Texture Mapping

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Objectives

- Introduce Mapping Methods
  - Texture Mapping
  - Environment Mapping
  - Bump Mapping
- Consider basic strategies
  - Forward vs backward mapping
  - Point sampling vs area averaging

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
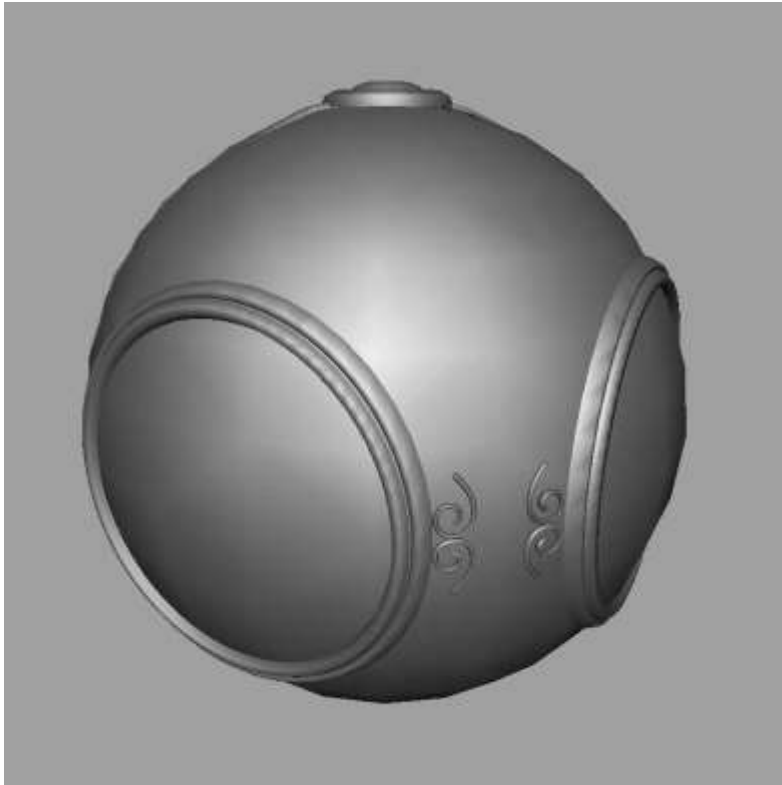 - Need to change local shape
  - Bump mapping

Three Types of Mapping

- Texture Mapping
  - Uses images to fill inside 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

Texture Mapping

geometric model   texture mapped

Environment Mapping

E. Angel and D. Shreiner: Interactive Computer Graphics 6E © Addison-Wesley 2012
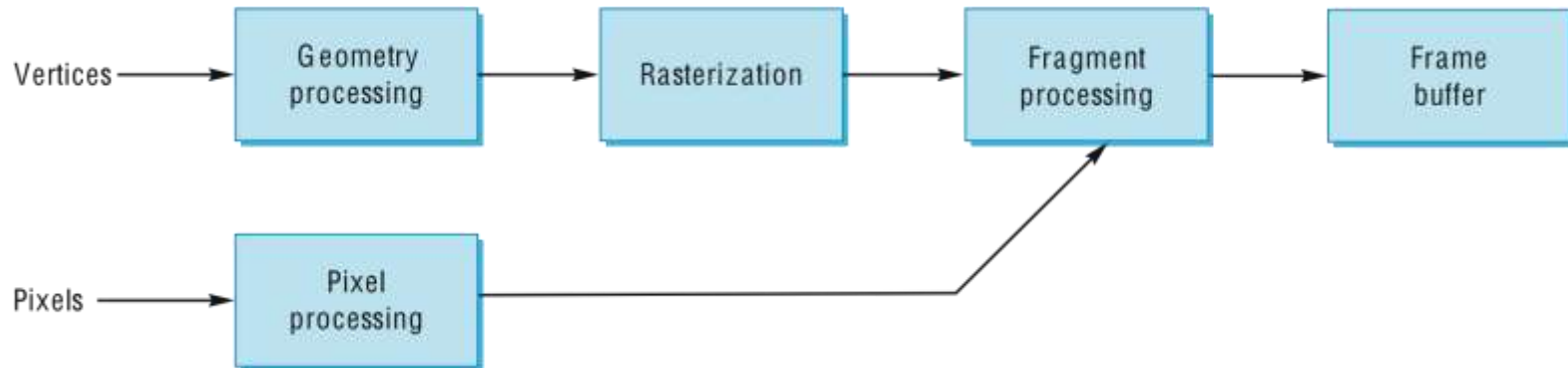
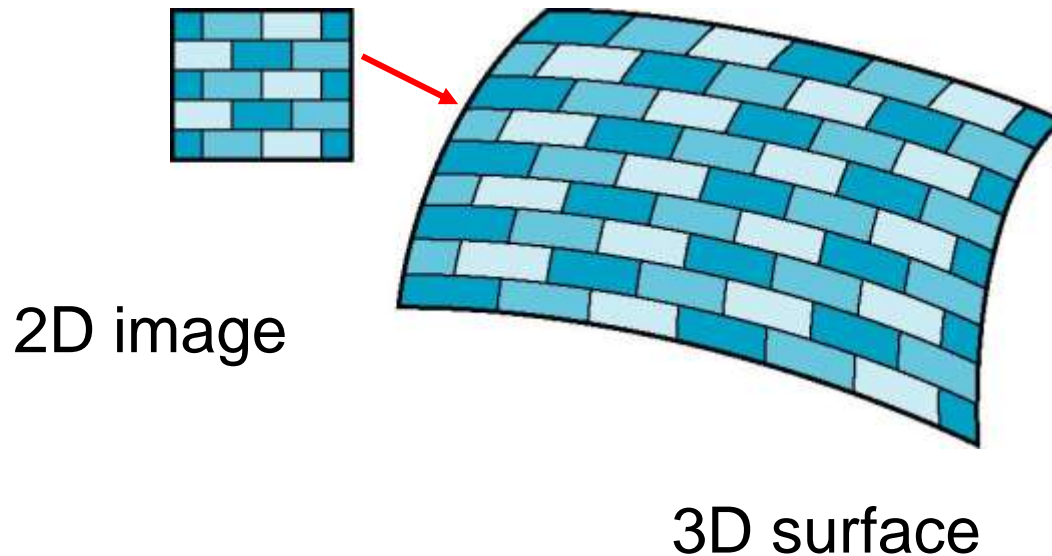# Bump Mapping

Where does mapping take place?

- Mapping techniques are implemented at the end of the rendering pipeline
  - Very efficient because few polygons make it past the clipper

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

- 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

parametric coordinates

texture coordinates

world coordinates
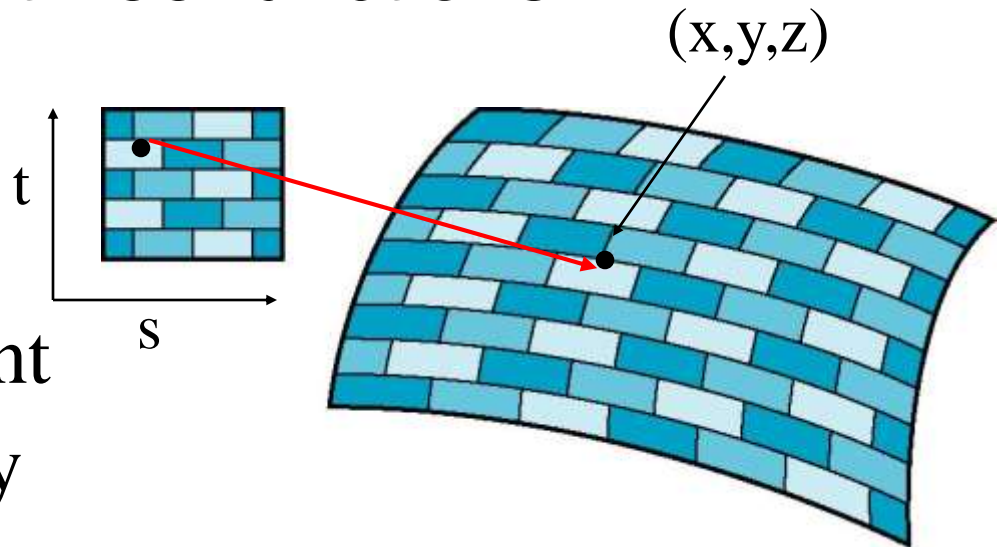
window coordinates
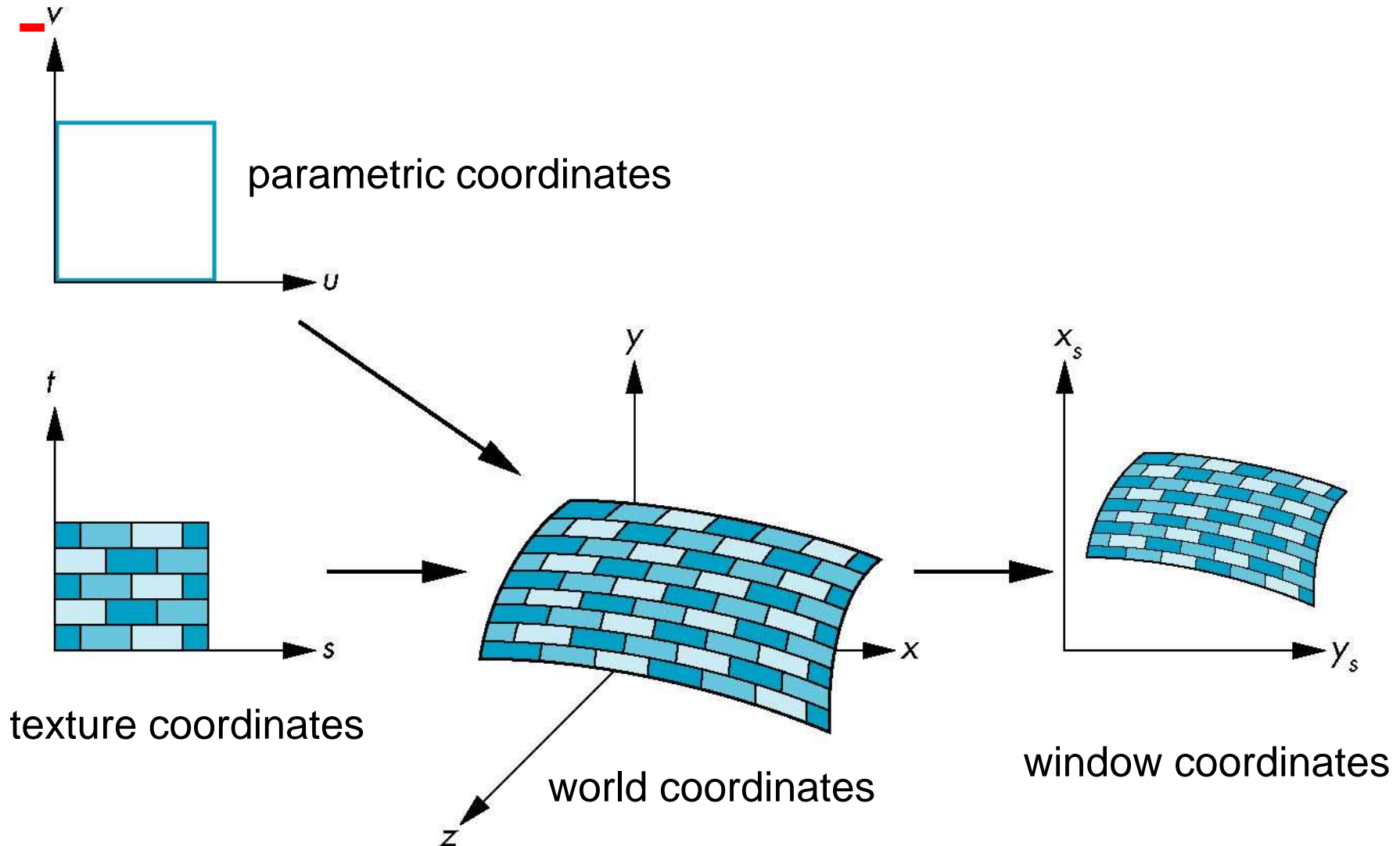
Mapping Functions

- Basic problem is how to find the maps
- Consider mapping from texture coordinates to a point a surface
- Appear to need three functions

$$x = x(s,t)$$
$$y = y(s,t)$$
$$z = z(s,t)$$

- But we really want
to go the other way

Backward Mapping

- We really want to go backwards

  - Given a pixel, we want to know to which point on an object it corresponds

  - Given a point on an object, we want to know to which point in the texture it corresponds

- Need a map of the form

  $$s = s(x,y,z)$$

  $$t = t(x,y,z)$$

- Such functions are difficult to find in general

Two-part mapping

- One solution to the mapping problem is to first map the texture to a simple intermediate surface

- Example: map to cylinder
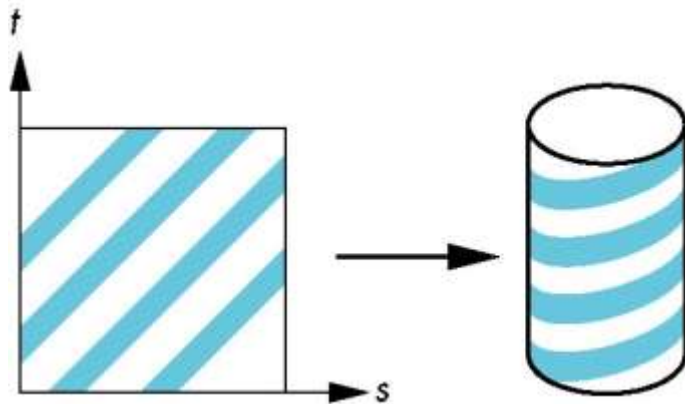
Cylindrical Mapping

parametric cylinder

$$x = r \cos 2\pi u$$
$$y = r \sin 2\pi u$$
$$z = v/h$$

maps rectangle in u,v space to cylinder
of radius r and height h in world coordinates

$$s = u$$
$$t = v$$

maps from texture space

Spherical Map

We can use a parametric sphere

$$x = r \cos 2\pi u$$
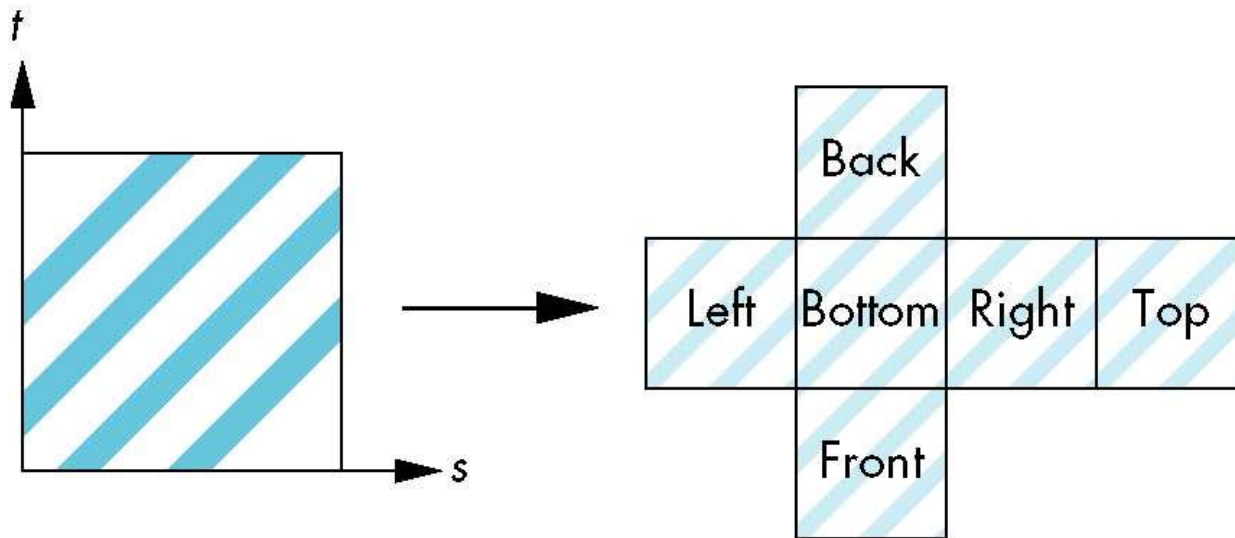$$y = r \sin 2\pi u \cos 2\pi v$$
$$z = r \sin 2\pi u \sin 2\pi v$$

in a similar manner to the cylinder
but have to decide where to put
the distortion

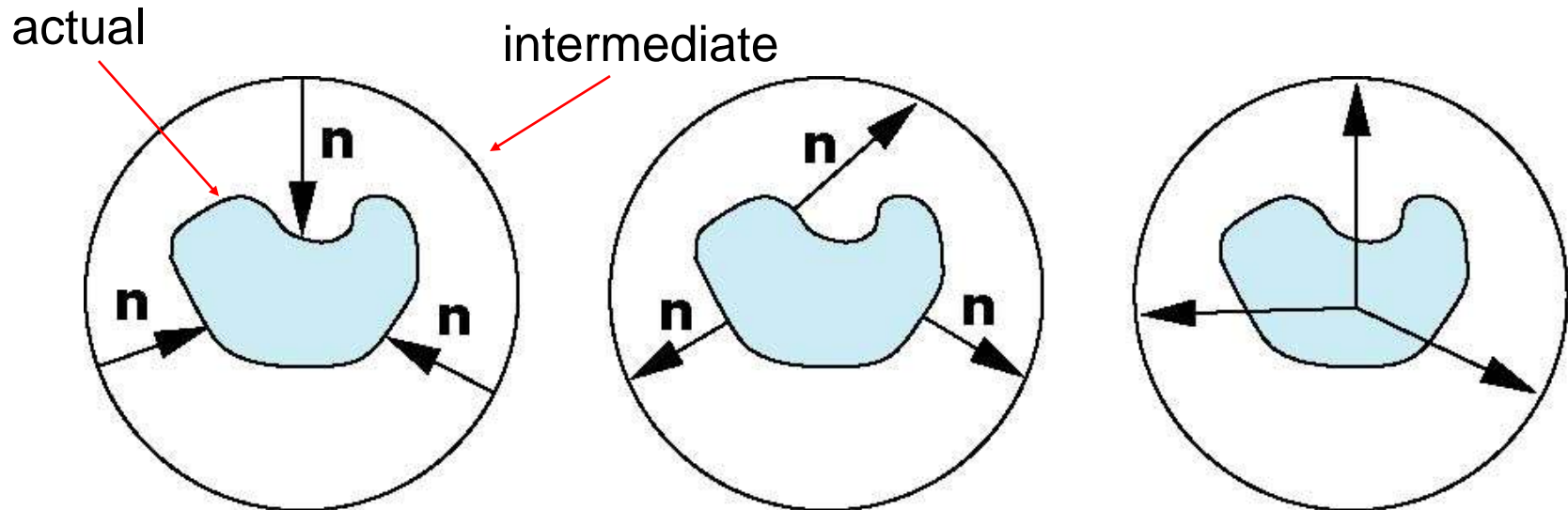Spheres are used in environmental maps

Box Mapping

- Easy to use with simple orthographic projection
- Also used in environment maps
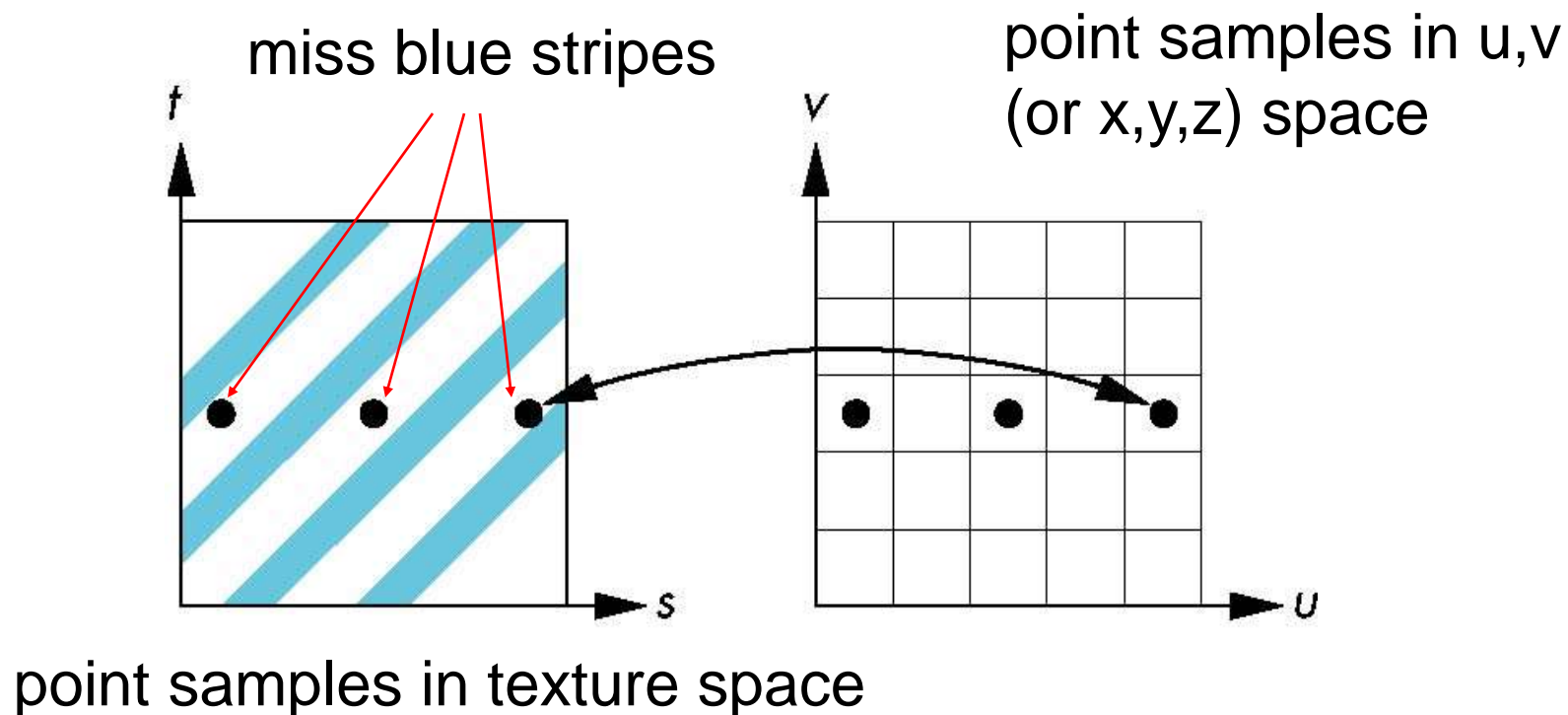
Second Mapping

- Map from intermediate object to actual object
  - Normals from intermediate to actual
  - Normals from actual to intermediate
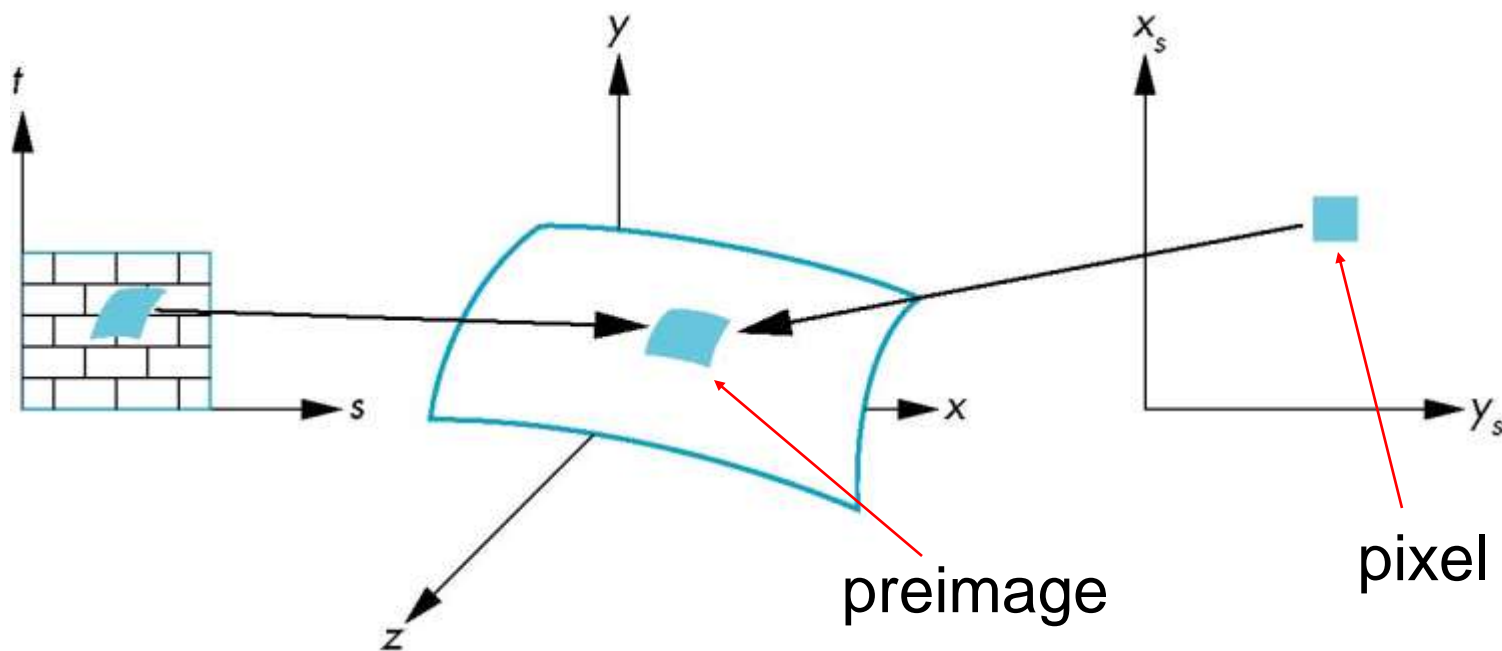 - Vectors from center of intermediate

actual

intermediate

Aliasing

- Point sampling of the texture can lead to aliasing errors

miss blue stripes

point samples in u,v (or x,y,z) space

point samples in texture space

Area Averaging

A better but slower option is to use *area averaging*

preimage

pixel

Note that *preimage* of pixel is curved