Texture Mapping

- A method for adding surface details
- Aims at increasing realism
  - Relying on mesh geometry to create such details is expensive
  - Lighting/shading models are not enough
- Associate 2D information with 3D surface

1 Texture and 3D object

- Texture image: 2D array of colour values (Texels)
- Assigning texture coordinates (s,t) at vertex with object coordinates (x,y,z,w)
  - Use interpolated (s,t) for texel lookup at each pixel
  - Use the retrieved colour value to modify a polygon's colour (or other surface properties)
  - Can be done manually or automatically

Definition: Texture Atlas

A large image containing a collection of sub-images, each of which is a texture for some part of an object

2 Types of texture mapping methods

Definition: Mapping

Identify the correspondence between a texel and a screen pixel

There are two types of mapping methods

Definition: Forward texture mapping

Compute 3D positions of the texture points and then project them onto the image plane

Definition: Inverse texture mapping

Select every pixel in the image plane and identify which point of the texture image is projected there

3 Coordinate systems in CG application

Definition: Parametric Coordinates

A logical coordinate system for processing the surface and the internal space of a 3D object

Definition: Texture coordinates

Used to identify points in the image to be mapped

Definition: Local or world coordinates

Used to position 3D objects

Definition: Window coordinates

Where the final output image is really produced

4 Types of texture mapping

4.1 Forward Texture Mapping

Mapping from texture coordinates to points on a surface, need three functions:

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

Main Problem - Adjacent texture points may project onto non adjacent image points, thus creating a non coloured image area

4.2 Backwards texture mapping

Given a point on an object, we identify to which point in the texture map it corresponds, need a map of the form

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

Good - Make sure every object has a corresponding texel, particularly visibility of an object point is considered.
Bad - Such functions are difficult to find in general

4.3 Two part mapping process

Map a texture image to a complicated shape to create texture mapping coordinates (UV map is difficult)

Break the texture mapping into two parts

- Map the texture to a simple intermediate surface
- The textured intermediate surface is then mapped to the object

4.4 Second mapping

Map from intermediate object

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

5 MIP Mapping

Use an image pyramid to precompute coarse versions of a texture, store the whole pyramid in a single block of memory. This helps with aliasing.

Advantages of MIP mapping

- Reduce memory consumption of running application
- Support anti aliasing, offering better output quality of a CG application
- Only 1/3 more space required

6 Normal Mapping

Normal vectors encoded as an image. Generate visually 3D effect by applying lighting to perturbed normal vectors on the object surface.

7 Bump mapping

- Treat the texture as a single valued height function
- Compute the normal from the partial derivatives in the texture
- The heights encode the amount by which to perturb N in the (u,v) directions of the parametric space describing the object surface

8 Normal Map vs Bump Map

Bump Map:

- Texture (greyscale) encodes height
- Modifies the geometric normal
- Harder to implement
- Easier to specify

Normal map:

- Texture (RGB) encodes normal directly
- Replaces the normal
- Easier to implement
- Harder to specify

9 Displacement Mapping

- Use texture map to actually move surface points
- Geometry must be displaced before visibility is determined
- Done as a preprocess or with complicated vertex/fragment shader implementation

10 Environment Maps

- We can simulate reflections by using the direction of the reflected ray to index a spherical texture map at ”infinity”
- Assumes that all reflected rays begin from the same point

11 Light mapping

- Realistic lighting can be achieved
- Every single bit of expensive lighting calculation is done pre-process time, avoiding overhead
- At run times, all calculations are done by hardware and so is very fast
- Visual quality of the lighting is directly dependent on the size of the light map texture(s)
- For every triangle, a diffuse texture map is applied first and then a light map is usually modulated with it

12 Fog maps

- Dynamic modification of light maps
- Put fog objects into the scene
- Compute where they intersect with geometry and paint the fog density into a dynamic light map
- Apply the fog map as with a light map