Texture Mapping

CSCI 4229/5229
Computer Graphics
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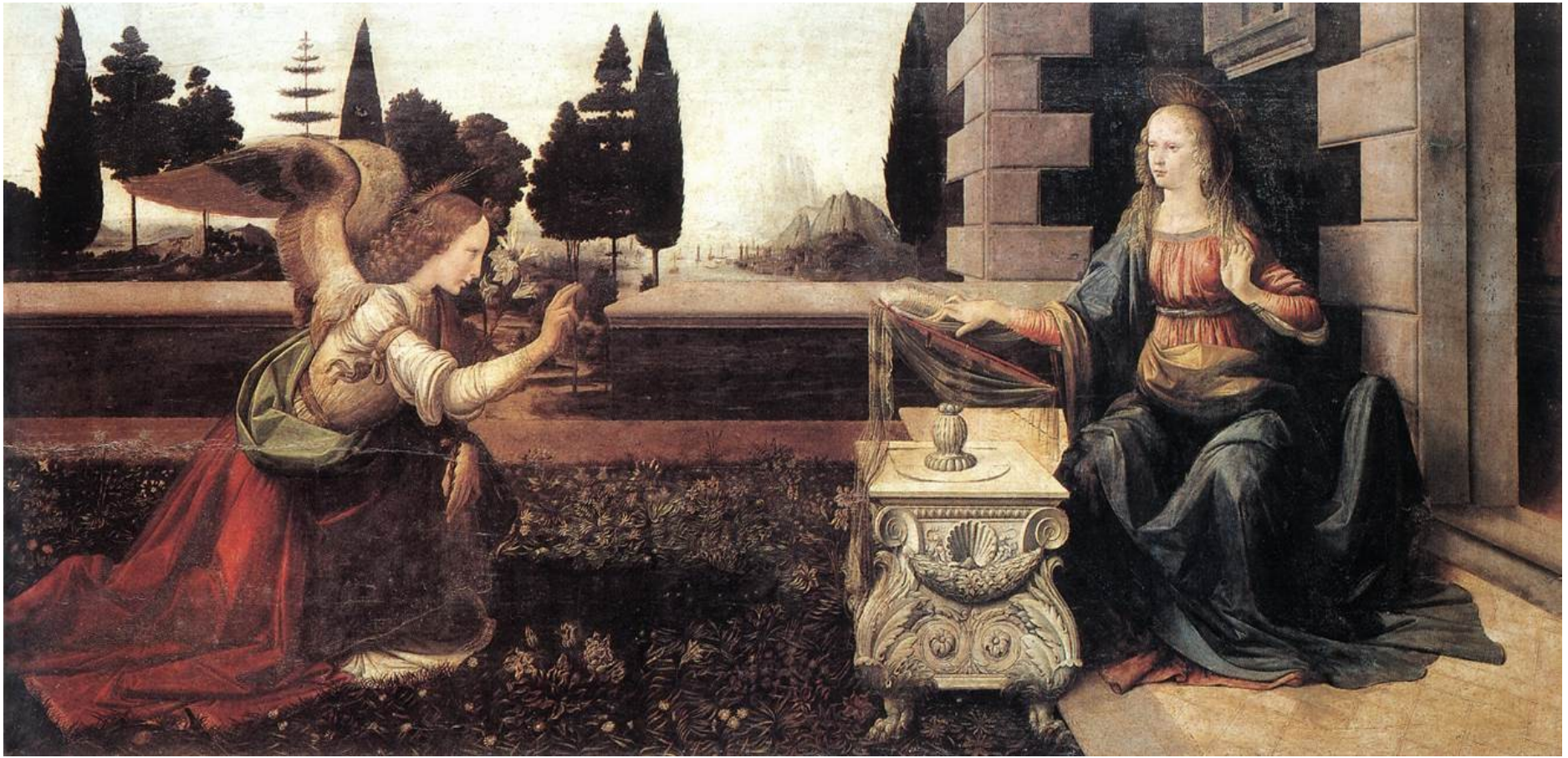
What are texture maps?

- Bitmap images used to assign fine texture to displayed surfaces
- Used to make surfaces appear more realistic
- Must move with the surfaces
- Can be stretched or repeated
- Simple in concept, but hardware intensive

Annunciation
Leonardo da Vinci (1472)



OpenGL Texture Types

- Images are draped over polygon surfaces
- 1D, 2D and 3D textures
  - (s,t,r,q) coordinates
  - 2D uses (s,t), q is the homogeneous w
- 1D, 2D and 3D textures set separately
- 2D textures most commonly used

OpenGL Texture Calls

- glGenTextures
  - Returns unused texture name(s)
- glBindTexture
  - Sets the active (current) texture
- glTexImage*
  - Copies image to texture memory
- glTexCoord*
  - Sets texture coordinates for vertex
- glTexEnv*, glTexParameter*
  - Control application of textures

Creating a Texture

- glGenTextures(1,&texname);
  - Returns unique texture name
- glBindTexture(GL_TEXTURE_2D,texname);
  - First use – allocates memory and makes current
- glTexImage2D(GL_TEXTURE_2D,0,3,dx,dy,
  0,GL_RGB,GL_UNSIGNED_BYTE,image);
  - Copies RGB *image* to texture memory (size *dx,dy*)
  - Image size must be power of two before OpenGL 2

Setting the Texture Properties

glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MAG_FILTER,GL_LINEAR);

- How to magnify texture

glTexParameteri(GL_TEXTURE_2D, GL_TEXTURE_MIN_FILTER,GL_LINEAR);

- How to minify texture

glTexEnvi(GL_TEXTURE_2D, GL_TEXTURE_ENV_MODE,GL_MODULATE);

- How textures interact with underlying surface

Applying a Texture Map

```
glBindTexture(GL_TEXTURE_2D,texname);
glBegin(GL_POLYGON);
for (i=0;i<n;i++)
{
   glTexCoord2d(s[i],t[i]);
   glVertex3d(x[i],y[i],z[i]);
}
glEnd();
```

Automatic Texture Coordinates

- glTexGen*()
  - Can generate textures automatically for polygons
- glutSolidTeapot()
  - Textures coordinates generated
- gluQuadric objects
  - gluQuadricTexture(obj,bool) controls automatic texture coordinate generation

Creating a Texture

- glGenTextures(n,texname[]);
  - Returns *n* unique texture names
- glBindTexture(GL_TEXTURE_2D,texname);
  - First use – allocates memory and makes current
  - Subsequent uses just makes it current
  - All operations applies to current texture
    - Current texture is applied to surfaces
    - Current texture is modified by glTexImage, etc

glTexImage2D(GL_TEXTURE_2D,0,3,dx,dy, 0,GL_RGB,GL_UNSIGNED_BYTE,image);

- GL_TEXTURE_2D or GL_PROXY_TEXTURE_2D
- Level 0 (or higher for MIPmaps)
- Internal representation 3 (or one of many others)
- Size *dx* x *dy* [must be 2^n before OpenGL 2.0]
- Border 0 (none) or 1 (pixel width)
- Source image is RGB (or one of many others)
- Source data is unsigned char (or short, etc)
- Image data pointer (can be freed after call)

glTexParameter*(GL_TEXTURE_2D,par,val);

- GL_TEXTURE_MAG_FILTER (magnification)
  - GL_LINEAR (interpolate)
  - GL_NEAREST
- GL_TEXTURE_MIN_FILTER (minification)
  - GL_LINEAR (interpolate)
  - GL_NEAREST
  - GL_NEAREST_MIPMAP_NEAREST
  - GL_NEAREST_MIPMAP_LINEAR
  - GL_LINEAR_MIPMAP_NEAREST
  - GL_LINEAR_MIPMAP_LINEAR

glTexParameter*(GL_TEXTURE_2D,par,val);

- GL_TEXTURE_WRAP_S (horizontal)
- GL_TEXTURE_WRAP_T (vertical)
- GL_TEXTURE_WRAP_R (depth)
  - GL_REPEAT (ignore integer part of *s*,*t*)
  - GL_MIRRORED_REPEAT (odds backward)
  - GL_CLAMP - limit to (0,1)
  - GL_CLAMP_TO_EDGE – limit to ½ pixel in
  - GL_CLAMP_TO_BORDER – limit to ½ pixel out

glTexParameter*(GL_TEXTURE_2D,par,val);

- GL_TEXTURE_BORDER_COLOR
  - Set border RGBA (4 component float vector)
- GL_TEXTURE_PRIORITY (0-1)
- *and many more ...*

glTexEnvi(GL_TEXTURE_2D,val,par)

- GL_TEXTURE_ENV_MODE
  - GL_MODULATE (multiply)
  - GL_REPLACE
  - GL_DECAL (transparent combine)
  - GL_BLEND
  - GL_COMBINE
  - GL_ADD (arithmetic)
- *and many more ...*

Multiple Textures

- glActivateTexture(GL_TEXTURE*n*);
  - Call BEFORE glBindTexture() etc
- Specify multiple texture coordinates per vertex
  - glMultiTexCoord2f(GL_TEXTURE0,r0,s0);
  - glMultiTexCoord2f(GL_TEXTURE1,r1,s1);
  - glMultiTexCoord2f(GL_TEXTURE2,r2,s2);
  - glVertex3d(x,y,z);

MIPmaps

- *multum in parvo* (much in little)
- Textures adapted to great distances
  - Level 0=64x64, Level 1=32x32, ... ,
    Level 6=1x1
- Can be generated manually or automatically
  - gluBuild2DMipmaps()
  - gluBuild2DMipmapLevels()