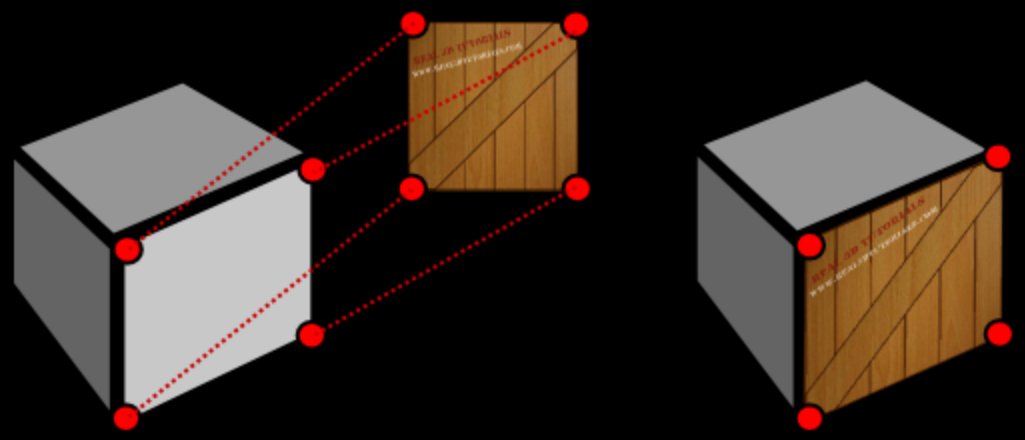
TEXTURE MAPPING



OUTLINE

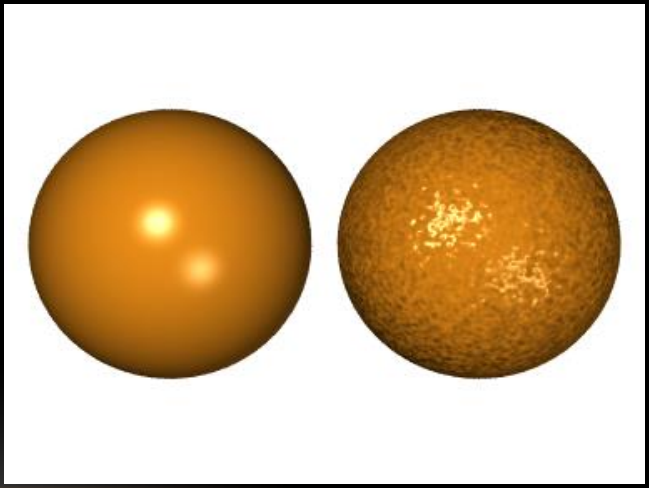
- Introduce Mapping Methods
  - Texture Mapping
  - Environment Mapping
  - Bump Mapping
- Basic mapping strategies
  - Forward vs backward mapping
  - Point sampling vs area averaging
- Introduce texture mapping
  - Two-dimensional texture maps
  - Assigning texture coordinates

THE LIMITS OF GEOMETRIC MODELING

- Although graphics cards can render over 10 million polygons per second, that number is insufficient for many phenomena
  - Clouds
  - Grass
  - Terrain
  - Skin

MODELING AN ORANGE

- Consider the problem of modeling an orange (the fruit)
- Start with an orange-colored sphere
  - Too simple
- Replace sphere with a more complex shape
  - Does not capture surface characteristics (small dimples)
  - Takes too many polygons to model all the dimples



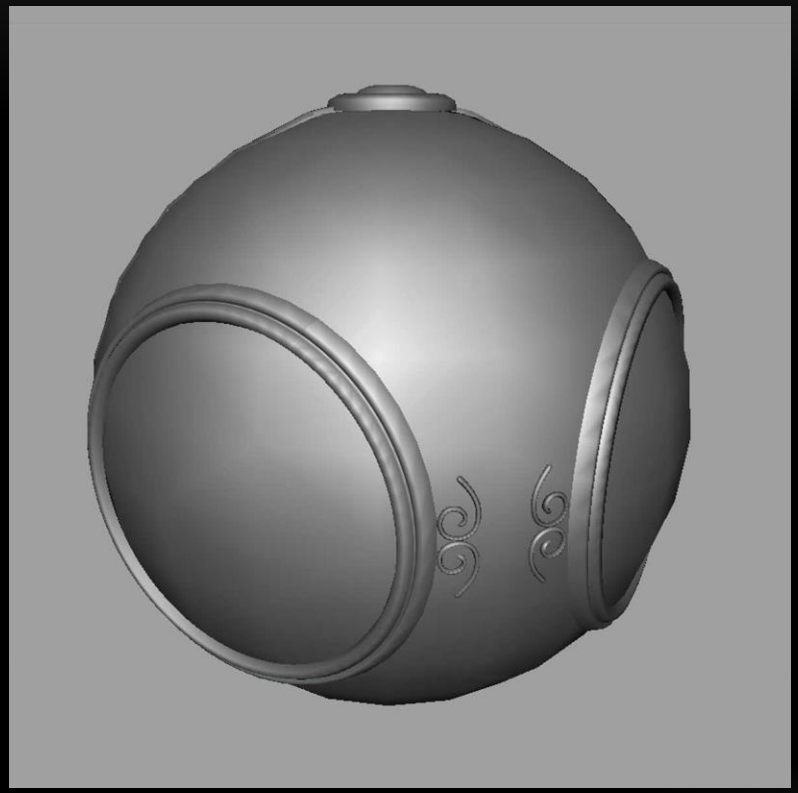
MODELING AN ORANGE (2)

- Take a picture of a real orange, scan it, and “paste” onto simple geometric model
  - This process is known as texture mapping
- Still might not be sufficient because resulting surface will be smooth
  - Need to change local shape
  - Bump mapping

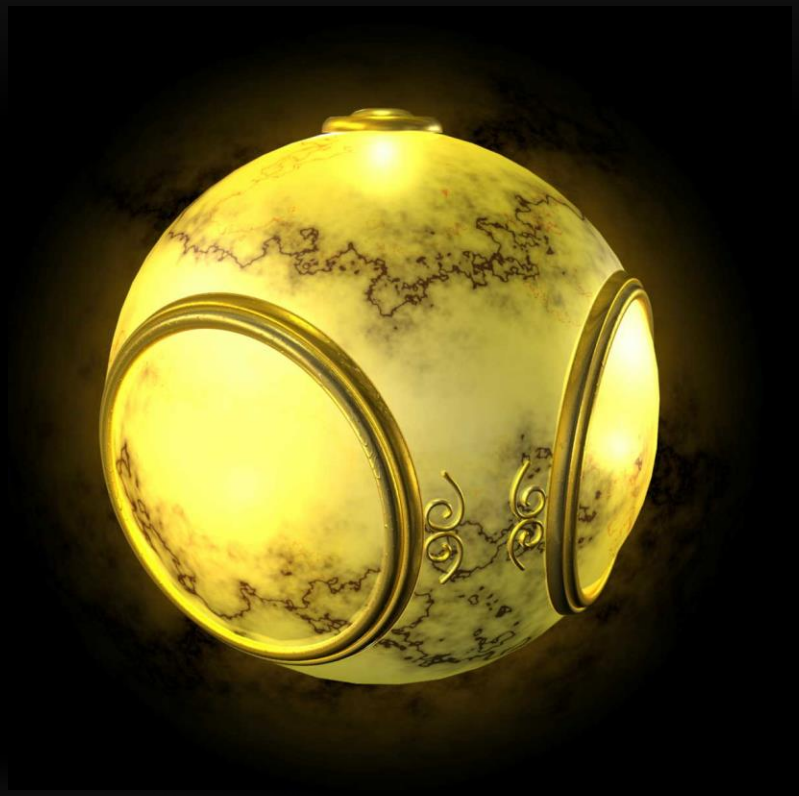
THREE TYPES OF MAPPING

- Texture Mapping
  - Uses images to fill interior points of polygons
- Environment (reflection mapping)
  - Uses a picture of the environment for texture maps
  - Allows simulation of highly specular surfaces
- Bump mapping
  - Emulates altering normal vectors during the rendering process
- We will talk about environment and bump mapping later – after lighting – but some image examples follow…

TEXTURE MAPPING



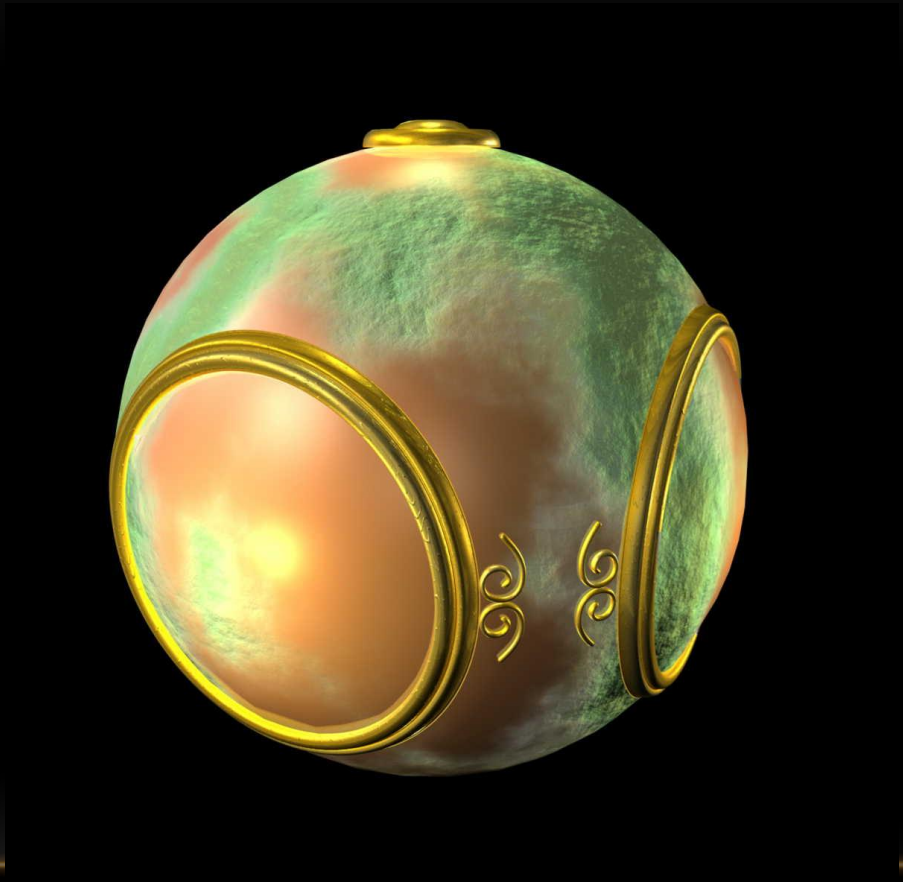
geometric model



texture mapped

ENVIRONMENT MAPPING

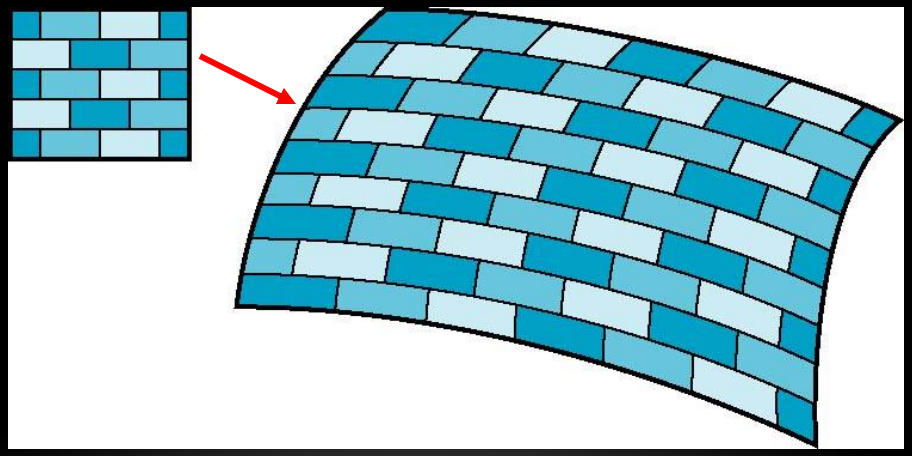
BUMP MAPPING



IS IT SIMPLE?

- Although the idea is simple---map an image to a surface---there are 3 or 4 coordinate systems involved

2D image

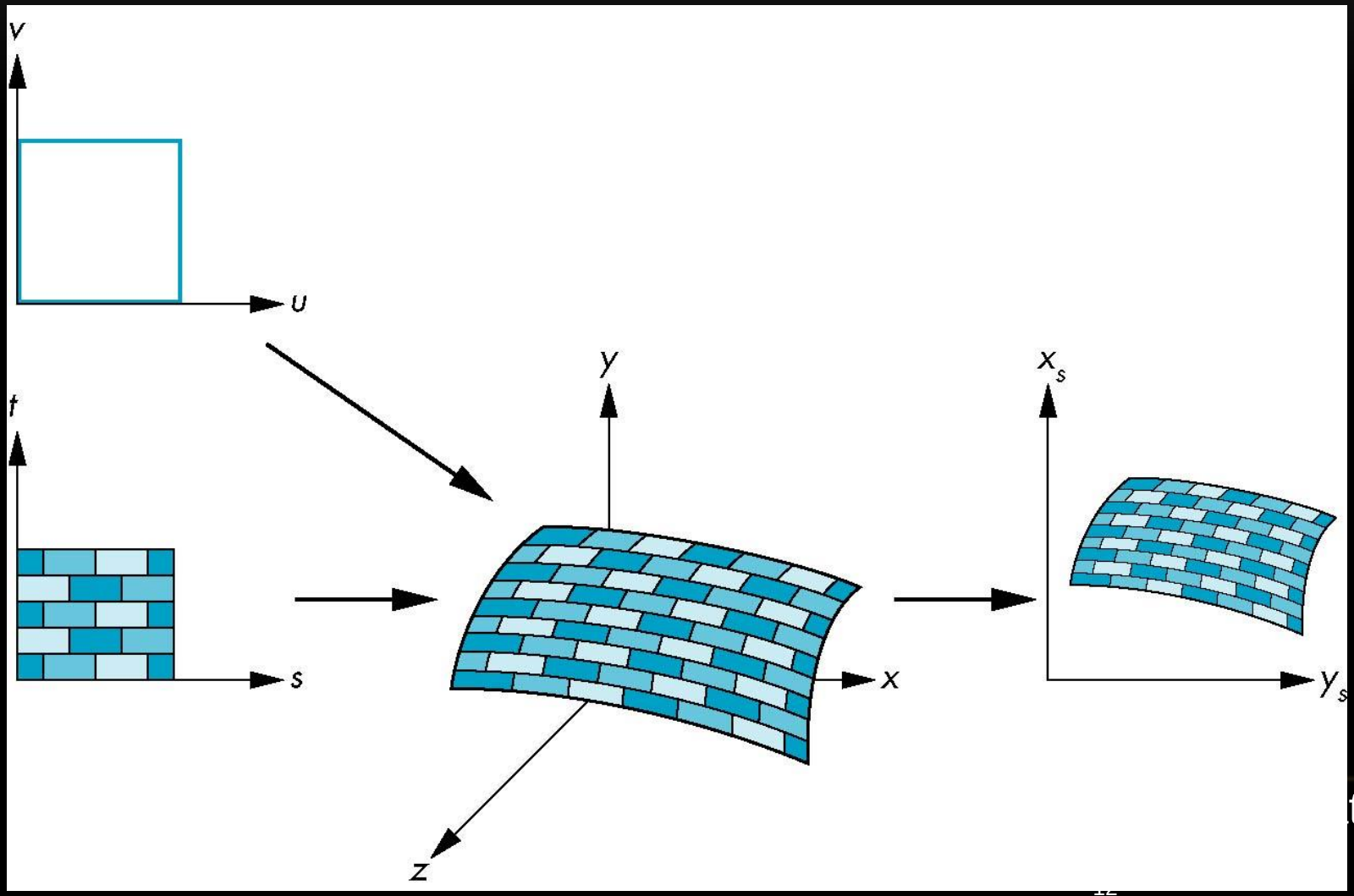


3D surface

COORDINATE SYSTEMS

- Parametric coordinates
  - May be used to model curves and surfaces
    - We haven't talked about this yet – we will
- Texture coordinates
  - Used to identify points in the image to be mapped
- Object or World Coordinates
  - Conceptually, where the mapping takes place
- Window Coordinates
  - Where the final image is really produced

TEXTURE MAPPING



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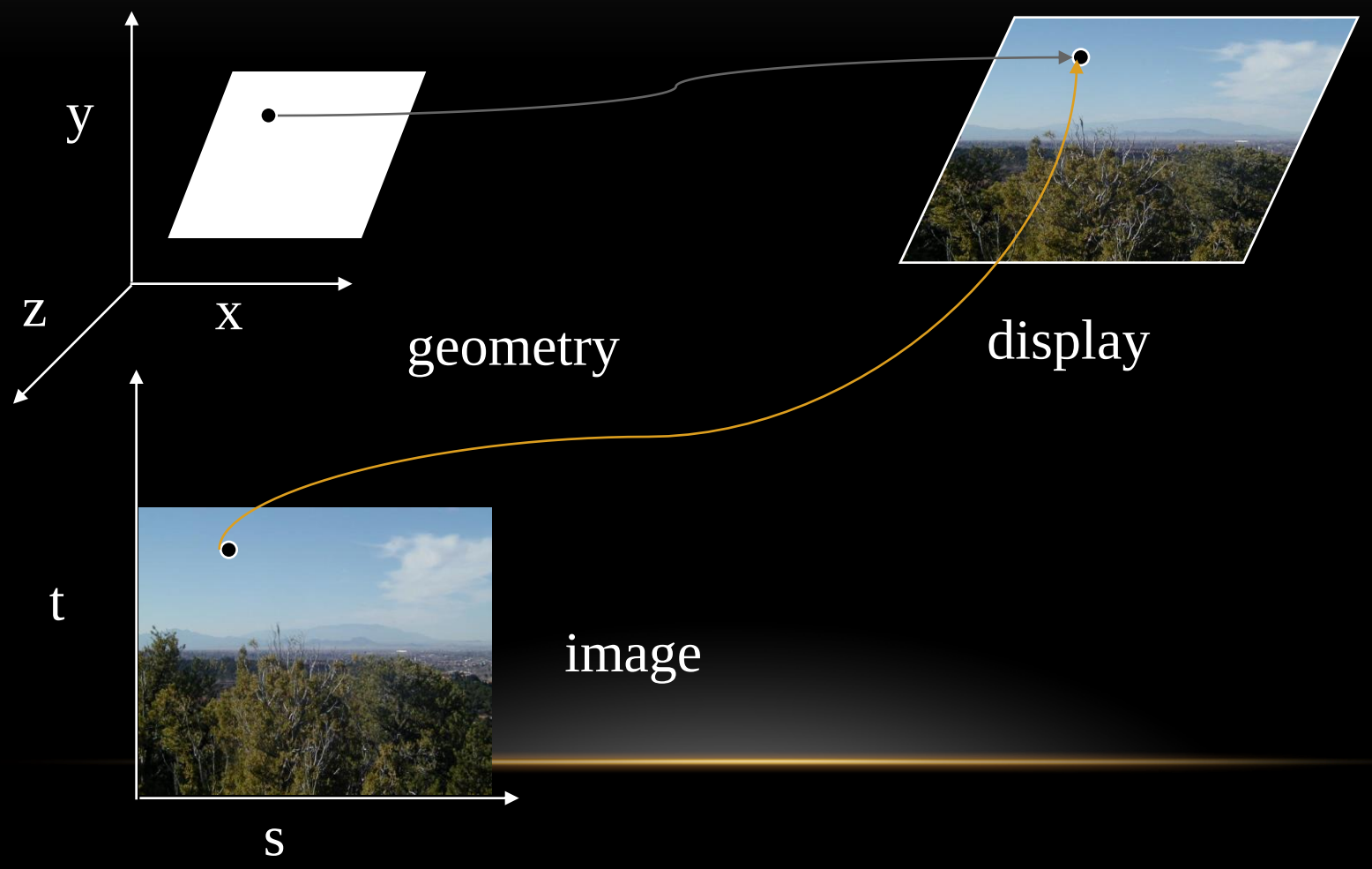
BASIC STRAGEGY

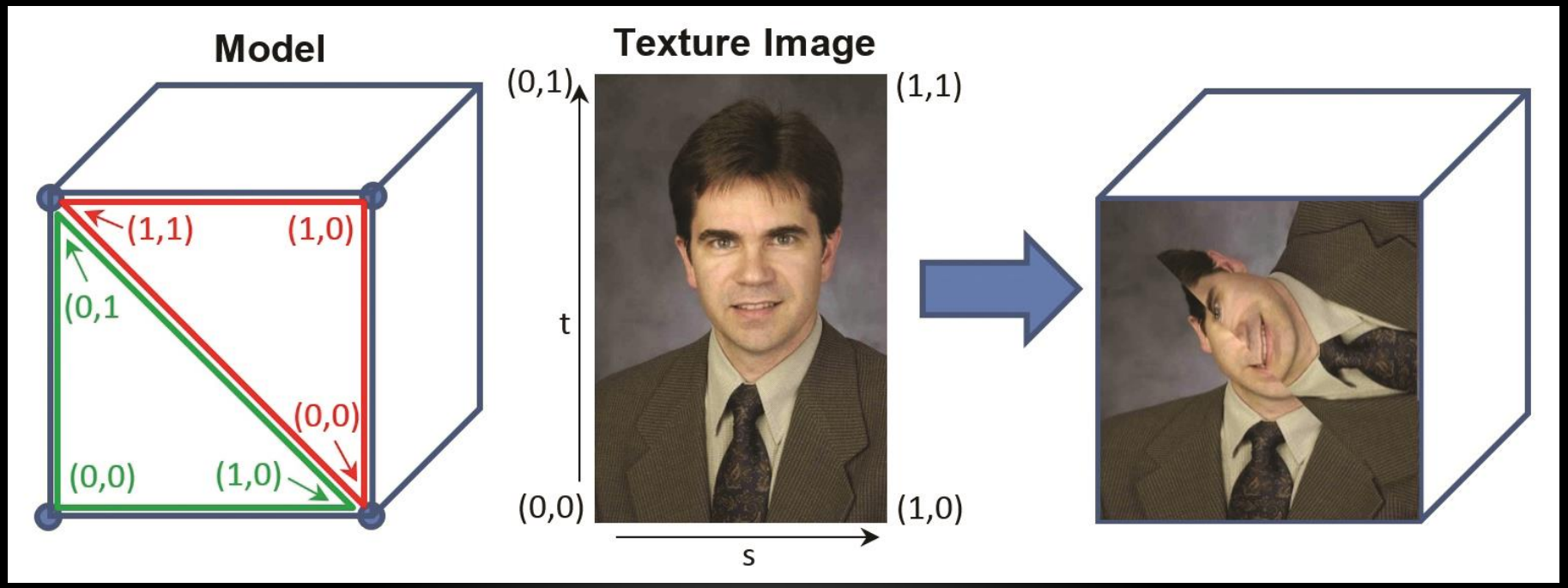
Three steps to applying a texture

1. specify the texture
   - read or generate image
   - assign to texture
   - enable texturing
2. assign texture coordinates to vertices
   - Proper mapping function is left to application
3. specify texture parameters
   - wrapping, filtering

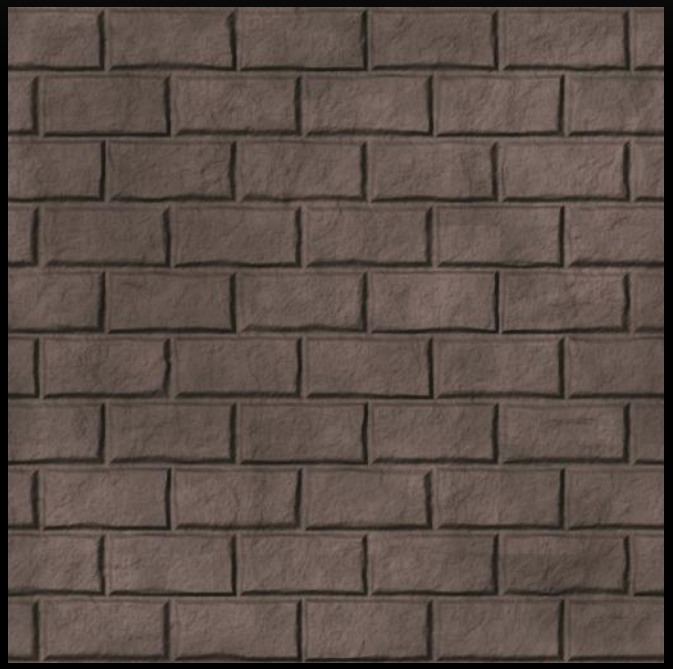
TEXTURE MAPPING

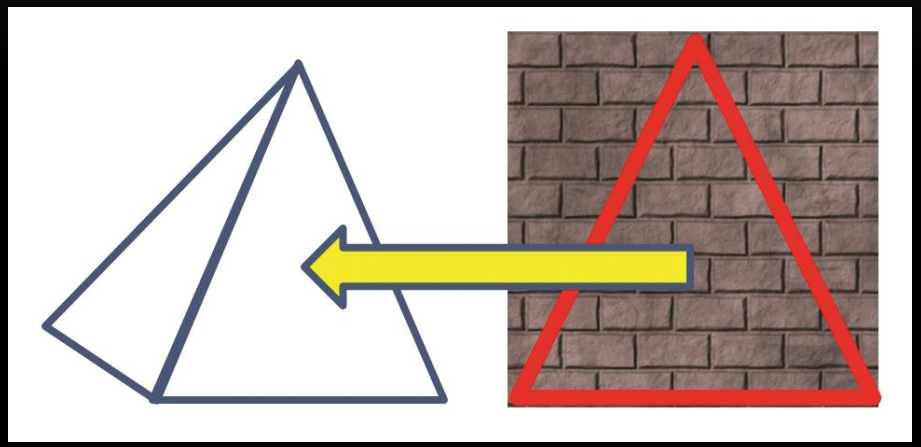


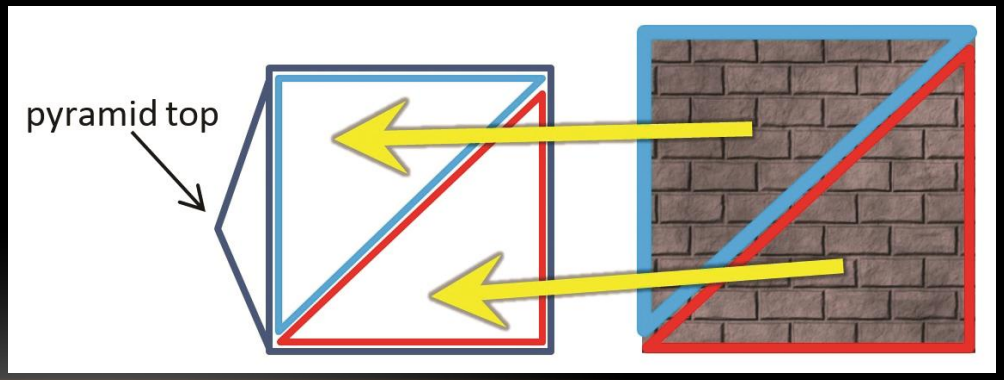
TEXTURE MAPPING GONE WRONG



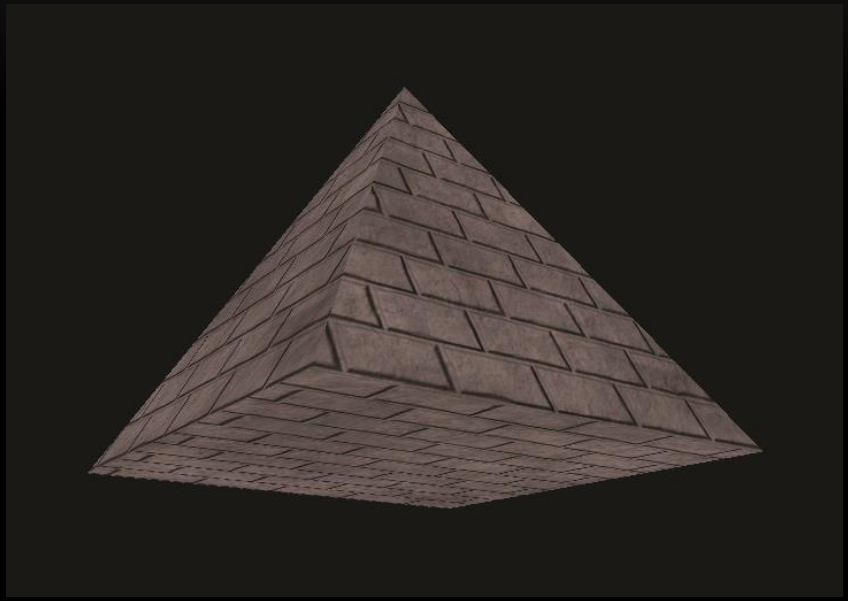
TEXTURE MAPPING

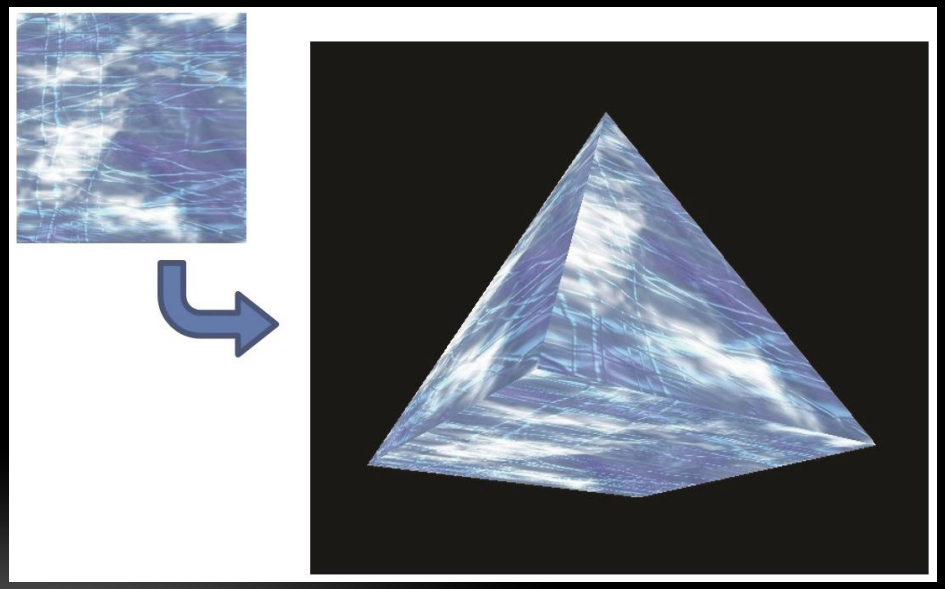






TEXTURE MAPPING DONE WELL



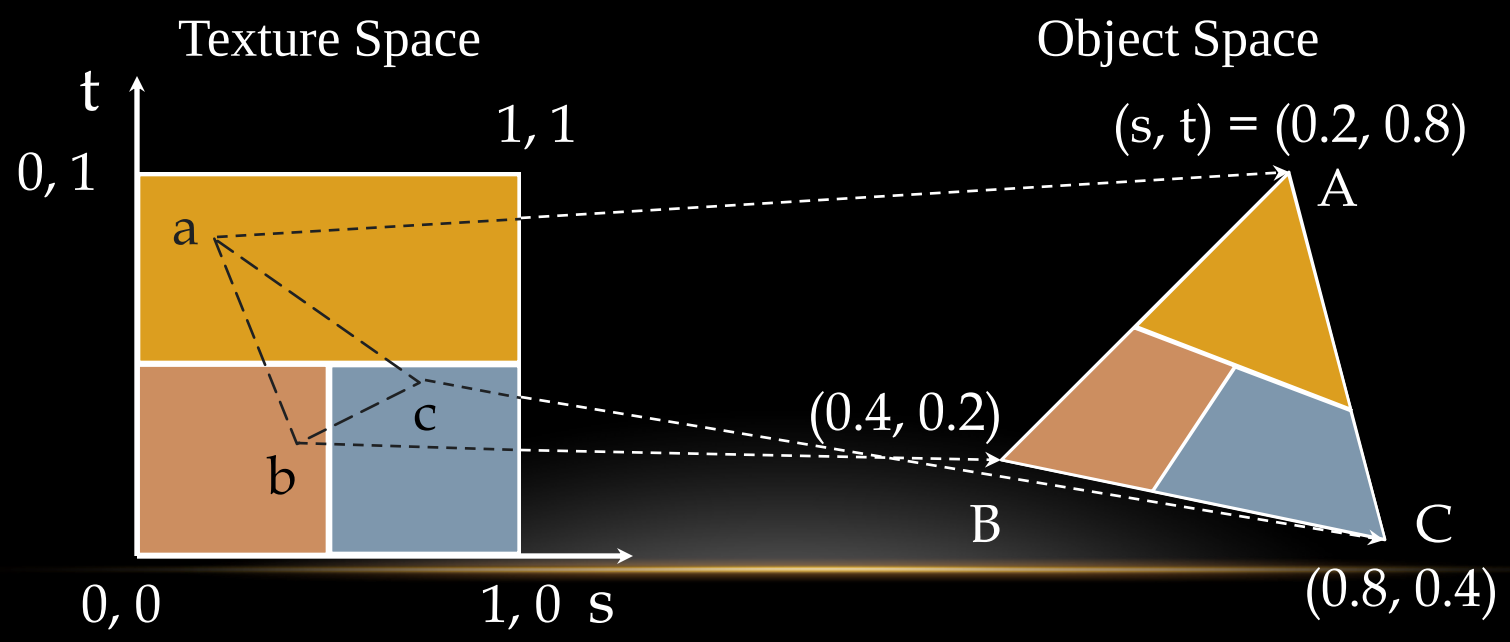


SPECIFYING A TEXTURE IMAGE

- Define a texture image from an array of *texels* (texture elements) in CPU memory
- Use an image in a standard format such as JPEG
  - Scanned image
  - Generate by application code

MAPPING A TEXTURE

- Based on parametric texture coordinates
- Specify as a 2D vertex attribute



INTERPOLATION

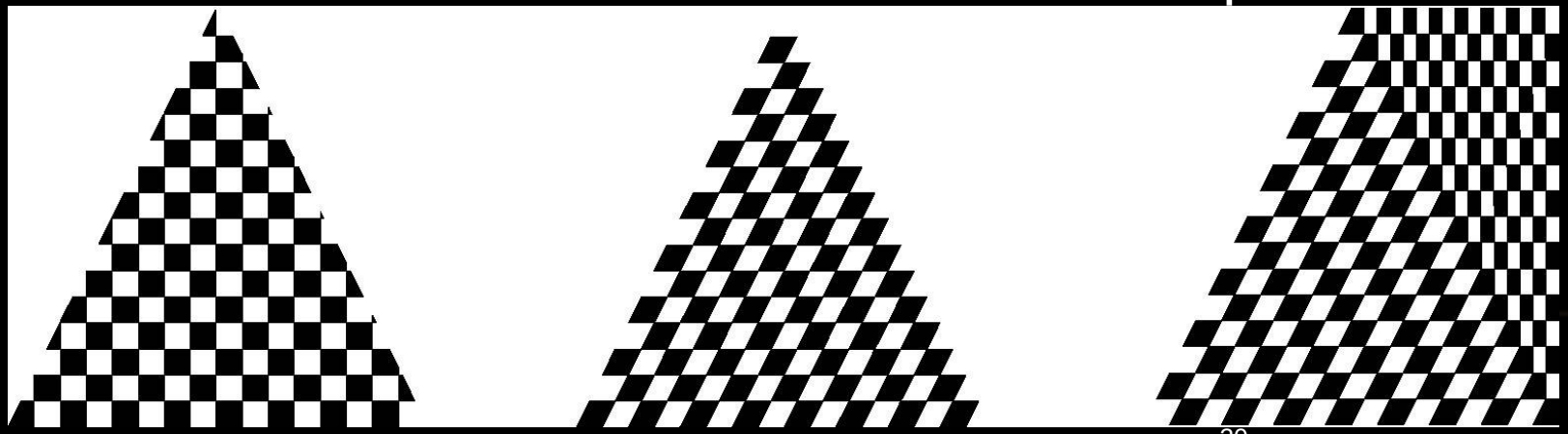
OpenGL uses interpolation to find proper texels from specified texture coordinates

Can be distortions

good selection of tex coordinates

poor selection of tex coordinates

texture stretched over trapezoid showing effects of bilinear interpolation



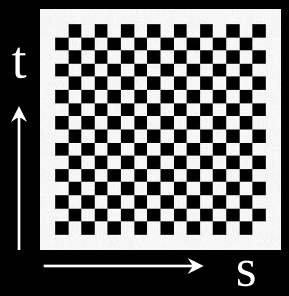
TEXTURE PARAMETERS

- Variety of parameters that determine how texture is applied
  - Wrapping parameters determine what happens if s and t are outside the (0,1) range
  - Filter modes allow us to use area averaging instead of point samples
  - Mipmapping allows us to use textures at multiple resolutions
  - Environment parameters determine how texture mapping interacts with shading

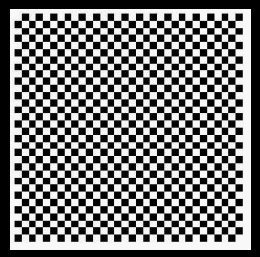
WRAPPING MODE

Clamping: if s,t > 1 use 1, if s,t <0 use 0

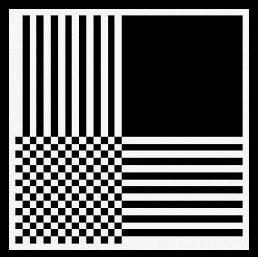
Wrapping: use s,t modulo 1



texture



gl.REPEAT wrapping



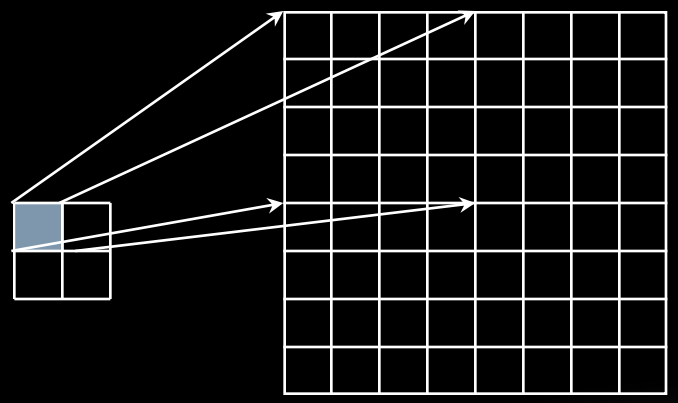
gl.CLAMP wrapping

MIRRORED REPEAT, CLAMP TO EDGE, AND CLAMP TO BORDER

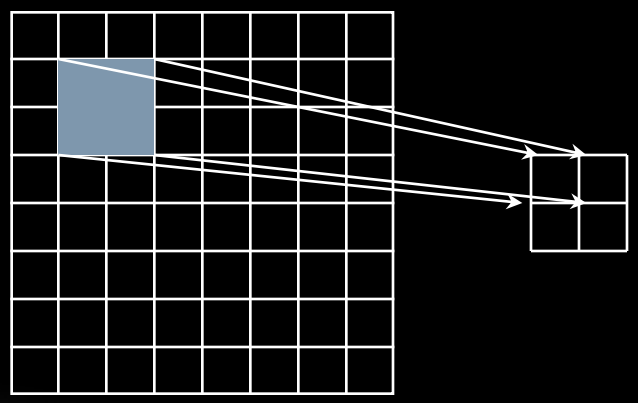
MAGNIFICATION AND MINIFICATION

More than one texel can cover a pixel (*minification*) or more than one pixel can cover a texel (*magnification*)

Can use point sampling (nearest texel) or linear filtering (2 x 2 filter) to obtain texture values



Magnification



Minification

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