VGP351 – Week 10

- Agenda:
  - More anti-aliasing:
    - AA during primitive rendering
    - FSAA
      - Supersampling
      - Multisampling
    - Temporal AA
  - Discuss the final

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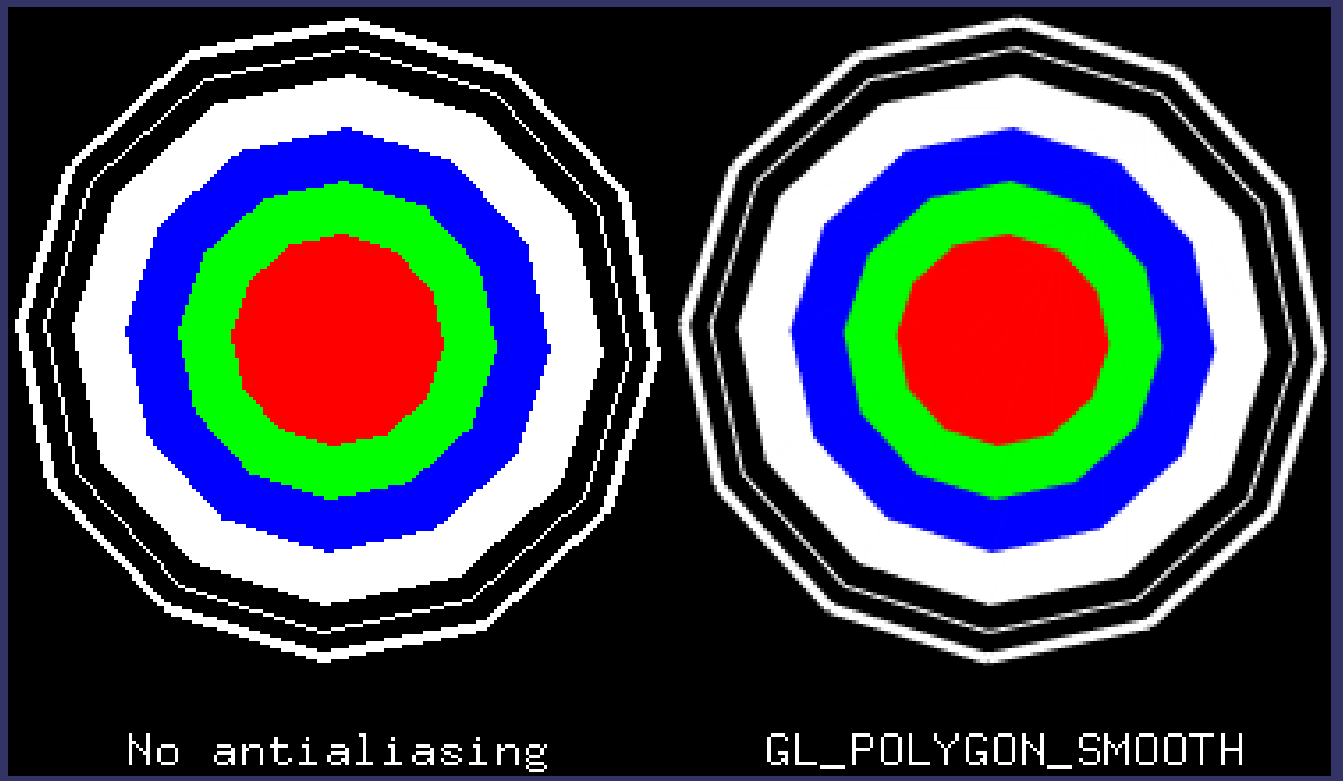
Aliasing During Rendering

- 3D world is sampled at fixed locations
  - We call these locations pixels
  - The resolution is the sample rate
- If the world has higher frequency elements than the sample rate can support, we get aliasing
  - In other words, if there are details smaller than two pixels, there will be aliasing

Rasterization AA

- Edges pass partially through pixel locations
  - We can calculate which pixels the edge intersects, and give some color to each



Rasterization AA

- However...
  - Hardware doesn't optimize for this case anymore
    - So it either doesn't exist or is slow
  - Only really helps where edges meet
    - Does nothing for aliasing caused by the shader within the polygon
  - Quality depends on back-to-front rendering order
    - Just like transparency blending, and for the same reason

Full Screen Anti-Aliasing

- What to do?
  - If too few samples are the problem... get more samples

Supersampling

- Obvious answer:
  - Render at much higher resolution and down-sample
  - *Ideally* performance decreases linearly with the increase in samples
    - In reality, performance may be worse than that due to caches, etc.

Supersampling

- Supersampling executes the fragment pipeline for each sample
  - Adds memory bandwidth cost
  - Adds computation cost

Multisampling

- Increases the sample rate, just like supersampling
  - The same value is used for each subsample within a pixel

Multisampling

- Multisampling executes the fragment pipeline once per pixel
  - Adds memory bandwidth cost
  - Keeps the same computation cost

Multisampling

- Sample buffers are a property of the drawable
  - Must be requested when the drawable is created

```
SDL_GL_SetAttribute(SDL_GL_MULTISAMPLEBUFFERS, 1);
SDL_GL_SetAttribute(SDL_GL_MULTISAMPLESAMPLES, 2);
```

- Multisample rasterization is separately enabled:

```
glEnable(GL_MULTISAMPLE);
```

Multisampling

- Can also be used with alpha test
  - A special mode will cause the fragment alpha value to modify the coverage mask

```
glEnable(GL_SAMPLE_ALPHA_TO_COVERAGE);
```

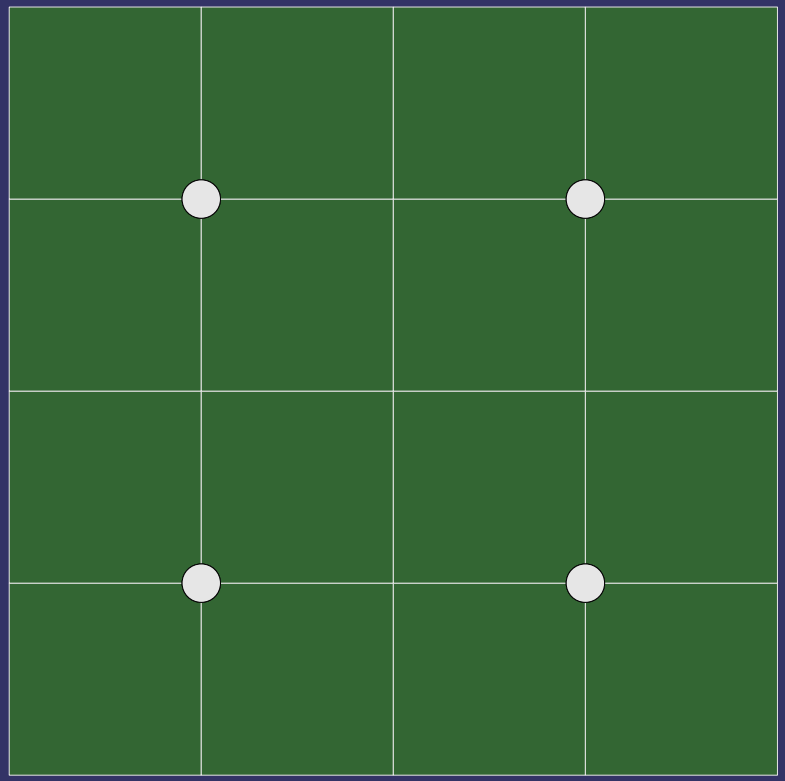
  - This can eliminate the need to alpha blend with alpha test
    - Yay! No sorting!

Multisample Resolve

- When a pixel is accessed, the samples are “resolved”
  - Accessing the pixel could be:
    - Reading via `glCopyTexImage` or `glReadPixels`
    - Displaying via `SwapBuffers`
  - Resolving involves filtering the samples together in some manner to generate a single color value

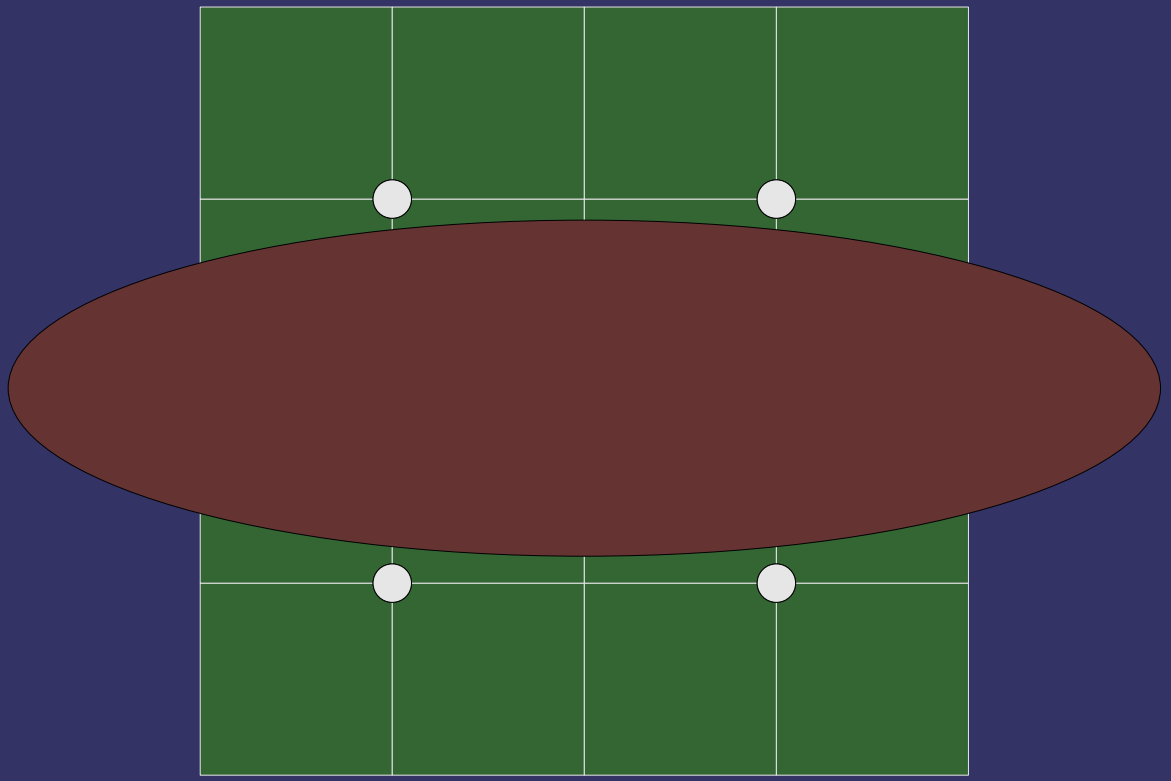
Sample Patterns

- Coverage can be sampled in many ways



Sample Patterns

- Coverage can be sampled in many ways



Sample Patterns

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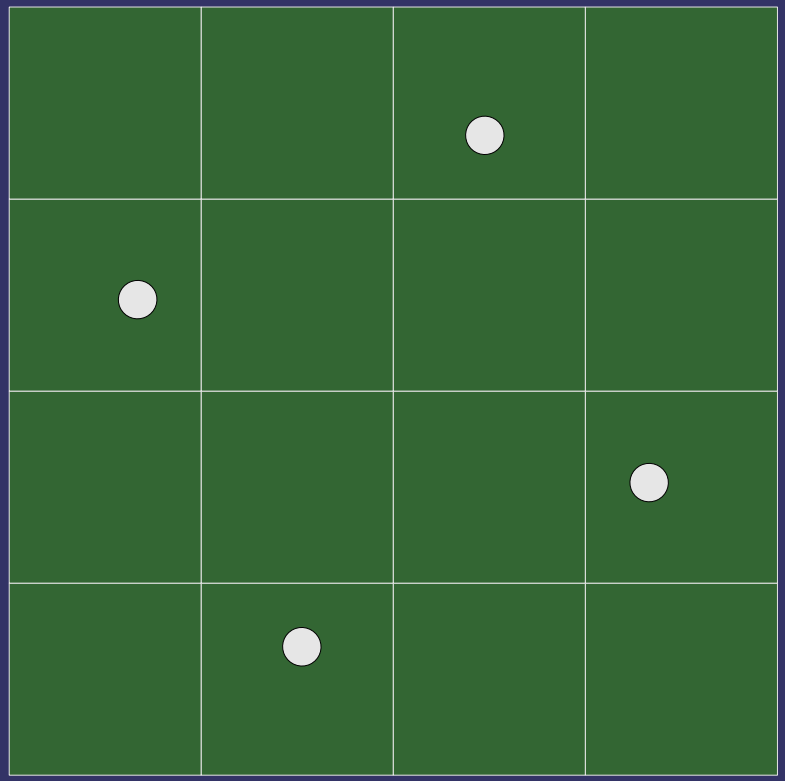
Rotated Grid Supersampling



Sample Patterns

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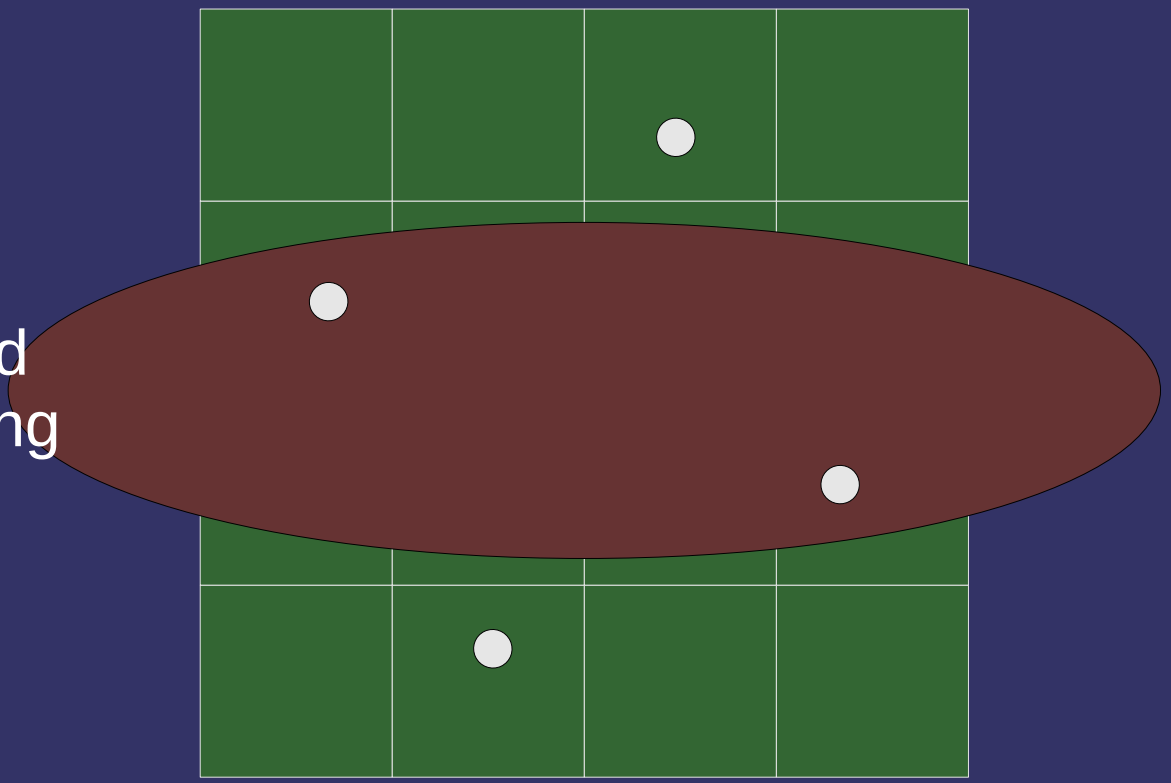
Rotated Grid Supersampling



Sample Patterns

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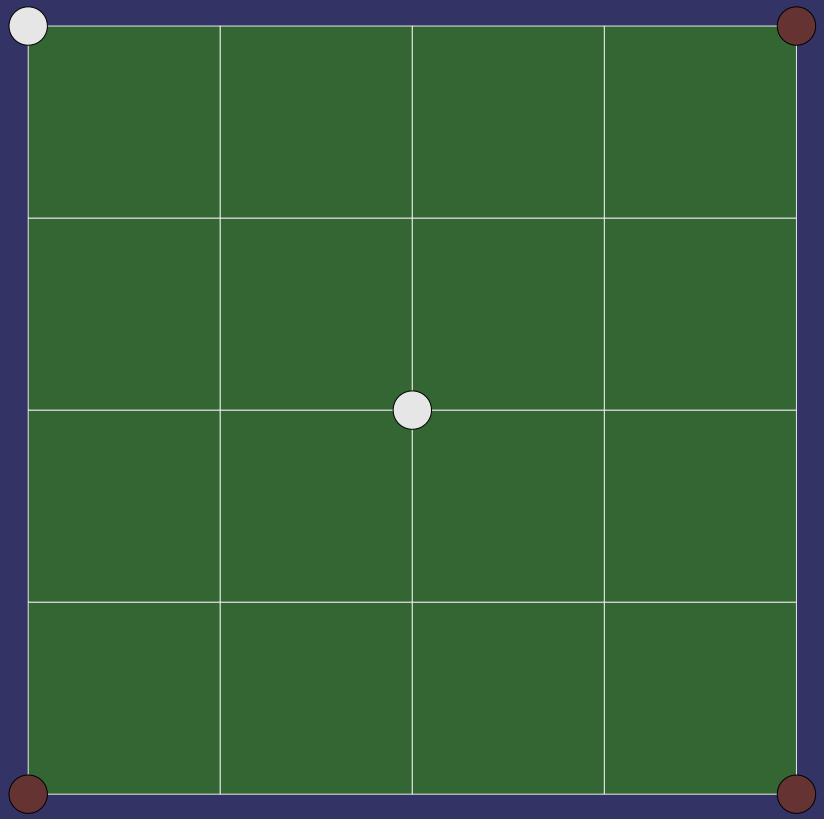
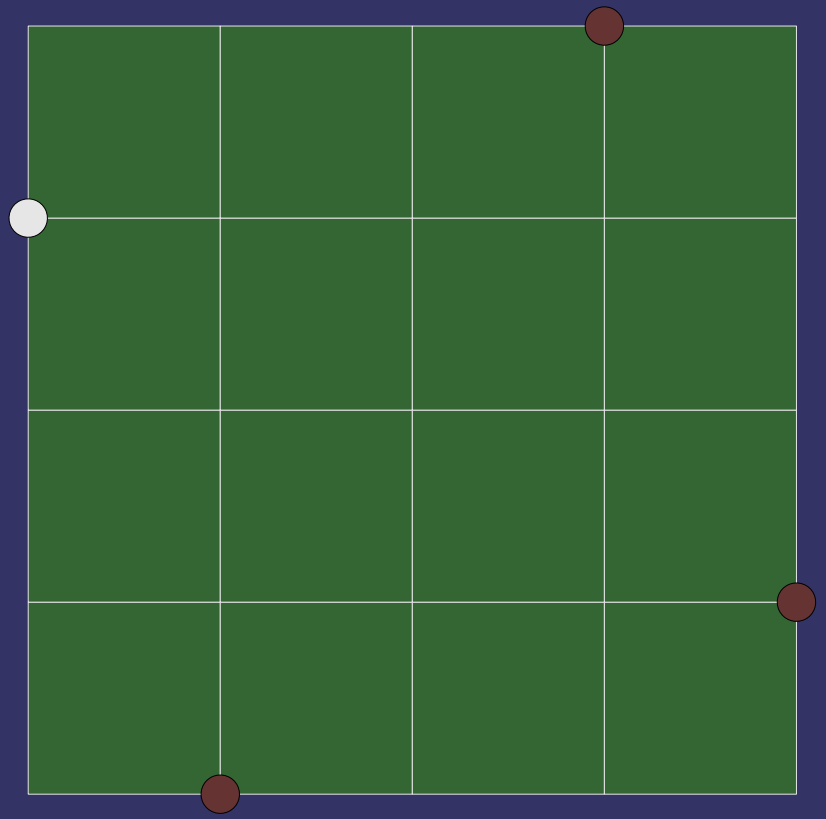
Quincunx



Sample Patterns

- Coverage can be sampled in many ways

FLIPQUAD



References

http://developer.nvidia.com/object/gdc_ogl_multisample.html

http://graphics.stanford.edu/courses/cs248-07/schedule.php

- Look at the lecture notes from October 11th
- Kurt Akeley is one of the original designers of OpenGL

http://en.wikipedia.org/wiki/Alpha_to_coverage

Temporal Aliasing

- Caused by the same problem as any aliasing:
  - Not enough samples *through time*
  - Have infer the missing information between rendered frames
  - Even if the brain infers correctly, the images seem unnatural

Temporal Aliasing

- Examples:

  http://www.youtube.com/watch?v=W1UbXriii_Y

  http://www.youtube.com/watch?v=cWGn6_EH2gM

  http://www.youtube.com/watch?v=4wW0txXoan8

Temporal Aliasing

- Film movie cameras generate motion blur...
  - Shutter is nearly a semi-circle that spins
    - For a little less than half of 1/24th of a second, the film is exposed to light
  - When the film is not exposed, it advances to the next frame

Temporal Aliasing

- Film movie cameras generate motion blur...
  - Shutter is nearly a semi-circle that spins
    - For a little less than half of 1/24th of a second, the film is exposed to light
  - When the film is not exposed, it advances to the next frame
- We can “defeat” this
  - Use a smaller shutter
    - The movie Gladiator used ~45° during some fight scenes
  - The film is exposed for less time
  - Results in *less* realism

Temporal Aliasing

- Examples:

  http://www.youtube.com/watch?v=czQfPdPaK_8

Temporal Anti-Aliasing

- Barriers in real-time graphics:
  - Limited by the refresh rate of the display
    - Usually 60fps
  - Limited by how fast we can render

Temporal Anti-Aliasing

- Naïve approach:
  - Render multiple frames at different time steps
  - Blend the results

Temporal Anti-Aliasing

- Pros:
  - Easy to implement
  - Produces good results *with fine enough time steps*
- Cons:
  - Expensive!
  - Produces really bad results if the time steps are not close enough

Temporal Anti-Aliasing

- We can fake motion blur on individual objects
  - Stretch the object from its previous position to its current position

Temporal Anti-Aliasing

- Algorithm overview:
  - Render the object once normally
  - Render a second time with alpha blending:
    - In the vertex shader, transform each vertex by it's current and previous transformation matrix
      - The vector, $\mathbf{m}$, between the two is the motion vector
    - Compare $\mathbf{m}$ and $\mathbf{n}$
      - If $\mathbf{m}$ and $\mathbf{n}$ point the same direction, use the current frame transform
      - Otherwise, use the previous frame transform and decrease the alpha

Temporal Anti-Aliasing

- Pros:
  - Produces good results on individual objects
  - Inexpensive
- Cons:
  - May be very complex to add to some shaders
  - Really only works on individual objects
    - Doesn't help if the camera is moving quickly

References

Wloka, M. and Zeleznik, R. “Interactive Real-Time Motion Blur.” The Visual Computer 12 (1996): 283 – 295.
http://graphics.cs.brown.edu/research/pub/papers/viscom-motionblur.ps

Wloka, M. "Implementing Motion Blur & Depth of Field using DirectX 8," *Meltdown 2001*, July 2001.
http://www.microsoft.com/mscorp/corpevents/meltdown2001/ppt/Externals/NVidia_MotionBlurDepthOfField.ppt

Next week...

- All assignments due
- The final!
  - **Wednesday** at 5:30PM... do **NOT** be late!

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