Post-Processing Effects 2: Antialiasing

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Topics

- Introduction to aliasing and antialiasing
- Sampling-based techniques
- Filtering-based techniques

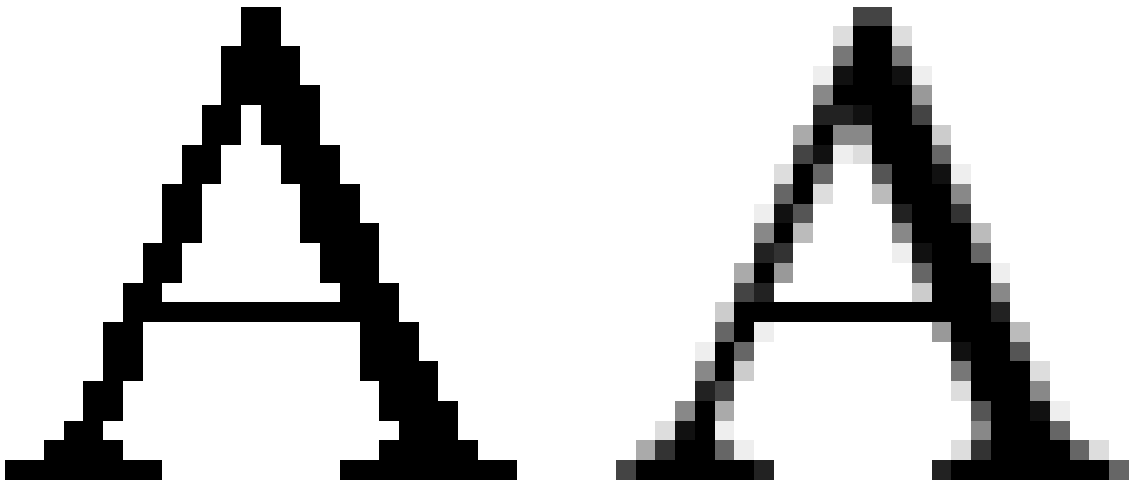
Definition of antialiasing

What is antialiasing?

- Any technique used to reduce the effects of aliasing

What is aliasing?

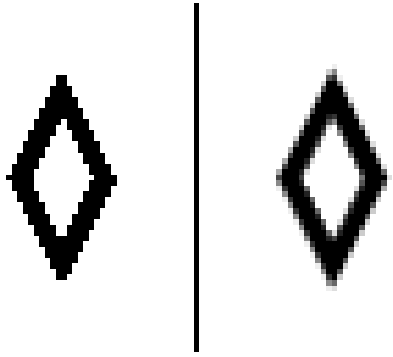
- In signal processing, an occurrence where multiple signals become indistinguishable from each other
- In computer graphics, particularly the artifacts (jagged edges) that occur when drawing edges



https://youtu.be/R0HapDklfAw?t=50s

What causes aliasing in CG

- Computer graphics objects are described in a continuous mathematical space (vertex coordinates are floating point values)
- A computer screen has a discrete number of pixels
- A discrete screen cannot accurately display objects from a continuous space
- Approximations cause jagged edges



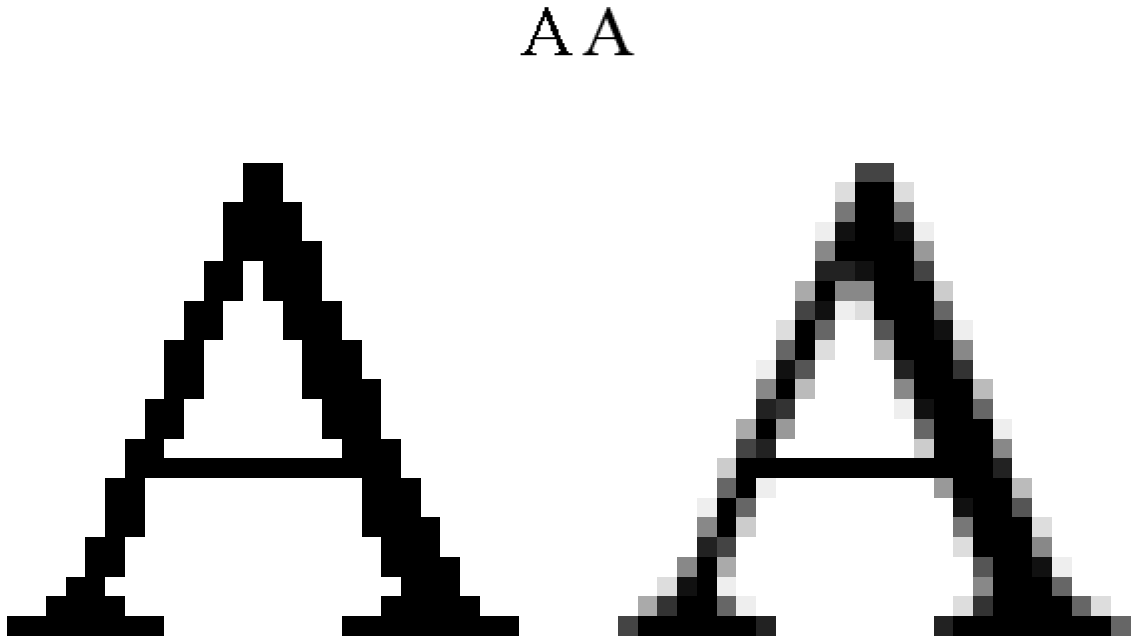
Solutions to aliasing 1

Impossible to fully remove

- Screens don't have infinite detail
- Possible to reduce visibility of aliasing

Physical improvements

- Higher screen resolution
- Higher pixel density
- Move the screen further away from the viewer



Solutions to aliasing 2

Sampling-based techniques

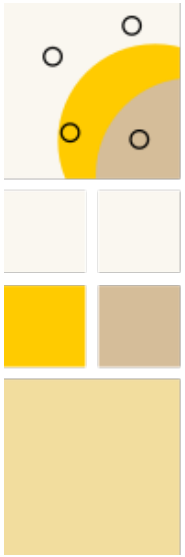
- Supersampling/Full-scene (SSAA, FSAA)
- Multisampling (MSAA)
- TAAA, Adaptive AA
- EQAA, CSAA
- TAA

Filtering-based techniques

- Fast Approximation (FXAA)
- Morphological (MLAA)
- Enhanced Subpixel Morphological (SMAA)
- TXAA
- *DLAA, DEAA, GPAA, GBAA, SRAA*

Sampling-based techniques

- Improve pixel color estimation by using additional data points
- For each pixel, calculate values of more than one point (take samples)
- Calculate pixel value based on samples
- More samples improve results (to a degree)
- More samples increase memory usage and computational cost
- Sampling pattern affects results



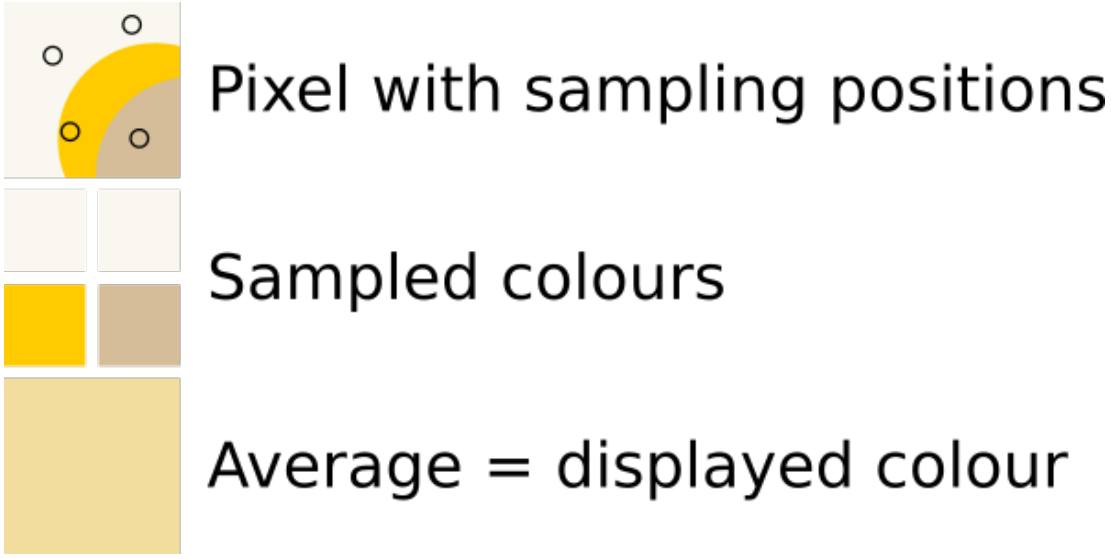
Pixel with sampling positions

Sampled colours

Average = displayed colour

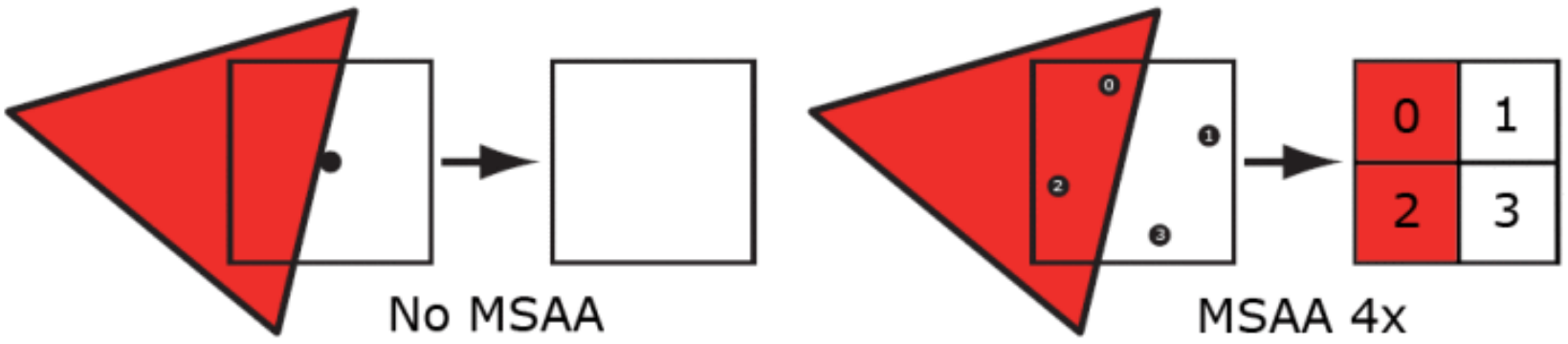
Supersampling (SSAA), Full-scene (FSAA)

- Idea: For every pixel, take samples and average the result
- Extremely expensive in both memory usage and computational cost
- Excellent visual results
- May blur fine vertical and horizontal details if applied carelessly



Multisampling (MSAA)

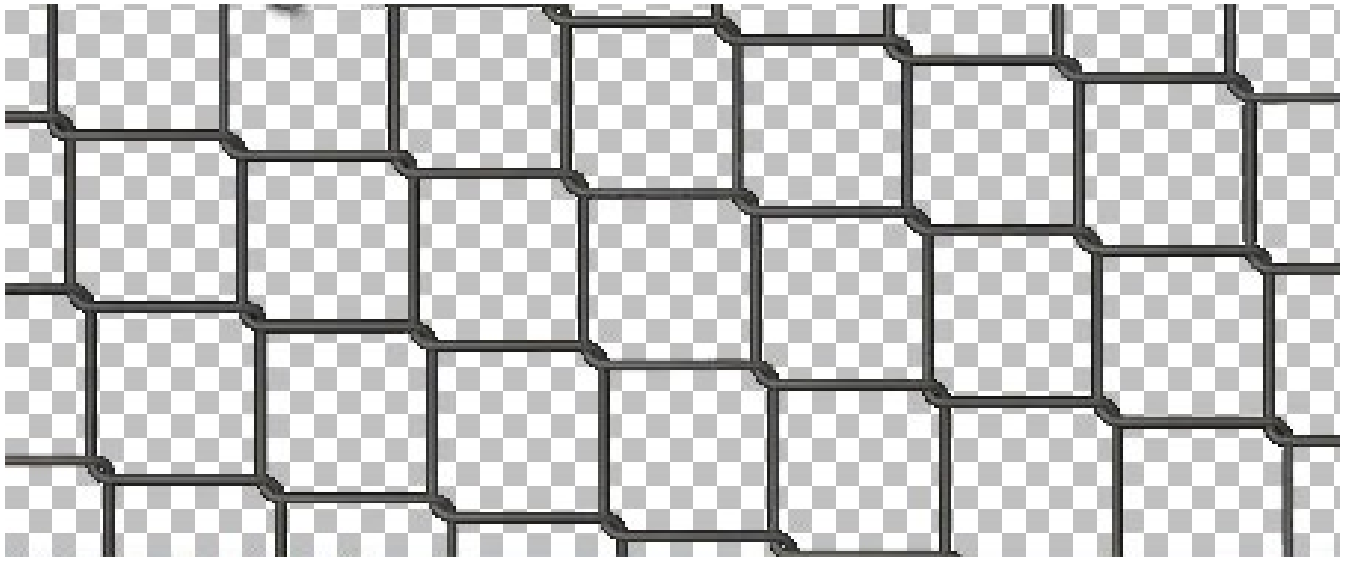
- Idea: Perform supersampling, but only on significant areas
- Coverage is sampled
  - It is known which subpixels share a triangle
- Pixel shading is executed only once per pixel
  - Samples that share a triangle are given the same values
  - Improved performance over SSAA
- Costly, but lower computational cost than SSAA
- Does not handle transparent textures (unlike SSAA)



https://mynameismjp.wordpress.com/2012/10/24/msaa-overview/

Transparency-adaptive (TAAA), Adaptive

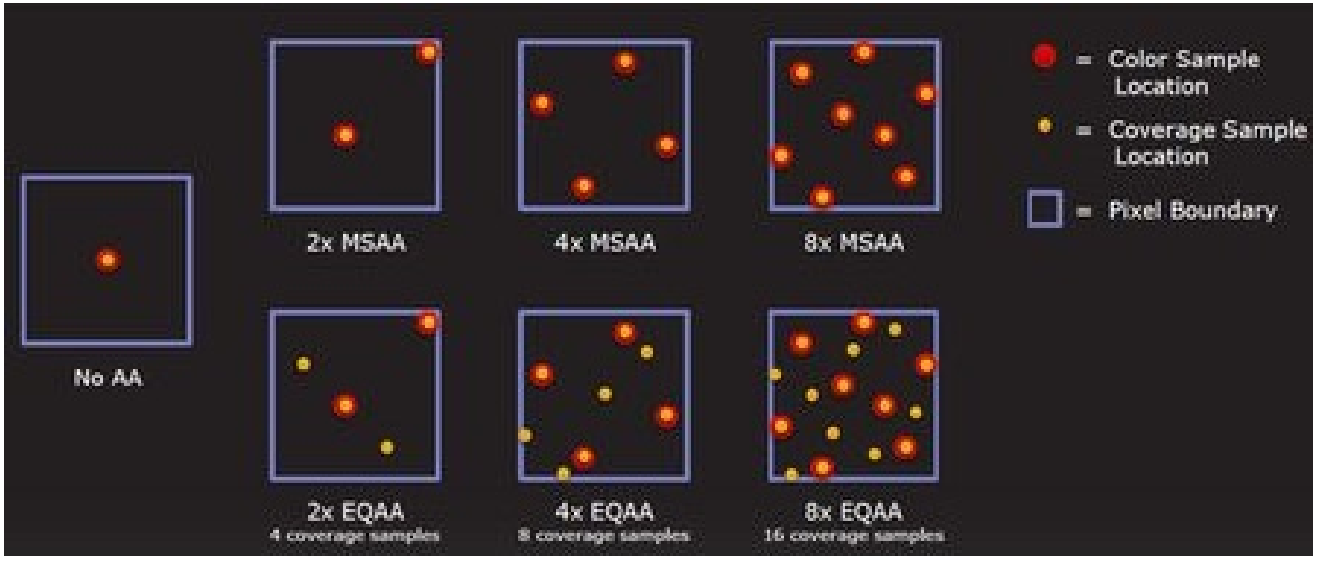
- Like MSAA, but flag pixels that contain transparent textures for sampling
- Functionally similar (Adaptive AA by AMD, TAAA by Nvidia)



http://www.nvidia.com/object/feature_intellisample4.0.html

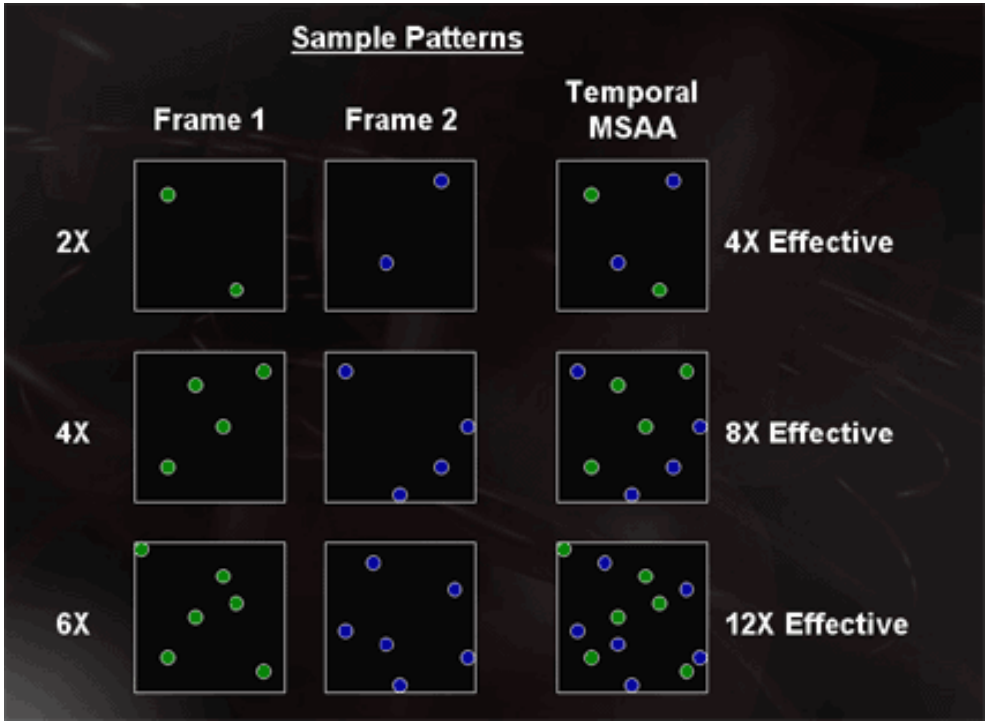
Enhanced quality (EQAA), Coverage sampling (CSAA)

- Further upgrades to MSAA
- Additional coverage samples decoupled from color samples
- Functionally similar (EQAA by AMD, CSAA by Nvidia)
- Compared to MSAA, minor cost increase with better results
- Improvement depends on pixel, sometimes no improvement at all



Temporal (TAA)

- Alternate between two MSAA sample patterns for effective double sample size
- Required V-Sync and at least 60 fps to work
- Formerly used by AMD
- Abandoned because it was difficult to get to work

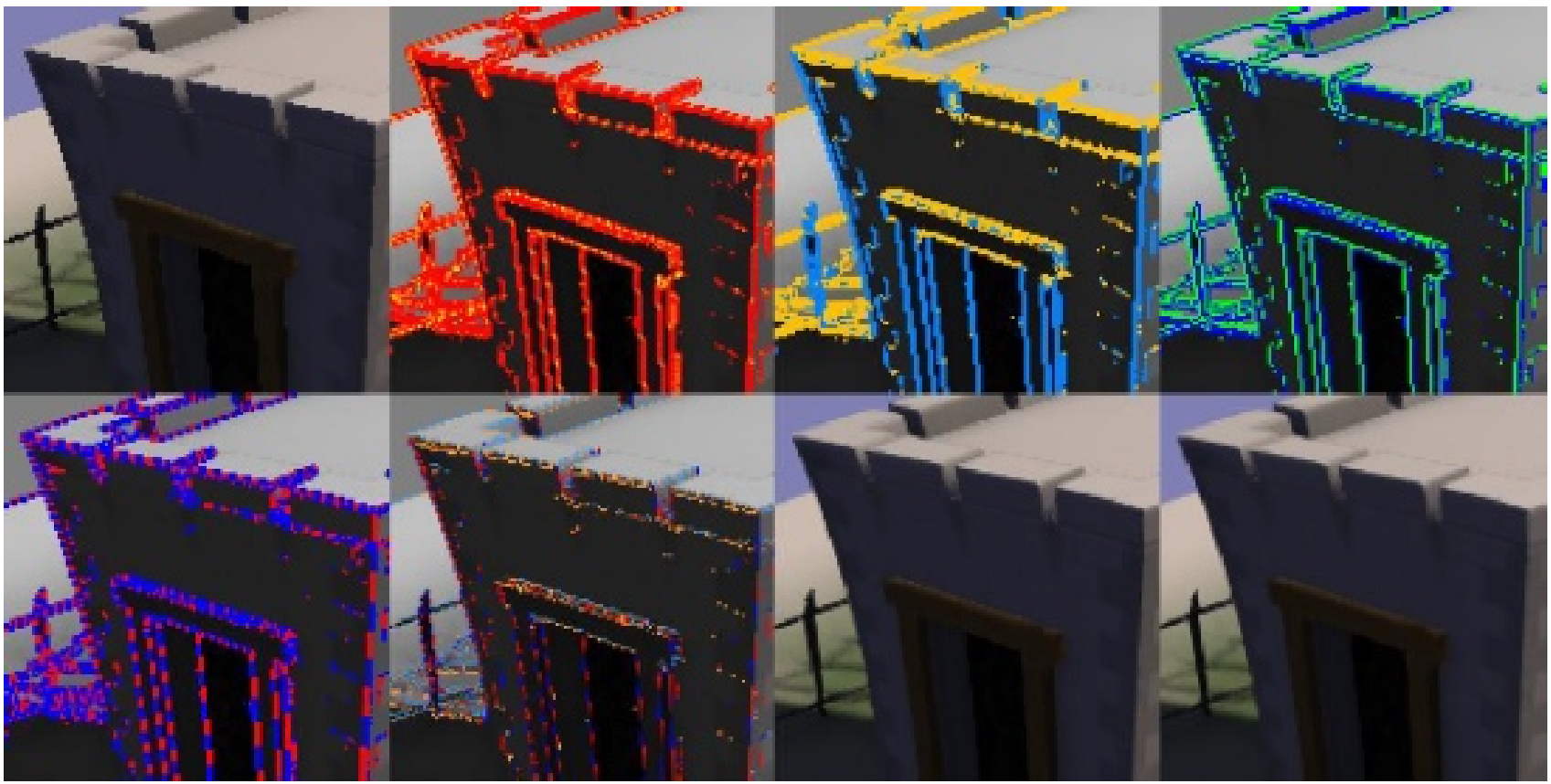


Filtering-based techniques

- Apply filtering to certain parts of the rendered image
- Mainly edge detection and blurring
- Much cheaper than sampling-based techniques
- May result in unwanted blurriness
  - Texture detail may be lost
- Can be combined with sampling-based techniques

Fast approximation (FXAA)

- Idea: Find edge pixels by luminosity, find edge ends by following edge pixels and luminosity, shift pixels on edges, resample shifted subpixels, blend result to starting image
- Created by Timothy Lottes (Nvidia)

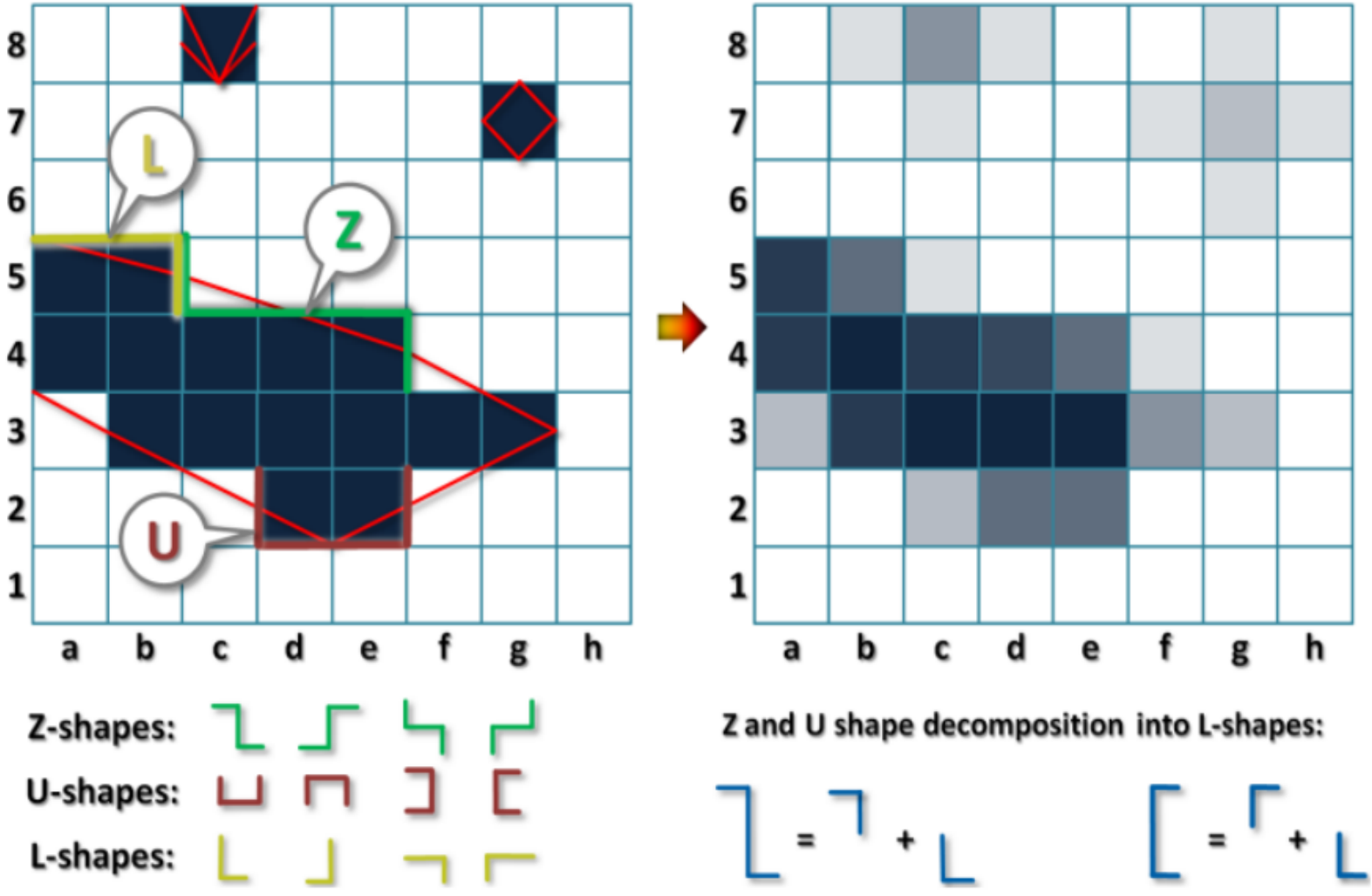


http://developer.download.nvidia.com/assets/gamedev/files/sdk/11/FXAA_WhitePaper.pdf

Morphological (MLAA)

- Idea: Find edge pixels/silhouettes, detect patterns/shapes, apply color filtering
- Multiple techniques named MLAA
  - Intel MLAA
  - Jimenez MLAA by Jorge Jimenez
- Lower cost than supersampling techniques, higher cost than FXAA
- Jimenez: Results approximated to between 4x and 8x MSAA (1x at worst, 16x at best)

VIDEO: `http://www.iryoku.com/mlaa/`

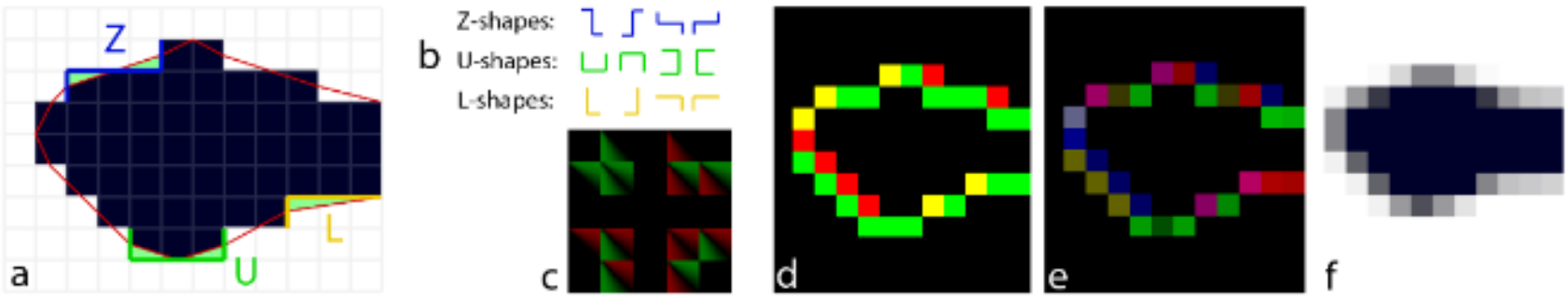


https://mynameismjp.wordpress.com/2012/10/24/msaa-overview/

Enhanced Subpixel Morphological (SMAA)

- Improved version of Jimenez MLAA
- Sharp geometric feature handling (sharp corners)
- Diagonal pattern handling
- Uses subpixel information when combined with multisampling

VIDEO: `http://www.iryoku.com/smaa/`
FXAA and SMAA visual comparison(link)

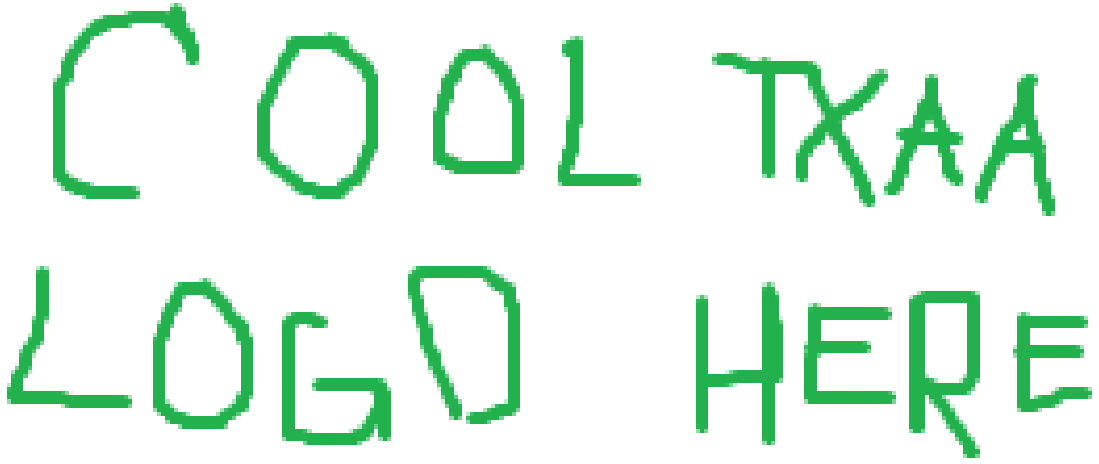


`http://www.iryoku.com/smaa/downloads/SMAA-Enhanced-Subpixel-Morphological-Antialiasing.pdf`

Temporal (TXAA)

- Created by Nvidia (not to confuse with AMD's TAA)
- Some combination of different methods (closed source)
- Visuals compared to MSAA + FXAA
- Designed to reduce temporal aliasing (edginess when moving)

VIDEO: `https://www.youtube.com/watch?v=MyE84ydeYRY`



More types of AA

Many other forms of antialiasing exist

- Directionally Localized (DLAA)
  `https://www.youtube.com/watch?v=5MkwyjORy-w`
- Distance-to-Edge (DEAA)
  `http://www.iryoku.com/aacourse/downloads/10-Distance-to-edge-AA-(DEAA).pdf`
- Geometric Post-processing (GPAA)
  `http://www.humus.name/index.php?page=3D&ID=86`
- Geometric Buffer (GBAA)
  `http://www.humus.name/index.php?page=3D&ID=87`
- Subpixel Reconstruction (SRAA)
  `http://iryoku.com/aacourse/downloads/07-SRAA-Subpixel-Reconstruction-Anti-Aliasing.pdf`

Thanks for listening

Any questions?

Sources (hyperlinks)

SMAA white paper
FXAA white paper
Jimenez's SMAA page
Jimenez's MLAA page
Tom's Hardware AA techniques overview
Intel MLAA presentation
A quick overview of MSAA
Jimenez MLAA showcase
Antialising and transparency of web page images
NVIDIA GeForce 3 antialising technique