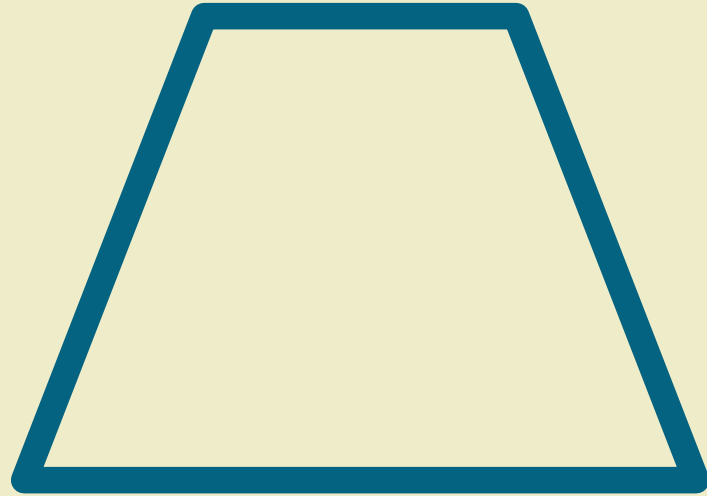
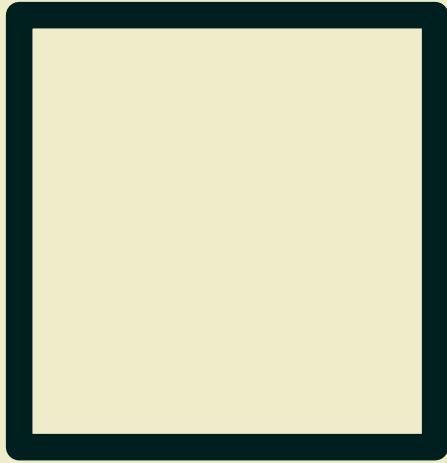


Character status and abilities section:

- Health: 568 / 568
- Mana: 208 / 208
- Attributes: 50 (Strength), 22 (Agility), 15 (Intelligence)
- Items: 3 (Shield), 310 (Boots)
- Abilities: Four ability icons are shown at the bottom.



Trilinear





Anisotropic Filtering

Isotropic

Uniform in all directions

Anisotropic

Antonym of isotropic

Anisotropic Filtering

“Non square mipmaps”

Anisotropic Filtering

Deals with **non-isotropic objects** in the scene

Not always the object is perfectly square at all angles
of the camera

Anisotropic Filtering

Scales the **height or width** of a mipmap by a ratio relative to the distortion of the texture

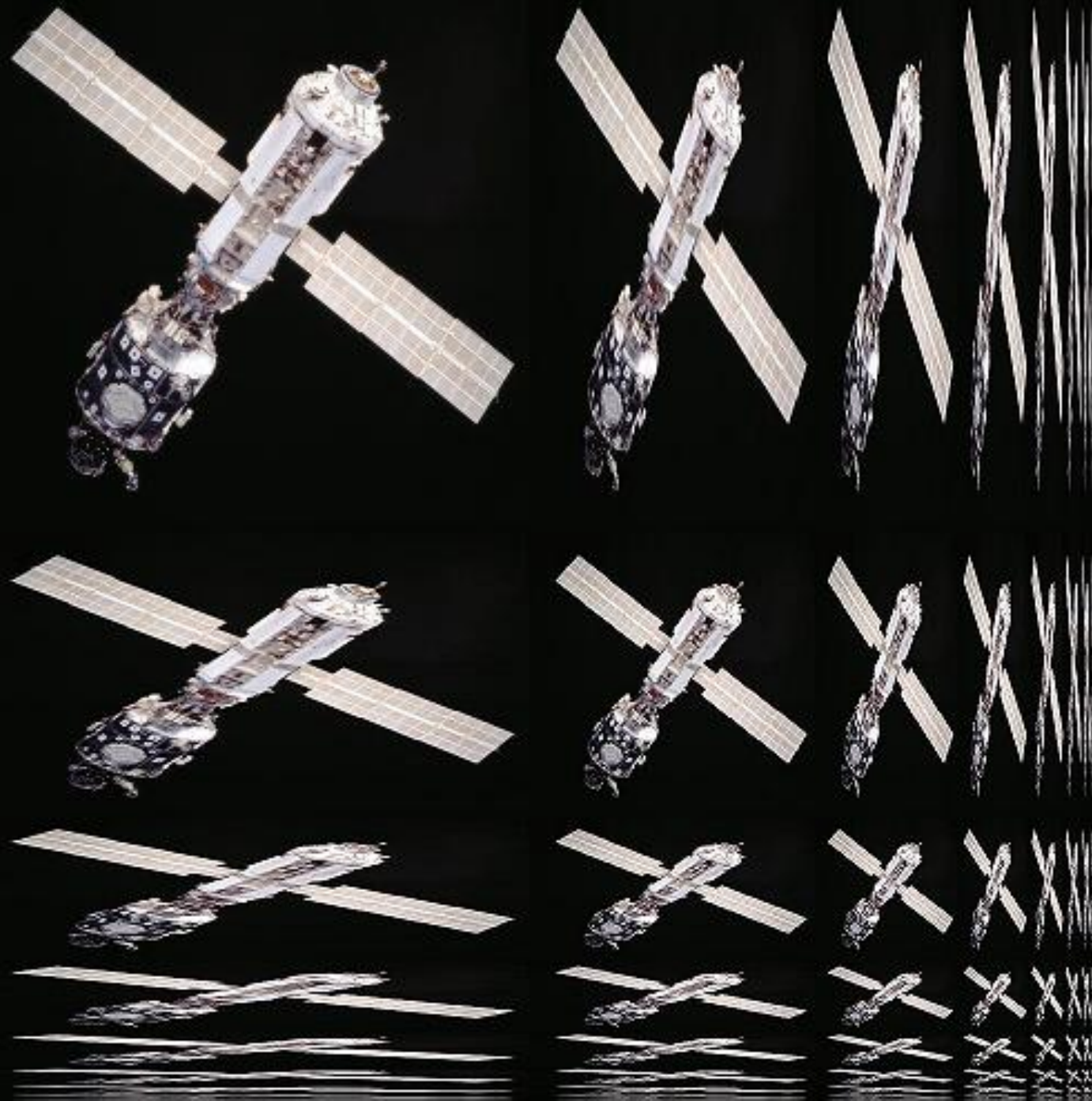
Anisotropic Filtering

It has anisotropy levels between 1 to 16

1x, 2x, 4x, 8x, 16x

Anisotropic Filtering

These levels specify the maximum degree a
mipmap can be scaled



$\approx 4x-8x$
AF

Smooth Lighting: OFF

Max Framerate: 60 fps

3D Anaglyph: OFF

View Bobbing: ON

GUI Scale: Auto

Advanced OpenGL: OFF

Brightness: Bright

Clouds: OFF

Particles: All

Server Textures: ON

Fullscreen: OFF

Use VSync: OFF

Mipmap Levels: 4

Anisotropic Filtering: OFF

Enable Post-Processing: OFF

Done





Trilinear Filtering



2x Anisotrope Filtering



16x Anisotrope Filtering



Bilinear

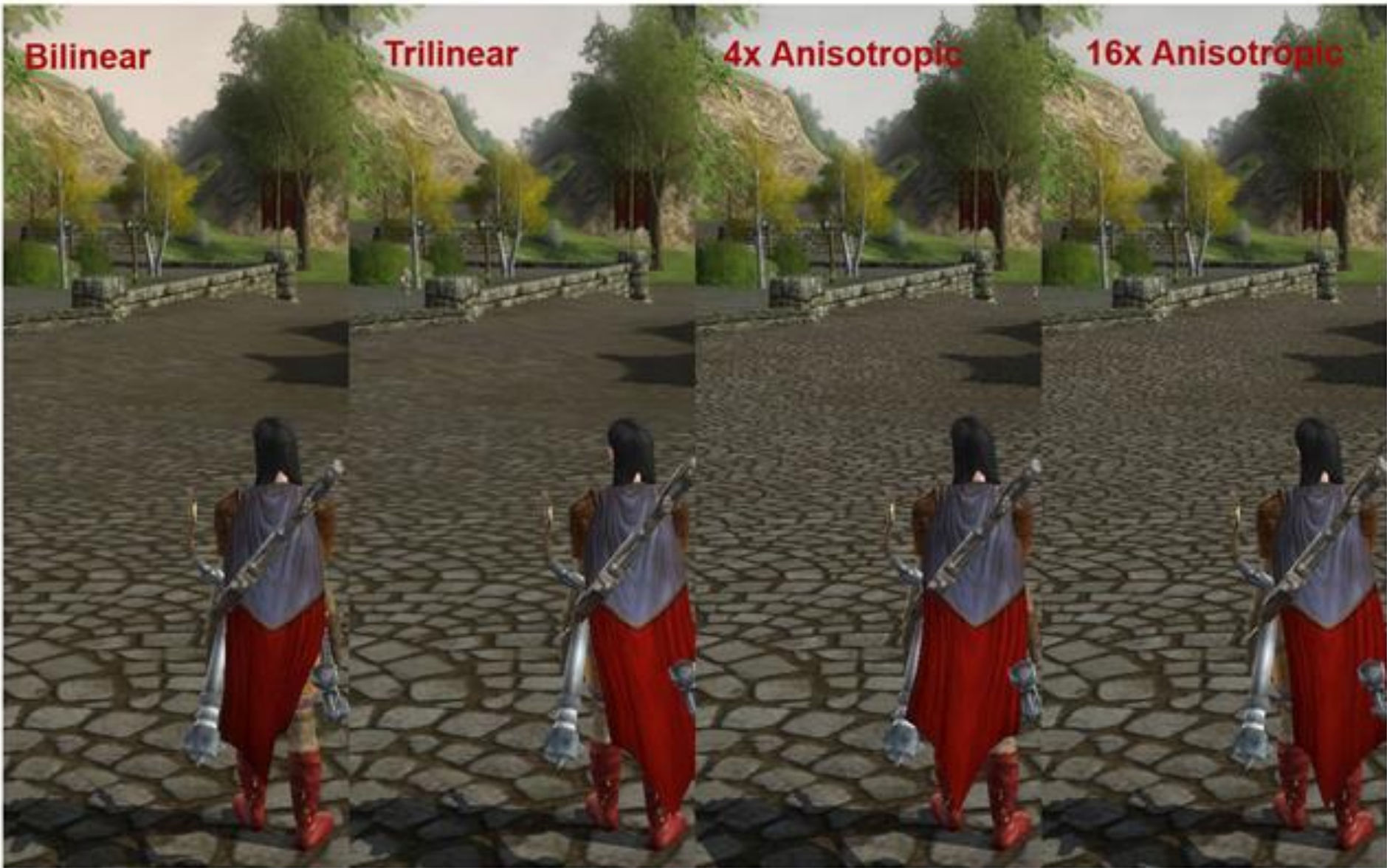
16x Anisotropic (Tr)

Bilinear

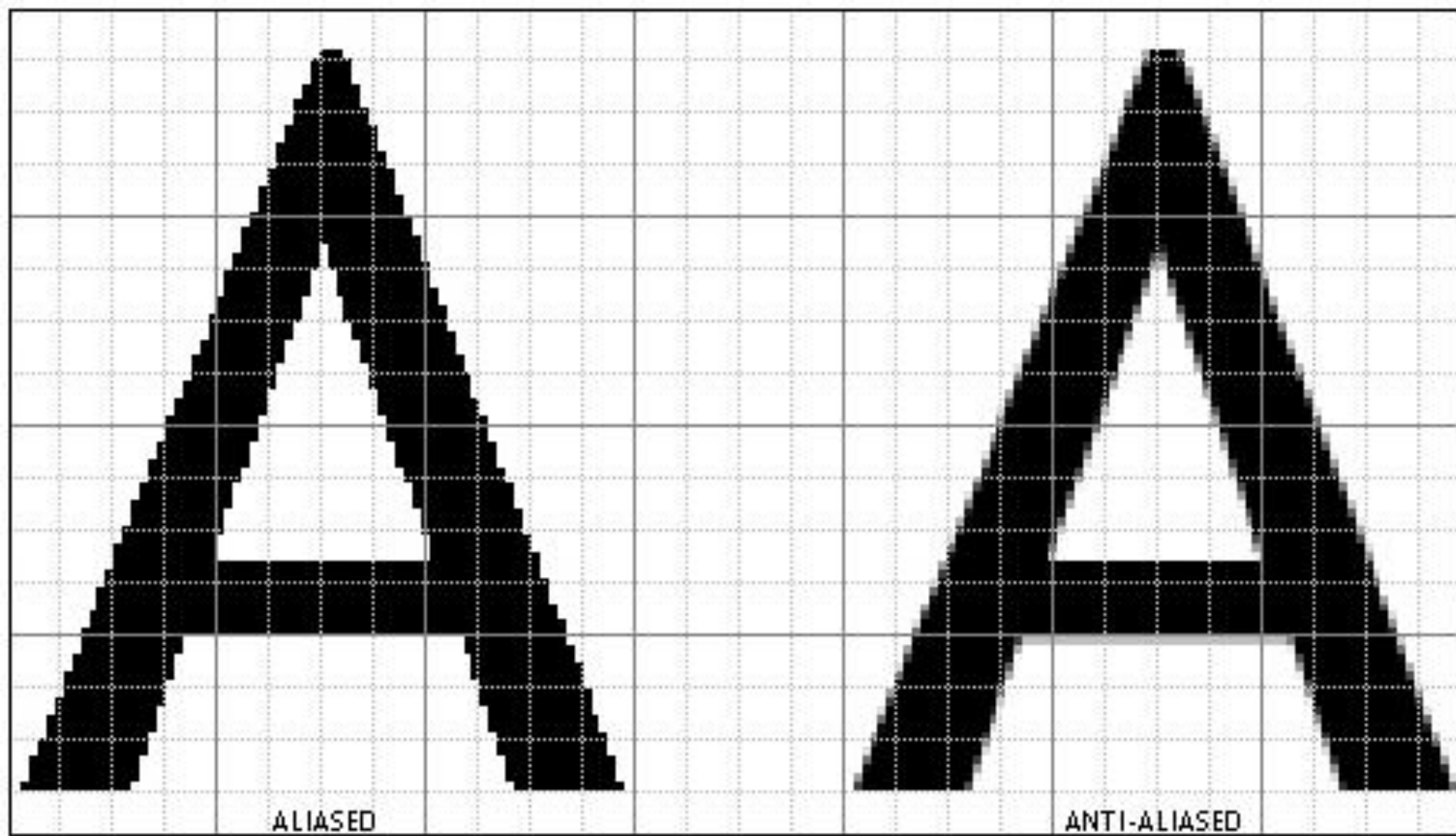
Trilinear

4x Anisotropic

16x Anisotropic



SAMPLING ALGORITHMS



Sampling

Conversion of a continuous signal to a
discrete signal

From a “perfect image” to a discrete image

From a analog audio to a discrete .mp3 audio

Super Sampling

Also known as **Full-Scene Sampling (FSAA)**

Old form of anti-aliasing

Super Sampling

Upscales an image, samples the pixels then
resizes it back down to a smaller size

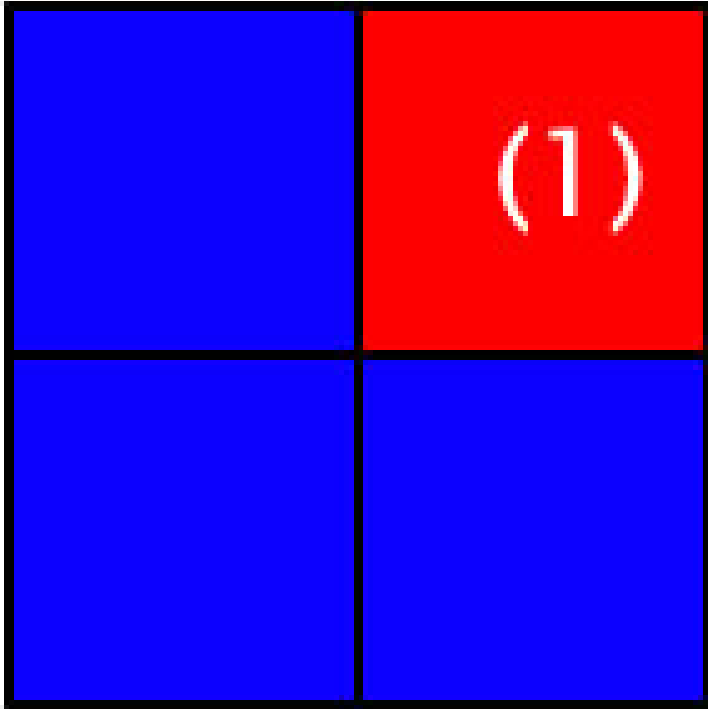
2x, 4x, 8x, 16x, ...

Super Sampling

800x600 image 4x FSAA

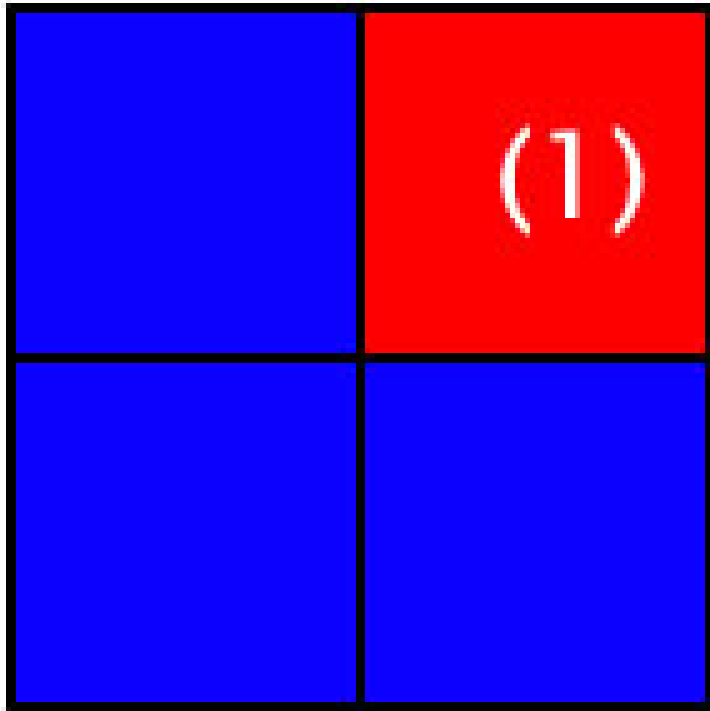
= 1600x1200 scaled image

Super Sampling

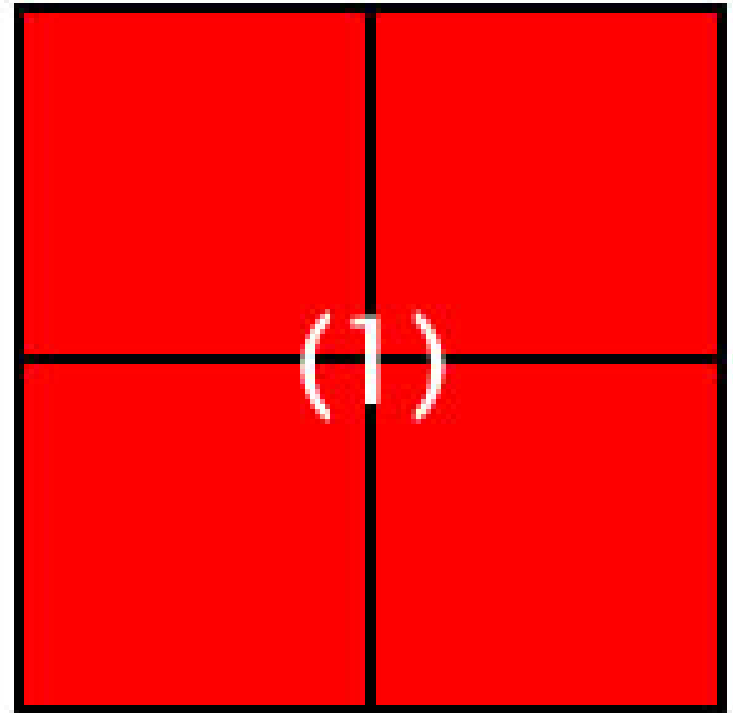
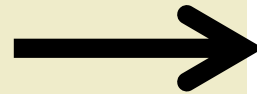


4 pixels

Super Sampling

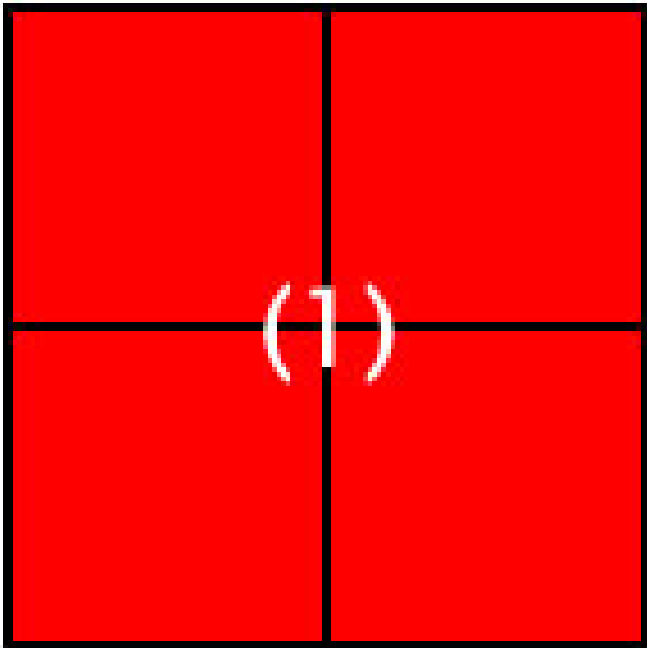


4 pixels



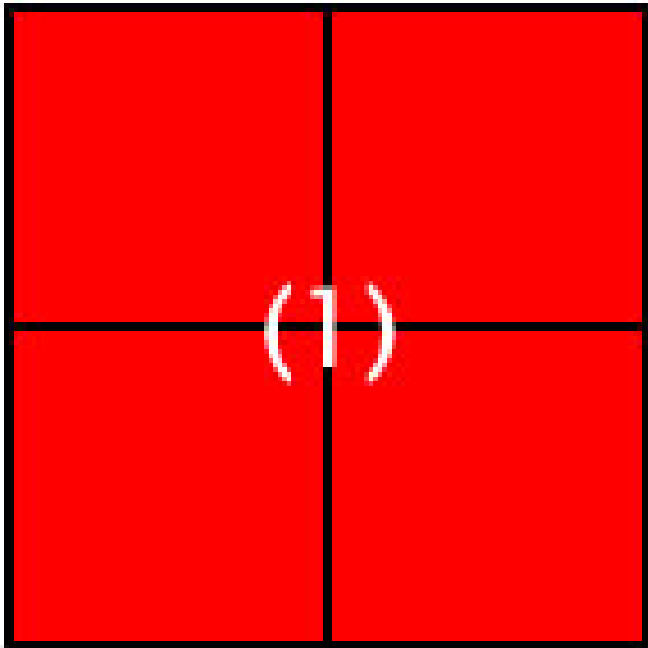
Pixel (1) gets
supersampled to 4
times the resolution

Super Sampling

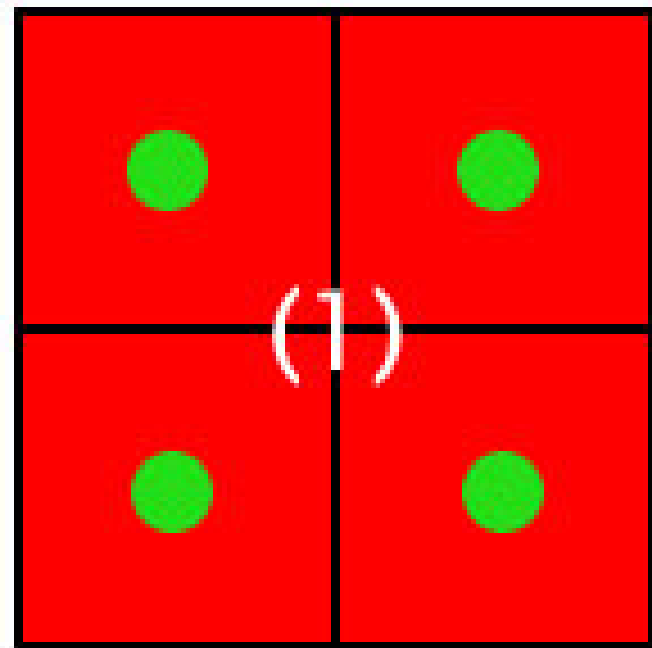


Pixel (1) gets
supersampled to 4
times the resolution

Super Sampling

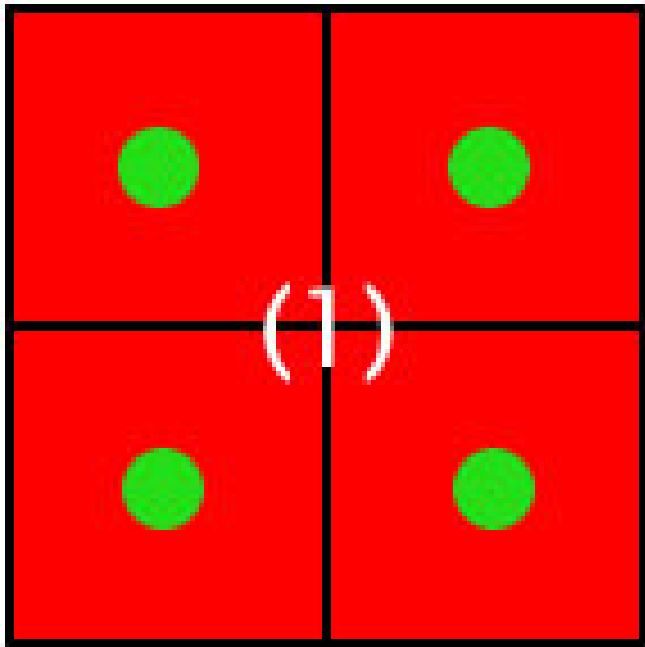


Pixel (1) gets
supersampled to 4
times the resolution



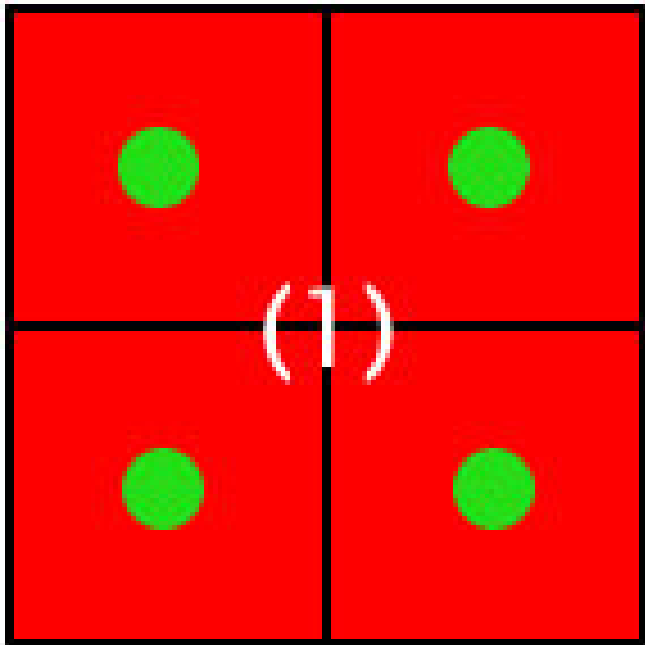
Colour averages are
taken from the 4
points in the pixel

Super Sampling

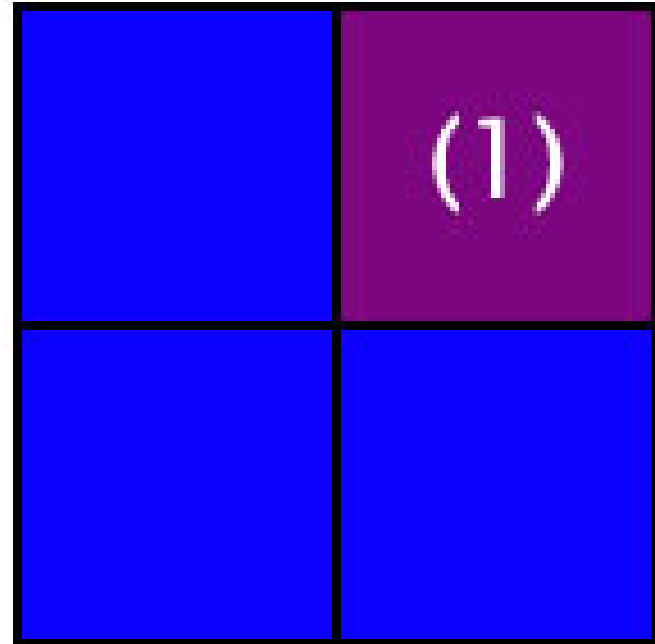
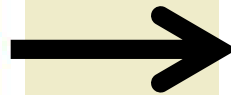


Colour averages are taken from the 4 points in the pixel

Super Sampling



Colour averages are taken from the 4 points in the pixel



When downsized again, (1) is a blended colour

Super Sampling

Significant performance overhead

Abandoned after discovering Multisampling

Multisampling

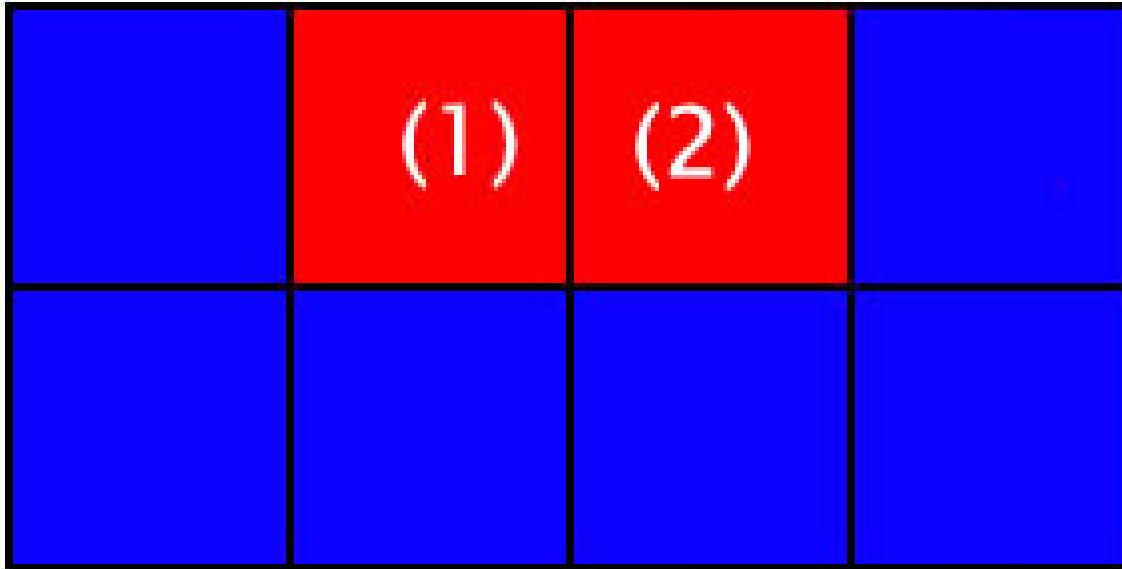
MSAA

Introduced along side Microsoft DirectX

Uses color averages from the original image

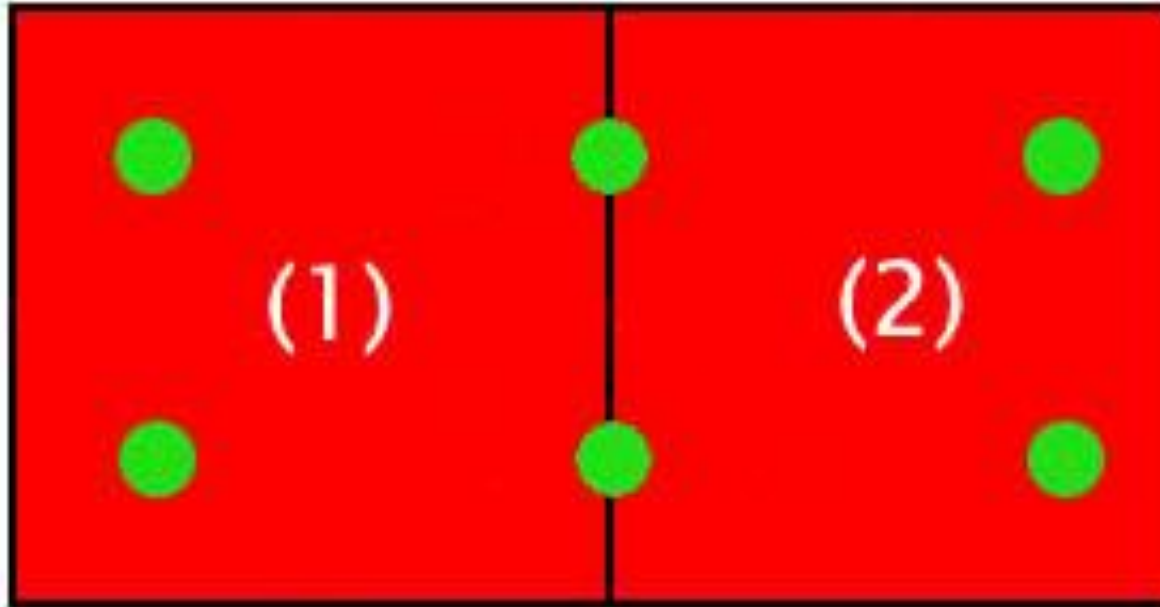
Samples are reused for neighboring pixels

Multi-Sampling



Rather than individually, pixels are sampled together. In this example, we've taken two. The pixels are not scaled up.

Multi-Sampling



Assuming 4x AA, the two pixels share two samples in the middle, meaning only six samples instead of eight.

Other Sampling Methods

Coverage-sampled anti-aliasing (CSAA)

Custom-filter anti-aliasing (CFAA)

Fast Approximate Anti-Aliasing (FXAA)

Morphological Anti-Aliasing (MLAA)

Enhanced Quality Anti-Aliasing (EQAA)

No AA



FXAA



2xMSAA



2xAdaptive



4xMSAA



4xAdaptive



2xMSAA/FXAA



SMAA



4xEQAA



2xSuperSampled



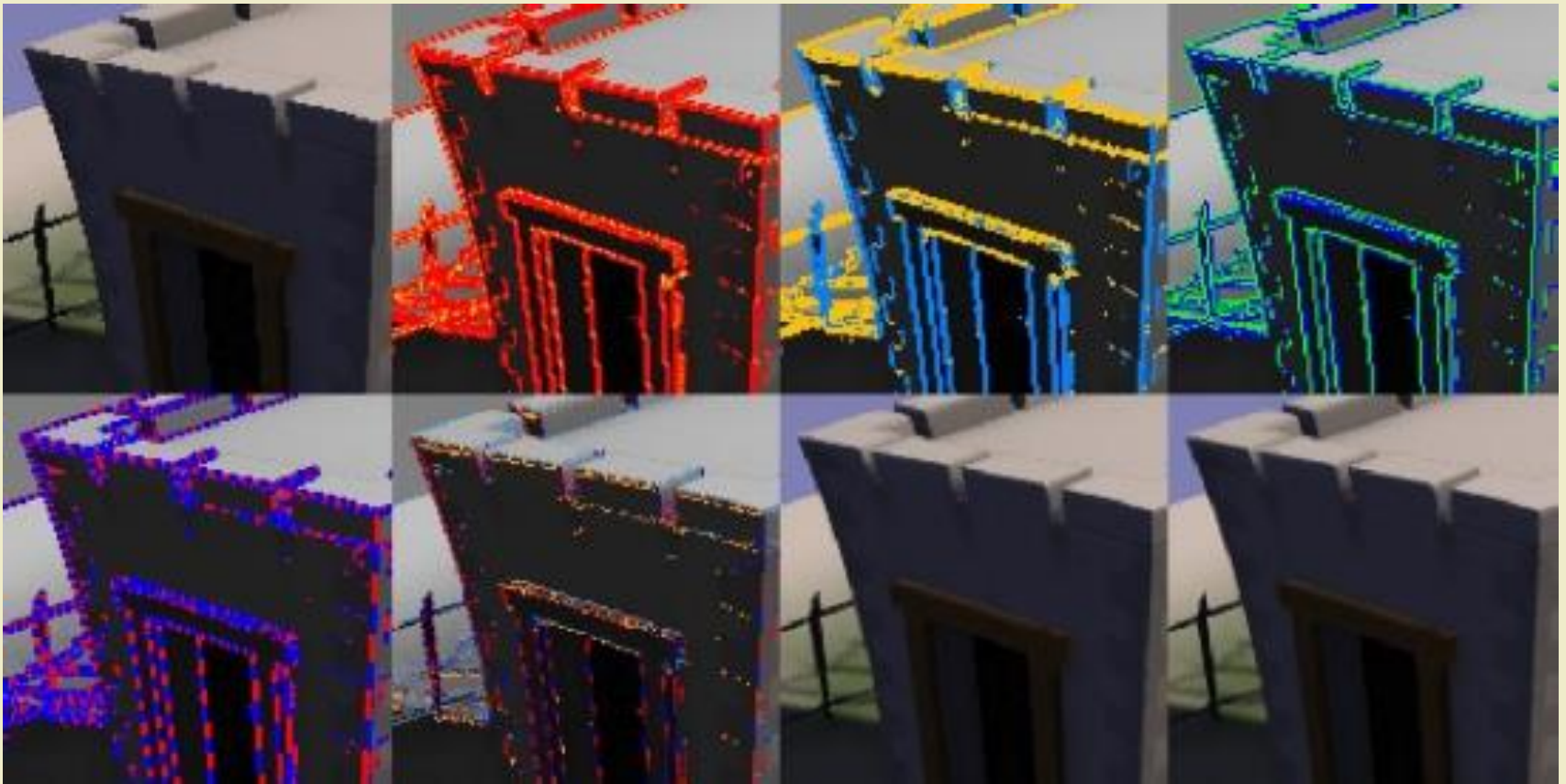
2xMSAA/MLAA



4xMSAA/SMAA



Fast approximate anti-aliasing



References

Books

- ANGEL, E. AND SHREINER, D. 2012. Interactive computer graphics : a top-down approach with shader-based OpenGL. Addison-Wesley. 6thed. Boston, MA.
- CANTOR, D. AND JONES, B. 2012. WebGL Beginner's Guide. Packt Publishing. Birmingham, UK.
- MATSUDA, K. AND LEA, R. 2013. WebGL Programming Guide: Interactive 3D Graphics Programming with WebGL.. Addison-Wesley. Upper Saddle River, NJ

Lecture Slides

- ALAMBRA, A. CMSC 161 1st Semester 2013-14 Lecture Slides

Images

- http://international.download.nvidia.com/webassets/en_US/shared/images/embed/aa-af-guide/embed-aa.jpg
- http://en.wikipedia.org/wiki/File:MipMap_Example_STS101.jpg
- http://commons.wikimedia.org/wiki/File:Anisotropic_filtering_en.png
- <http://img.tomshardware.com/us/2004/06/03/ati/pic06.jpg>
- <http://img.tomshardware.com/us/2004/06/03/ati/pic01.jpg>
- <http://cloud-3.steampowered.com/ugc/594761054307416065/74834985476F74EA1DA9309F4913A505FBC01D2E/>
- http://en.wikipedia.org/wiki/File:FXAA_process.jpg
- http://www.tweakguides.com/images/GGDSG_22.jpg
- <http://www.diablo1.ru/images/poe/settings/TextureFiltering.png>
- <http://benchmark3d.com/anti-aliasing-iq-performance-comparison-7-types-tested/2>
- http://international.download.nvidia.com/webassets/en_US/shared/images/embed/aa-af-guide/filtering.jpg