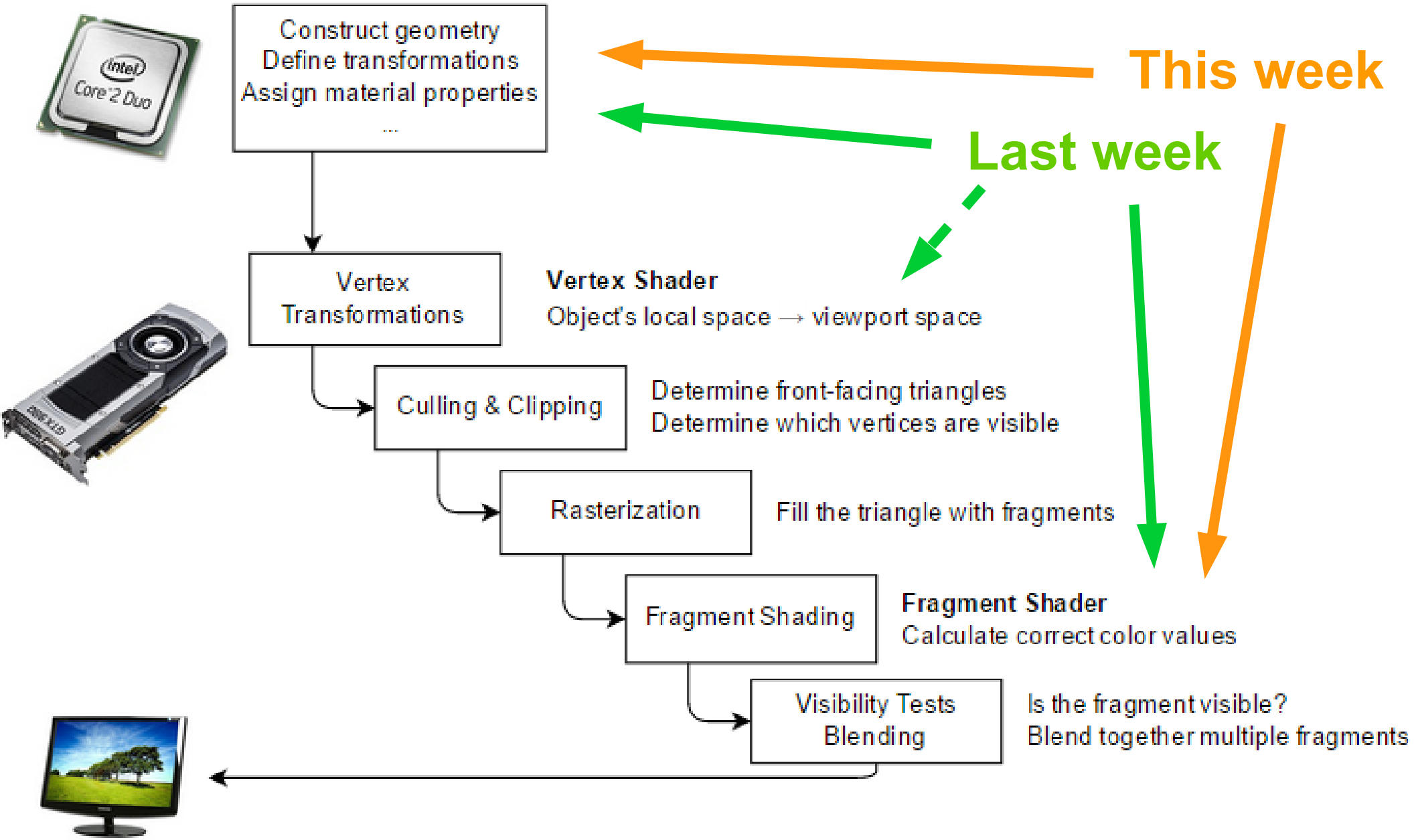
Computer Graphics

MTAT.03.015

Raimond Tunnel

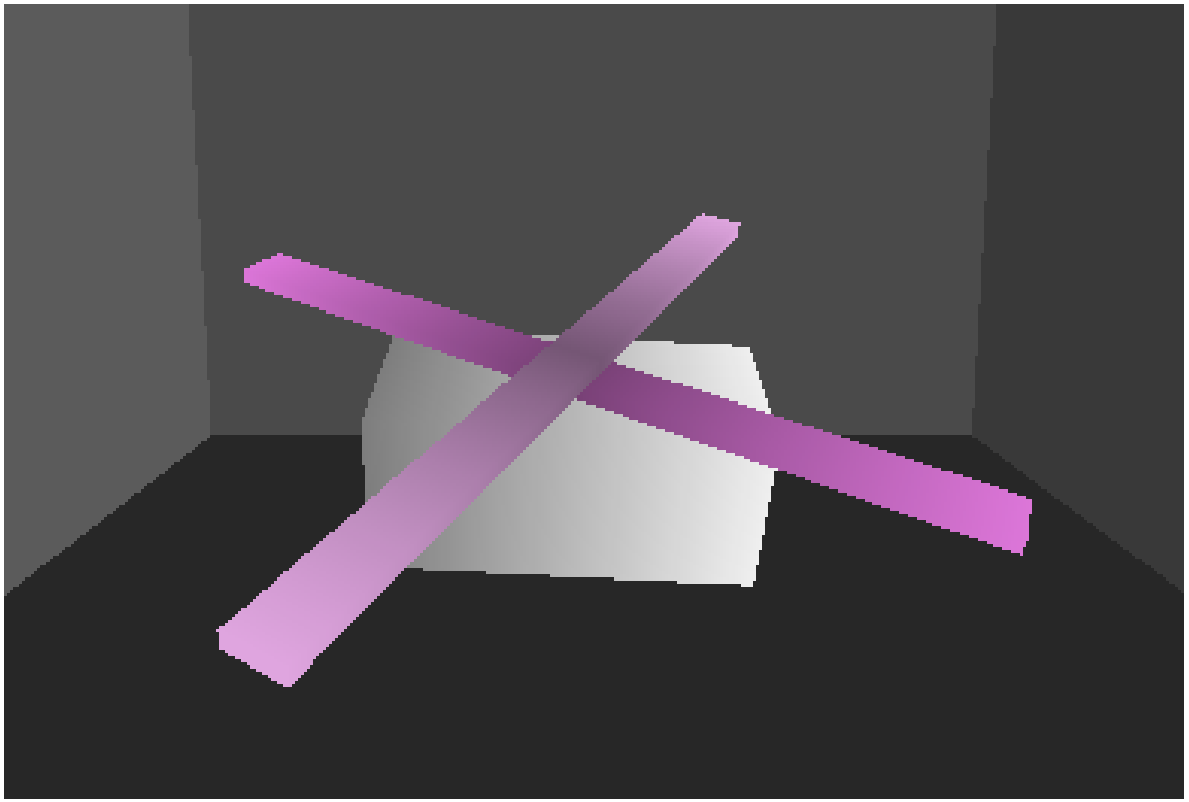
Study IT in .ee

The Road So Far...



More Granular Surface Color

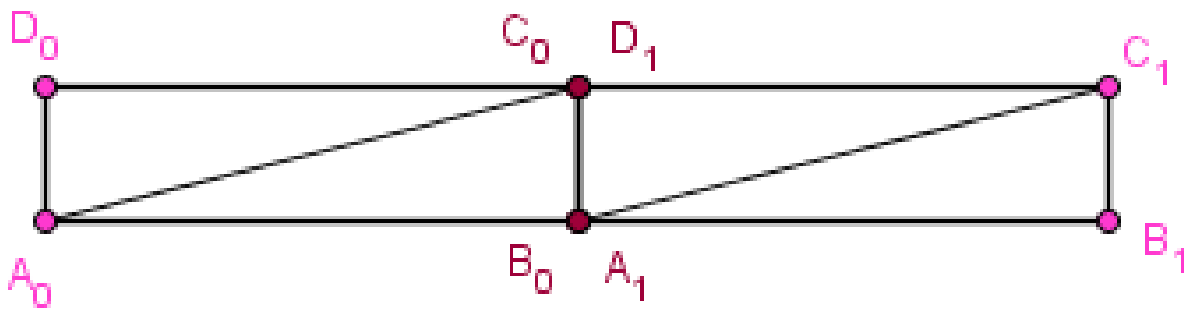
- Blades – 4 different meshes:
  - 2 blades
  - Each blade consists of two parts



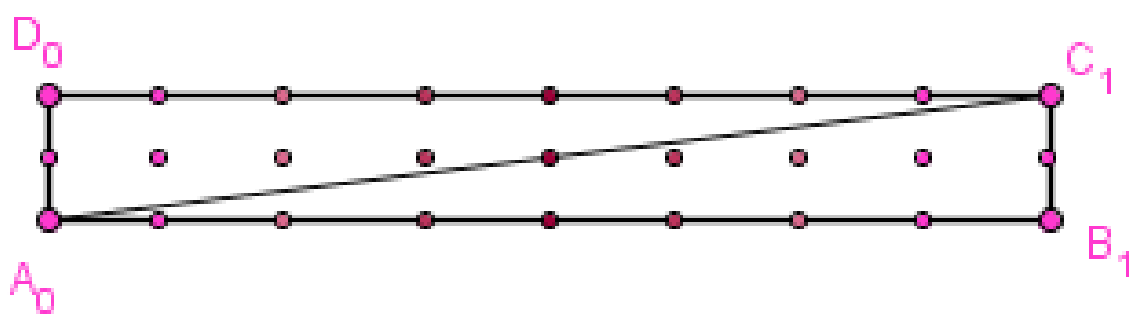
Chopper by Annika Hansalu

More Granular Surface Color

- Extra vertices and faces that all need parsing

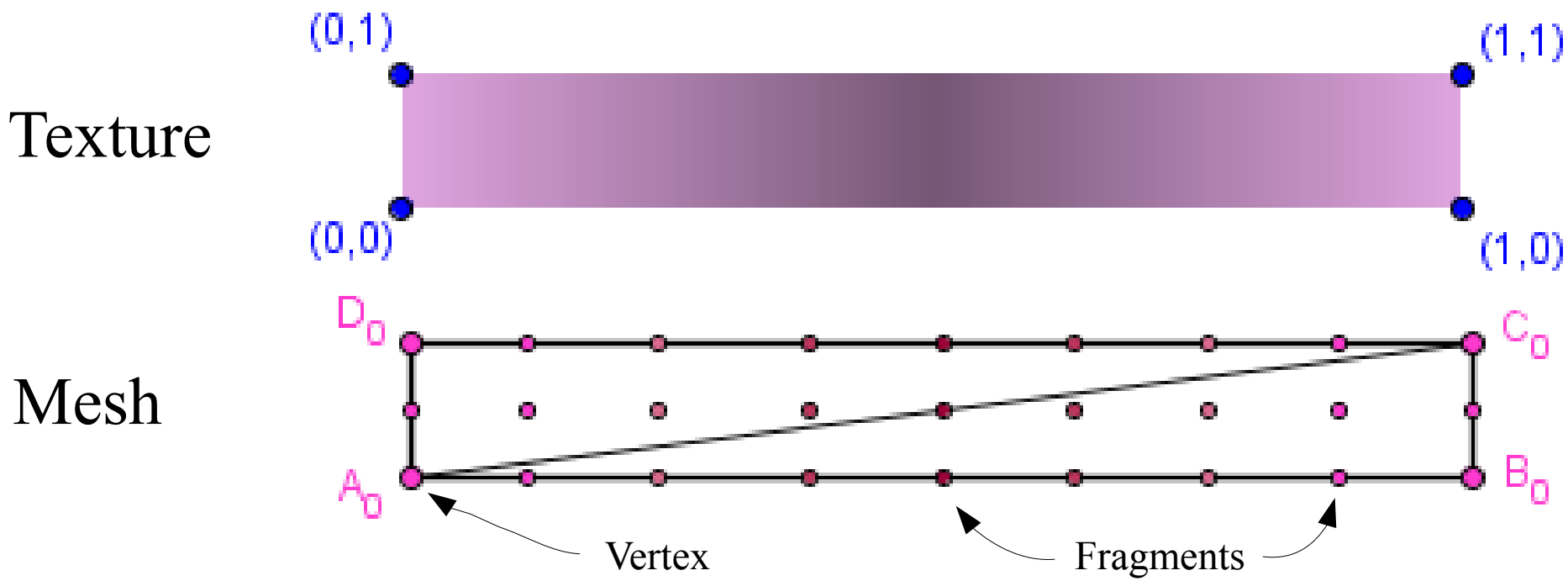


- Could we get the same result with only 4 vertices?



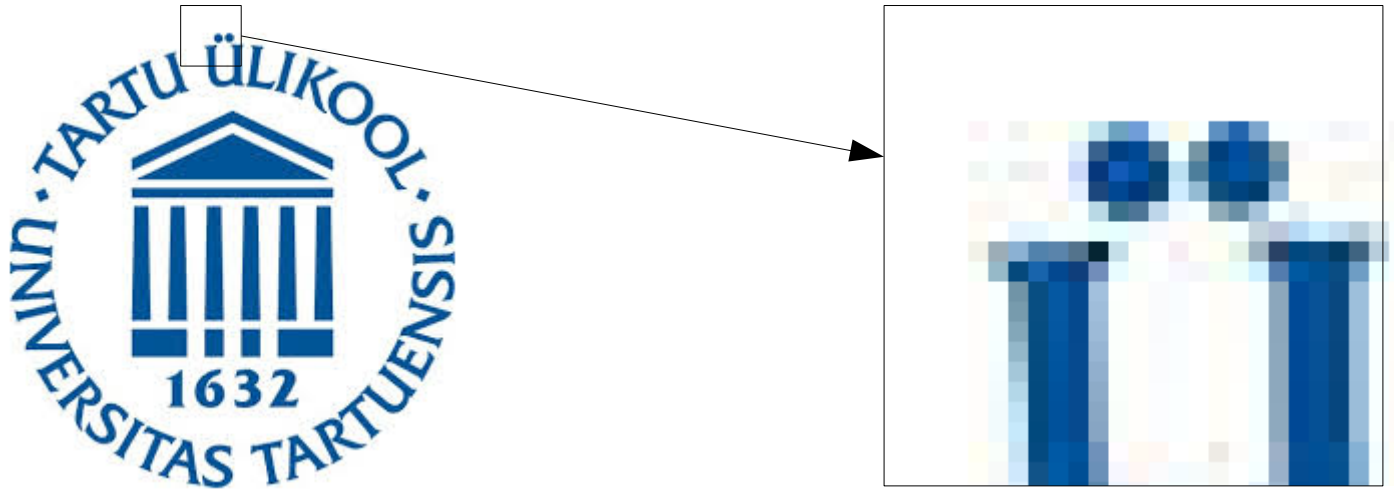
More Granular Surface Color

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



(Raster) Image

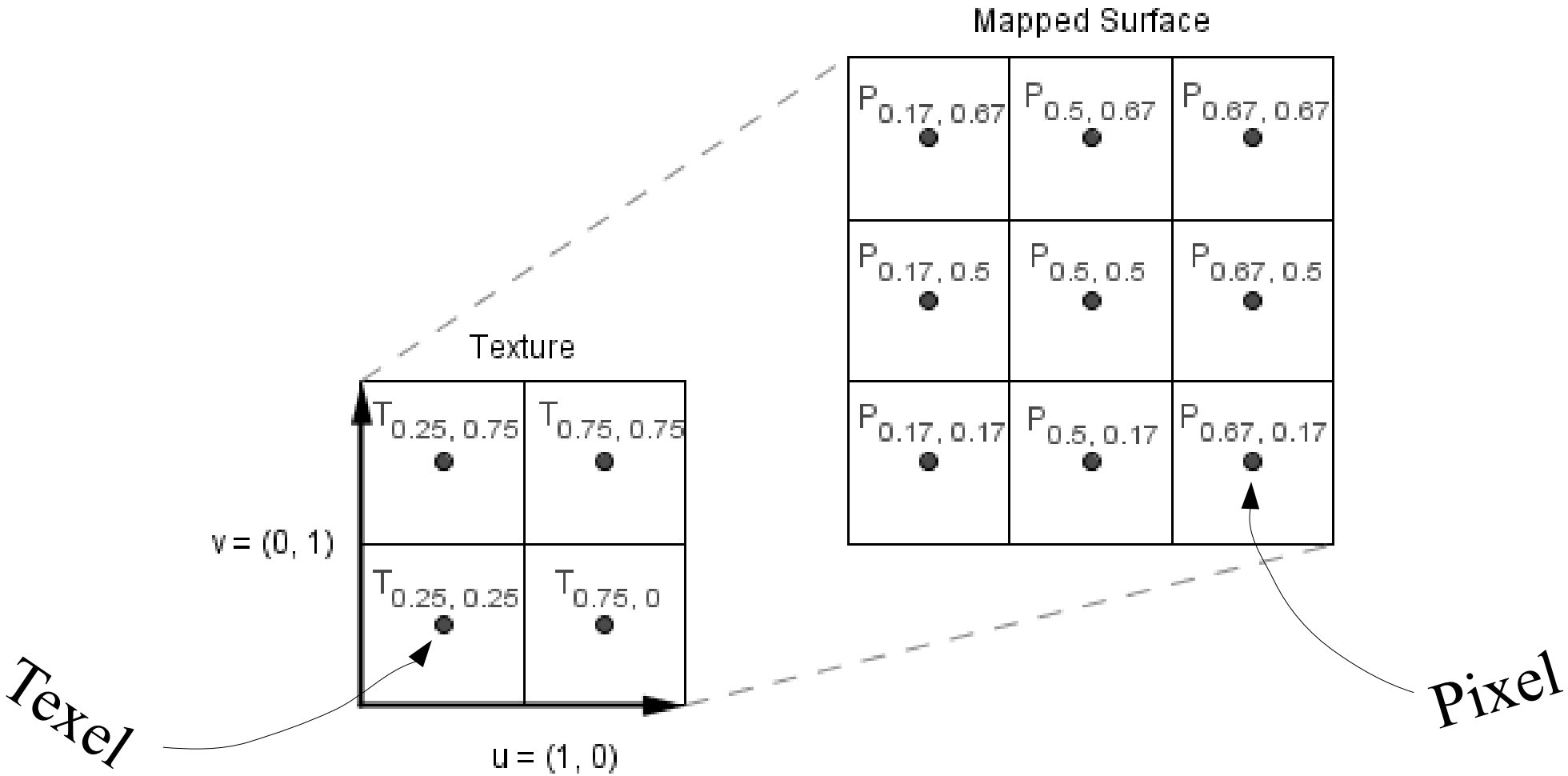
- Image is a matrix of point values.



- But, our 3D surface is continuous, we may rasterize a varying amount of points in a face.

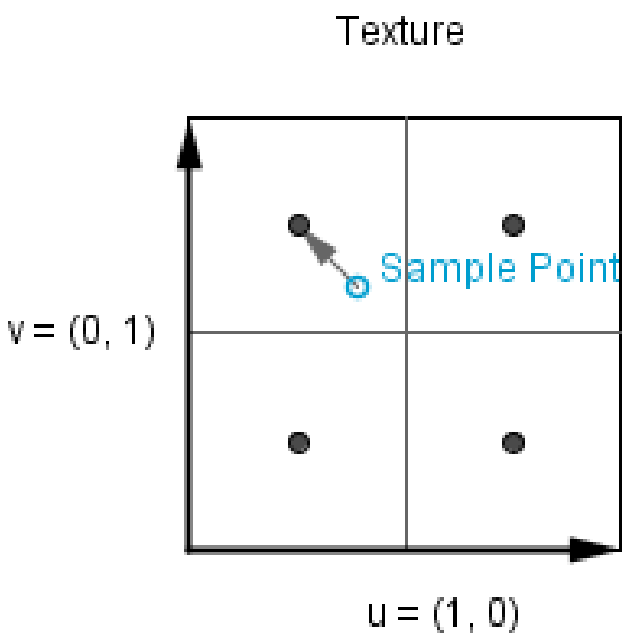
Upscale

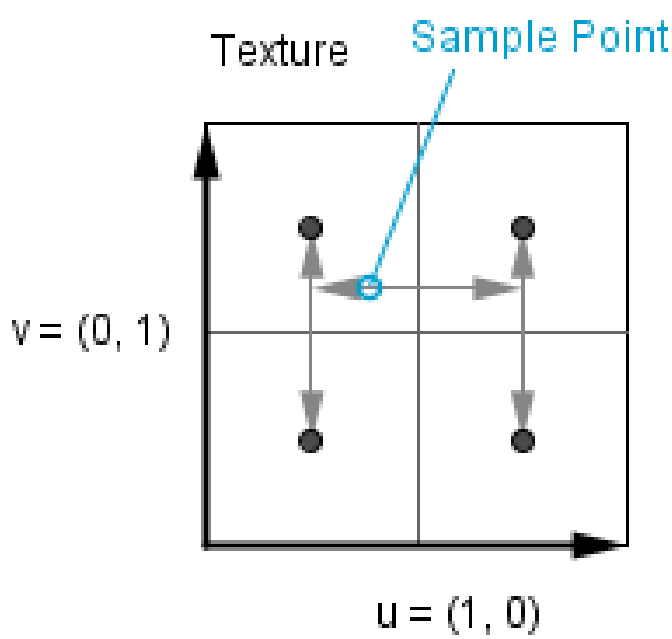
- Sometimes we want to see the surface in more detail than there are point values in the image.

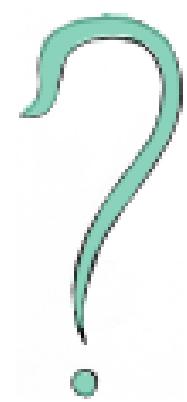


Upscale

- For a single point in the larger surface, we usually have 4 neighbours in the texture.
- What could be the exception?
- What possibilities we have to find a value?

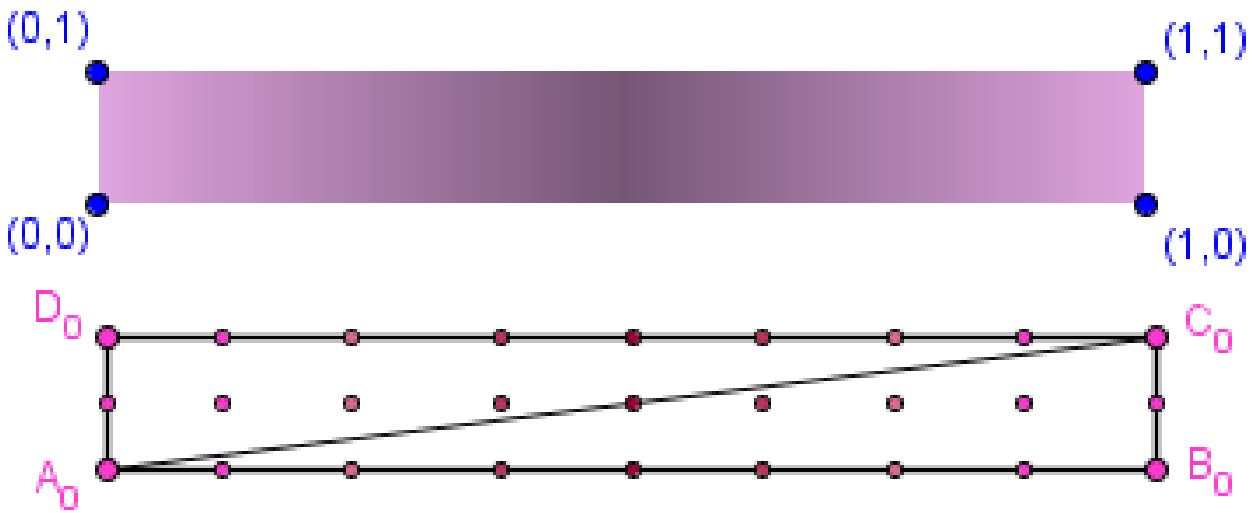






Upscale

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

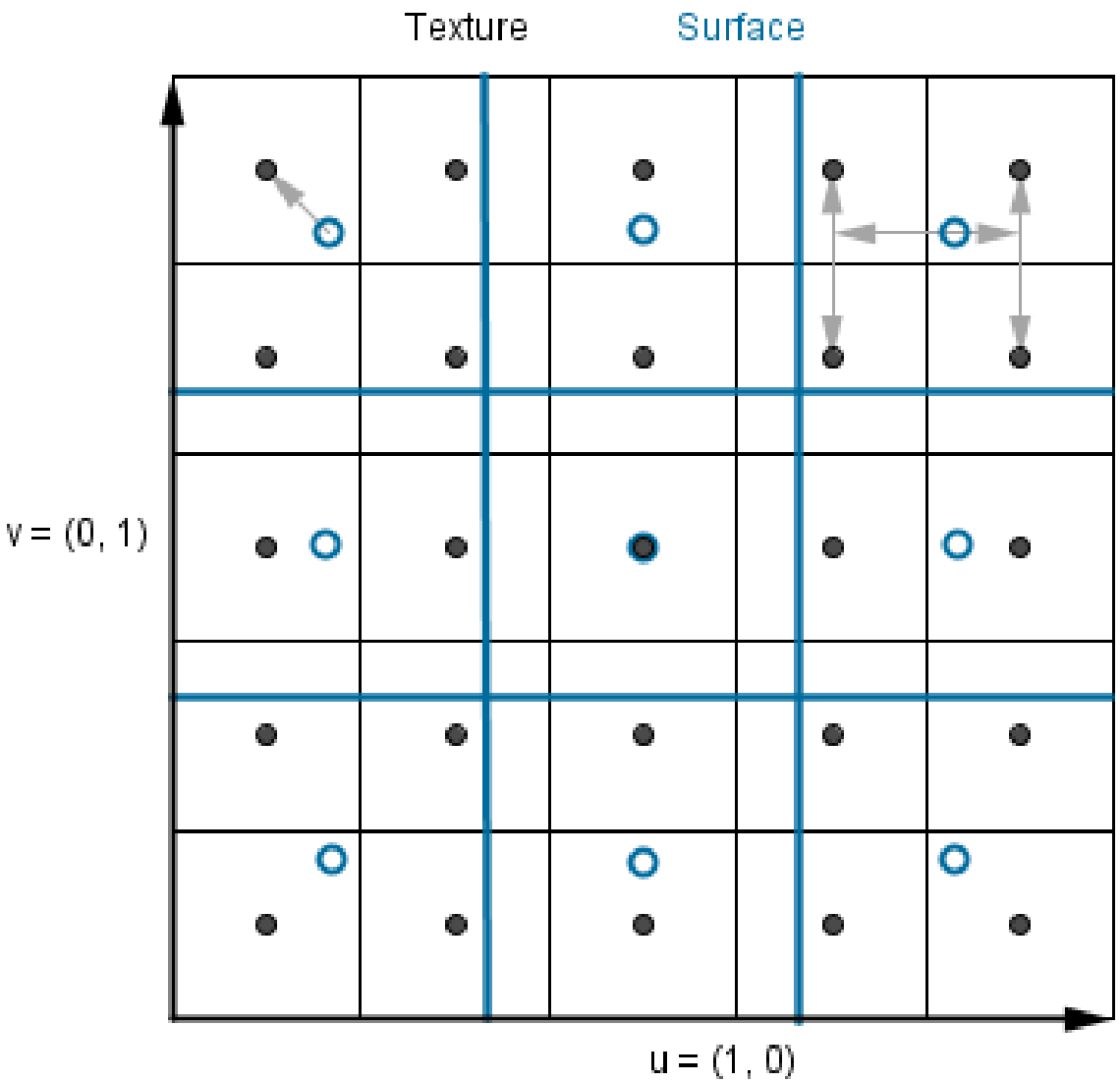


Upscale

- Given a texture with some *width*×*height*, how to find the nearest, or 4 nearest texels?

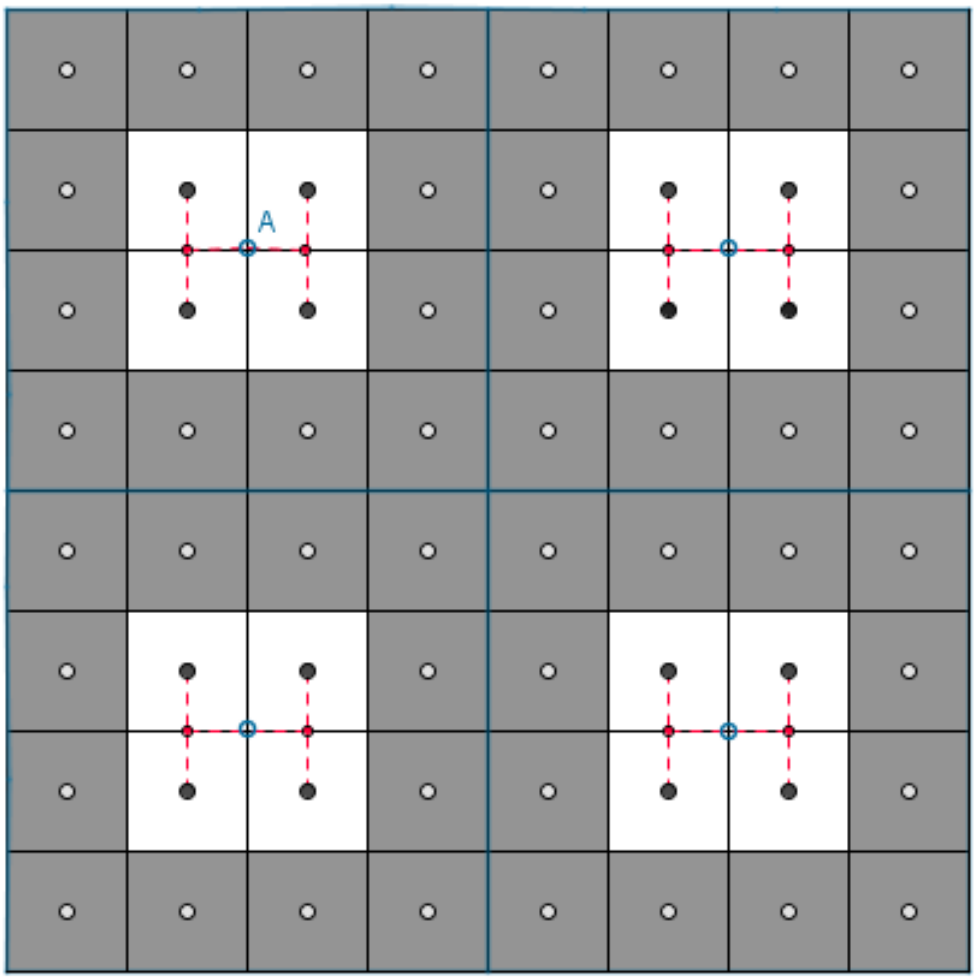
Downscale

- We can do the same interpolation for the downscale.

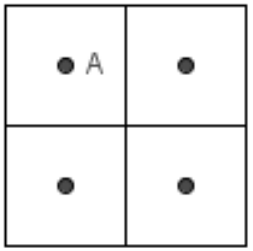


Downscale

- What can go wrong?



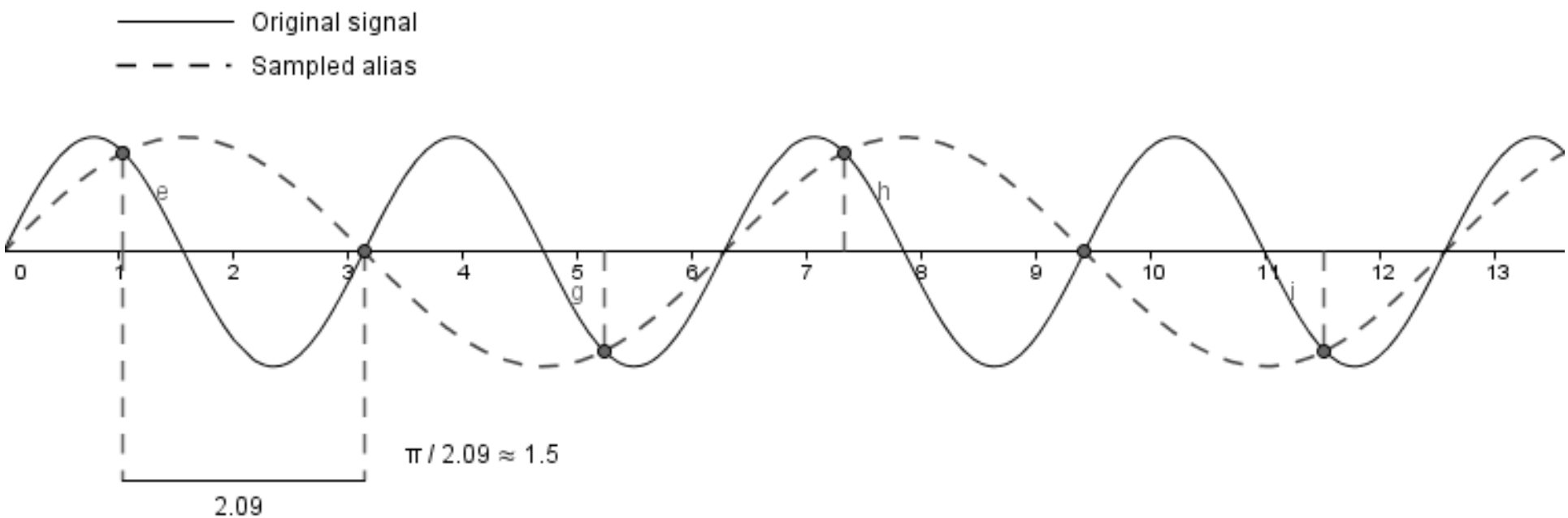
Texture



Downscaled

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.



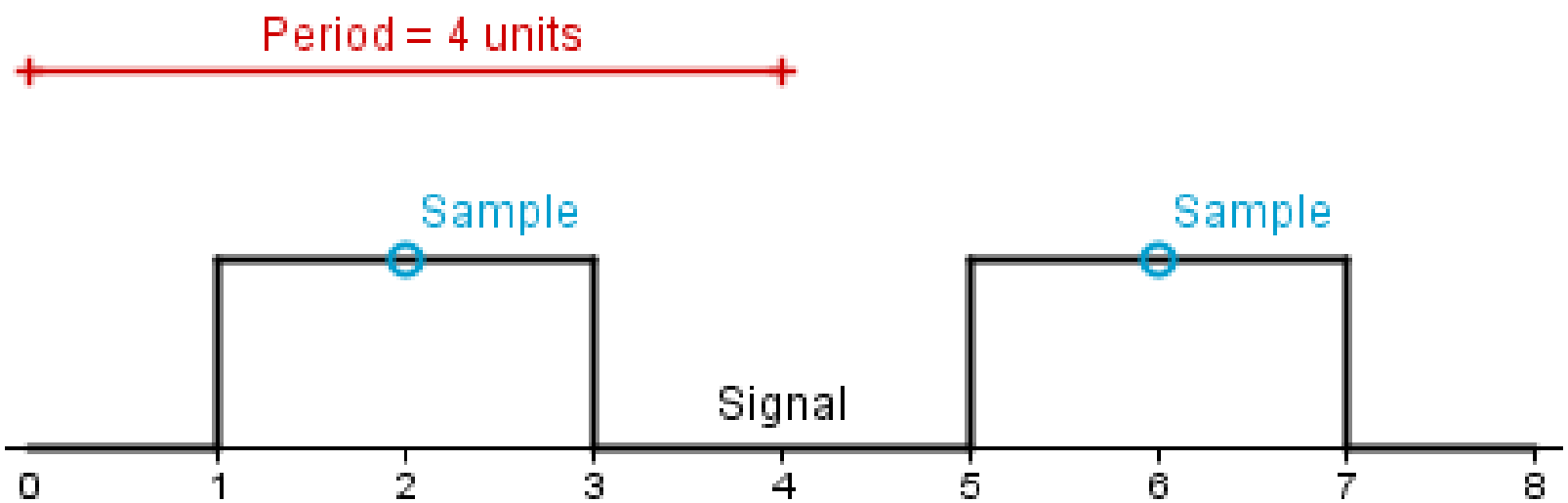
This means more than 2 samples per period, every period.

Nyquist–Shannon Sampling Theorem

- Band-limited signal – there is a fixed highest frequency in the signal.
- The signals in real life are not band-limited.
- Reconstruction is possible only when we know the shape of the signal.
- Sampling less frequently, we produce an alias – signal with a lower frequency.
- Usually assumes samples are taken over a length of time.
- More info: Http://www.skillbank.co.uk/SignalConversion/rate.htm
  http://blogs.msdn.com/b/shawnhar/archive/2011/04/29/texture-aliasing.aspx

Downscale

- So, what is happening in our example?



$$period = 4 \Rightarrow frequency = \frac{1}{4}$$

$$frequency_{Nyquist} = \frac{2}{4} = \frac{1}{2} \qquad frequency_{Us} = \frac{1}{4} < \frac{1}{2}$$

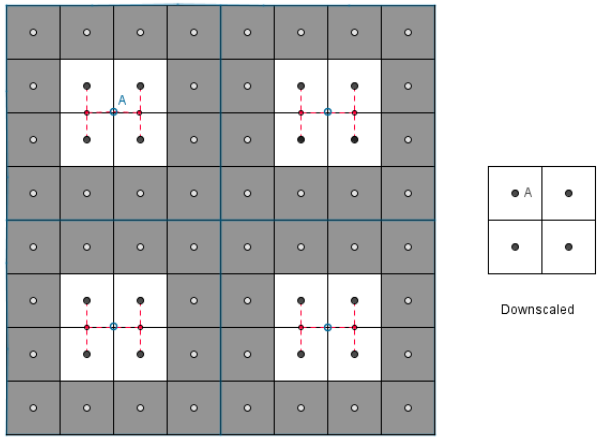
We need more than 1 sample per two units.

Downscale

- We need more than 1 sample per 2 units.
- Is this even possible, if we want to downscale from 8×8 to 2×2?

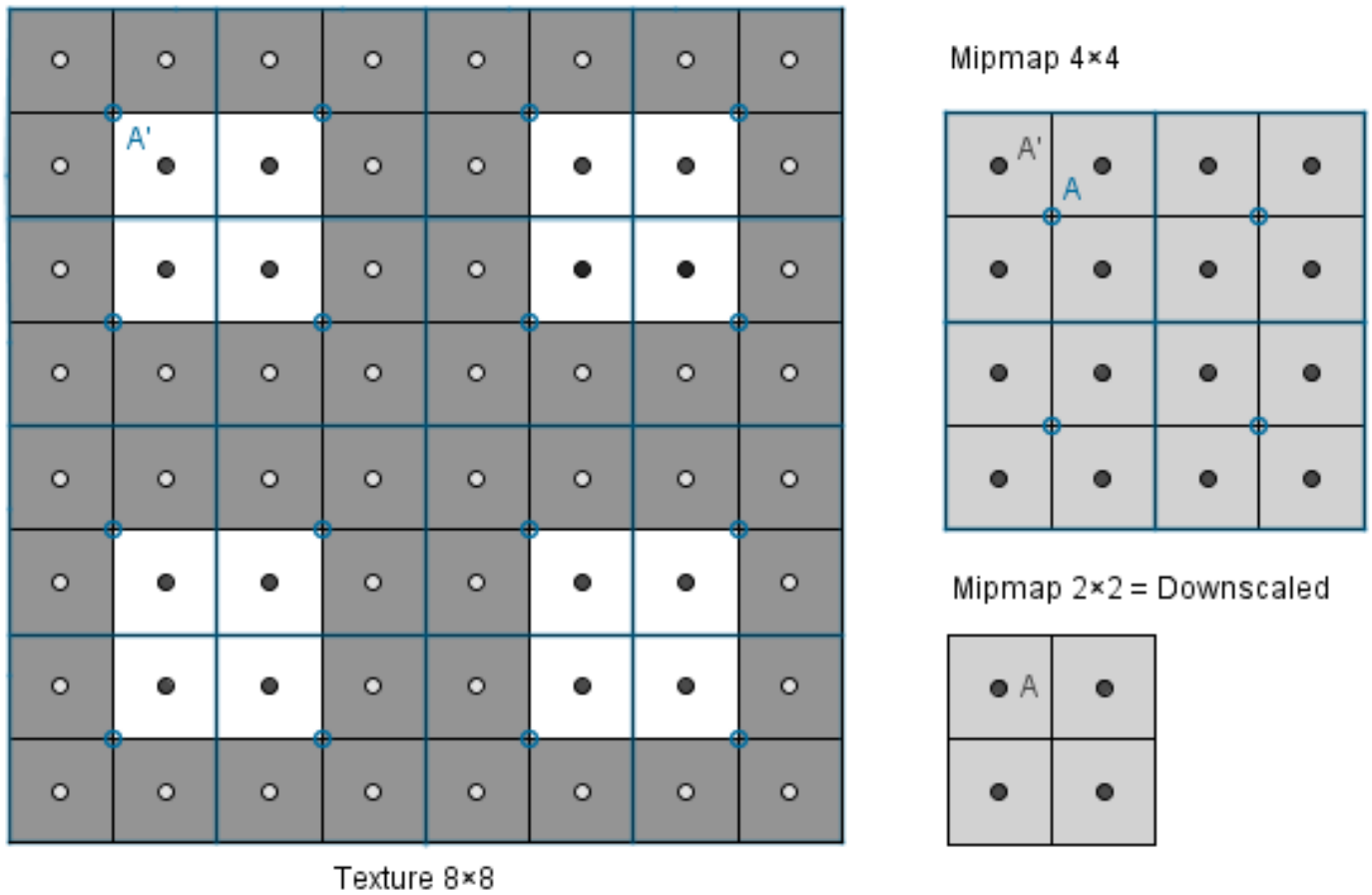
Downscale

- But we do not want to create Moire aliasing either.
- Our texture is not white, a 2×2 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

- What if we have a texture that is 10×10.
  - The first mipmap is the image itself – 10×10.
  - Then we take half the size – 5×5.
  - Next we take half the size – 2.5... Uh-oh.
- 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.
- We want to show our texture on a 6×6 area.
- Which mipmap should we sample?

Filtering

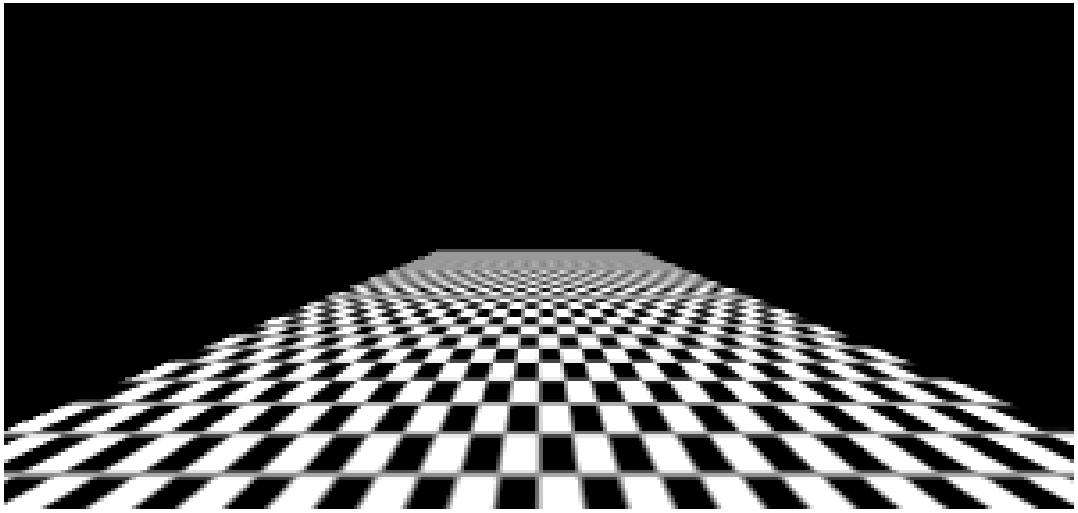
- We have seen several ways to sample the texture.
- Upscale (magnification filtering):
  - Nearest neighbour
  - Bilinear
- Downscale (minification filtering):
  - Nearest neighbour (mipmap: no, NN, linear)
  - Bilinear (mipmap: no, NN, linear)

Also called trilinear

Questions?

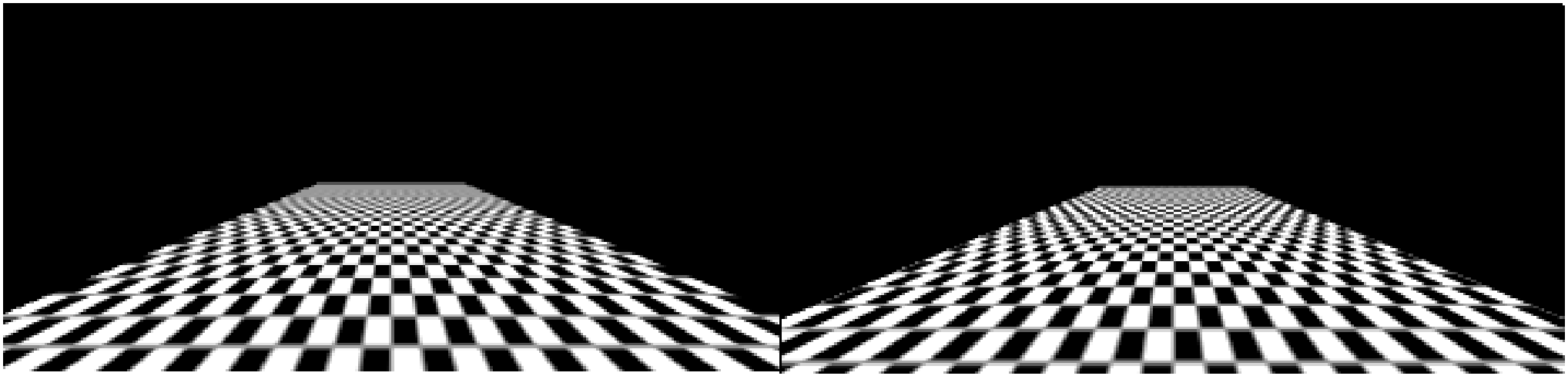
Anisotropic Filtering

- We assumed that the result we are showing our texture on is shown as a square. This is usually not the case.
- If we rotate our quad around the x-axis for example, then we might get that the texture needs to be shown on a 10×5 area instead of 10×10.



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.

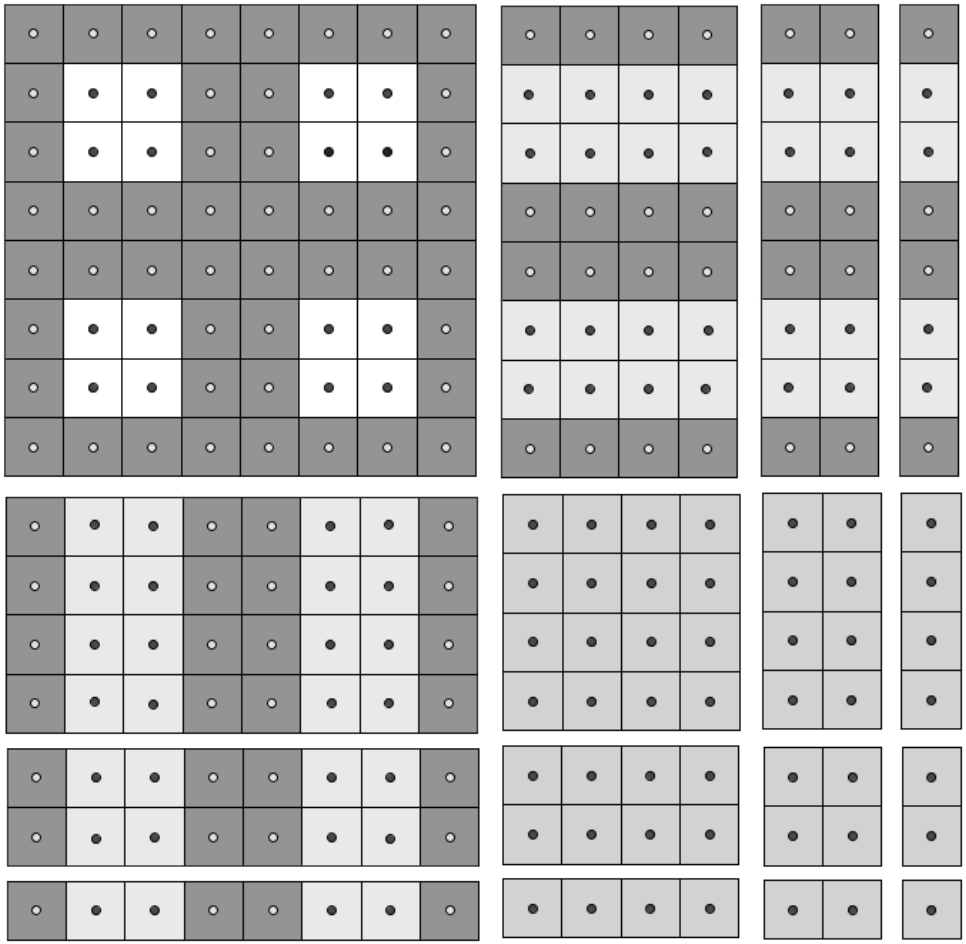


No anisotropic filtering

16x anisotropic filtering

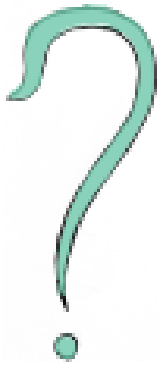
Anisotropic Filtering

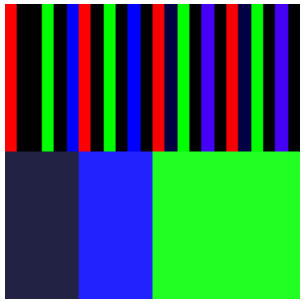
- Actual implementations are vendor dependant.
- One way would be to just create anisotropic mipmaps.

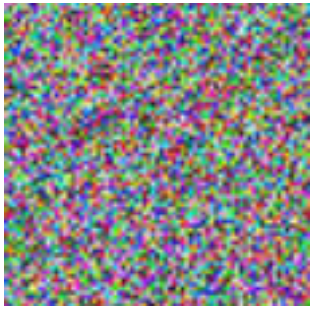


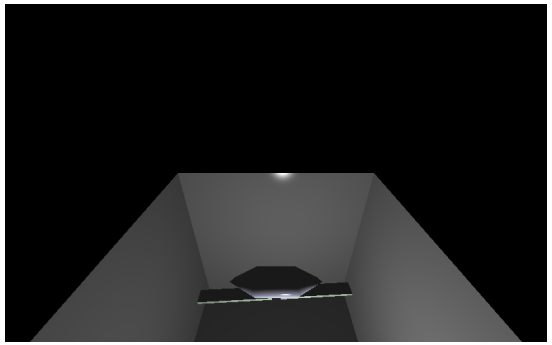
Textures

- There are more uses for textures than just storing granular color of a material.
  - Data textures – we can hold other data like normals or other values with 3 (or 4) coordinates.
  - Noise texture – we can store samples of a random function in a texture to procedurally generate things like the Perlin noise.
  - Render target – we could also render the current framebuffer to a texture.









What seemed useful today?

What more would you like to know?

Next time

Blending – *Jaanus Jaggo*