Computer Graphics

MTAT.03.015

Raimond Tunnel

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

Last week

This week

Construct geometry
Define transformations
Assign material properties...

Vertex Transformations

Culling & Clipping

Determine front-facing triangles
Determine which vertices are visible

Vertex Shader
Object's local space → viewport space

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

Chopper by Annika Hansalu
More Granular Surface Color

- Blades – 4 different meshes:
  - 2 blades
More Granular Surface Color

- Blades – 4 different meshes:
  - 2 blades
  - Each blade consists of 2 parts

Chopper by Annika Hansalu
More Granular Surface Color

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

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- 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.
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- We would need to specify at which fragment we take which color.
- We can no longer just interpolate the color, but should somehow specify a UV mapping.
(Raster) Image

- Image is a matrix of point values.
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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.
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- What are the exceptions?
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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 the smallest texture we need for the chopper blade here?
Upscale

- Given a texture image with some \textit{width} \times \textit{height}, how to find the nearest texels of an UV sample?
Downscale

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

- What can go wrong?
Nyquist–Shannon Sampling Theorem

- In order to reconstruct a band-limited signal, one has to sample with sampling rate more than twice the highest frequency.
Nyquist–Shannon Sampling Theorem

• In order to reconstruct a band-limited signal, one has to sample with sampling rate more than twice the highest frequency.

This means more than 2 samples per period, every period.
Nyquist–Shannon Sampling Theorem

- Band-limited signal – there is a fixed highest frequency in the signal.
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- The signals in real life are not band-limited.
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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](http://www.skillbank.co.uk/SignalConversion/rate.htm)
Downscale

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\[
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\text{Sample} \quad \text{Signal} \quad \text{Sample}
\]

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

- What if we have a texture that is 10×10.
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• How not to have that problem?
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- Assume we have mipmaps 8×8, 4×4, 2×2, 1×1.
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• We want to show our texture on a 6×6 area.
Mipmapping

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- We want to show our texture on a 6×6 area.
- Which mipmap should we sample?
Filtering

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Also called trilinear
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Questions?
Anisotropic Filtering

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

No anisotropic filtering
Anisotropic Filtering

- We have more resolution in width then 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.

No anisotropic filtering

16x anisotropic filtering
Anisotropic Filtering

- Actual implementations are vendor dependant.
- One way would be to just create anisotropic mipmap.
Textures

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● **Data textures** – we can hold other data like normals or other values with 3 (or 4) coordinates.
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  • **Render target** – we could also render the current framebuffer to a texture.
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What seemed useful today?

What more would you like to know?

Next time

Blending – Jaanus Jaggo