Computer Graphics
MTAT.03.015

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Study IT in .ee
The Road So Far...

Last week:
- Construct geometry
- Define transformations
- Assign material properties
  ...

This week:
- Vertex Transformations
- Vertex Shader
  Object's local space → viewport space
- Culling & Clipping
  Determine front-facing triangles
  Determine which vertices are visible
- Rasterization
  Fill the triangle with fragments
- Fragment Shading
  Calculate correct color values
- Visibility Tests
  Blending
  Is the fragment visible?
  Blend together multiple fragments
More Granular Surface Color

Chopper by Annika Hansalu
More Granular Surface Color

- Blades – 4 different meshes
More Granular Surface Color

- Blades – 4 different meshes:
  - 2 blades

Chopper by Annika Hansalu
More Granular Surface Color

- Blades – 4 different meshes:
  - 2 blades
  - Each blade consists of 2 parts
More Granular Surface Color

- Extra vertices and faces that all need parsing
More Granular Surface Color

• Extra vertices and faces that all need parsing

• Could we get the same result with only 4 vertices?
More Granular Surface Color

- We would need to specify at which fragment we take which color.

Mesh
More Granular Surface Color

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More Granular Surface Color

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Texture

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(Raster) Image

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- Our 3D surface is **continuous**, we may rasterize a **varying amount** of points for a face.
Upscale

- Sometimes we want to see the surface in more detail than there are point values in the image.
Upscale

- Sometimes we want to see the surface in more detail than there are point values in the image.

![Diagram showing texture points with coordinates (0.25, 0.75) and (0.75, 0.75) in the top right and (0.25, 0.25) and (0.75, 0.0) in the bottom left, with orientation vectors u = (1, 0) and v = (0, 1).]
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GL_NEAREST

GL_LINEAR
What do these do?

- GL_CLAMP_TO_EDGE
- GL_CLAMP_TO_BORDER
- GL_MIRRORED_REPEAT
- GL_REPEAT

Upscale

With that in mind, what would be a smallest texture we need for the chopper blade here?
Upscale

- Given a texture with some $width \times height$, how to find the nearest texels to an UV sample?
Downscale

- We can do the same interpolation for the downscale.
Downscale

• What can go wrong?
Nyquist–Shannon Sampling Theorem

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This is how radio works...
Nyquist–Shannon Sampling Theorem

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More info:  
Http://www.skillbank.co.uk/SignalConversion/rate.htm  
Downscale

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Downscale

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- Is this even possible, if we want to downscale our pattern from 8×8 to 2×2?
Downscale

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Downscale

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- Our texture is not white, a 2×2 downscale should not be white either.
Downscale

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- Our texture is not white, a \(2\times2\) downscale should not be white either.
- One unit in the result covers 16 units in the texture. How to represent all those 16 values?
Mipmapping

- In order not to take that many samples each time for downscaling, we take them beforehand.
Mipmapping

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- The last mipmap we could create is 5×5.
- For a smaller downscale (eg 2×2, 1×1) we still need to sample more than the 4 neighbouring pixels.
- How not to have that problem?
Mipmapping

- Assume we have mipmaps 8×8, 4×4, 2×2, 1×1.
Mipmapping

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- We want to show our texture on a 6×6 area.
Mipmapping

- Assume we have mipmaps $8 \times 8$, $4 \times 4$, $2 \times 2$, $1 \times 1$.
- We want to show our texture on a $6 \times 6$ area.
- Which mipmap should we sample?
Filtering

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- Upscale (magnification filtering)
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Also called trilinear
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Questions?
Anisotropic Filtering

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Anisotropic Filtering

• We assumed that the result we are showing our texture on is shown as a square. This is usually not the case.

• If we rotate our quad around the x-axis for example, then we might get that the texture needs to be shown on a $10 \times 5$ area instead of $10 \times 10$. 
Anisotropic Filtering

• We have more resolution in width than in height. It is unfair to average both dimensions equally.
Anisotropic Filtering

- We have more resolution in width than in height. It is unfair to average both dimensions equally.

- Anisotropic filtering will use the higher mipmap and take more samples along the denser direction.
• Actual implementations are vendor dependant.
• One way would be to just create anisotropic mipmaps.
Textures

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What seemed useful today?

What more would you like to know?

Next time

Blending – Jaanus Jaggo