Computer Graphics: Multiple Texturing

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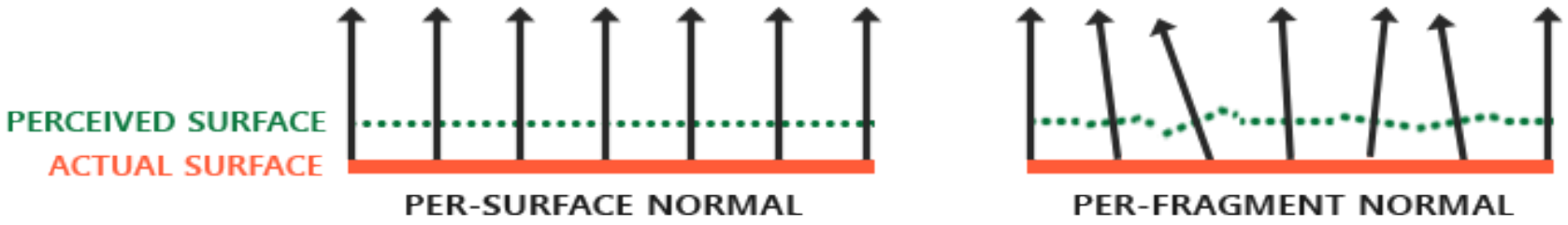
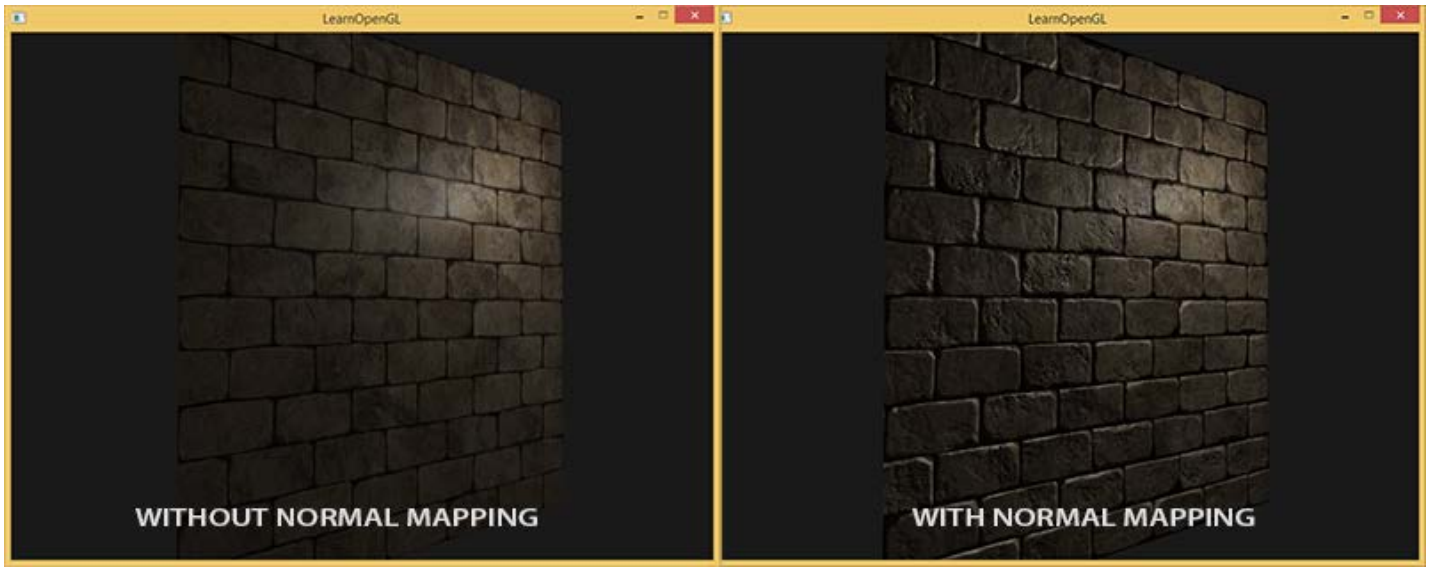
Overview

- Normal Mapping
- Environmental Mapping
- Tutorials

Normal Mapping

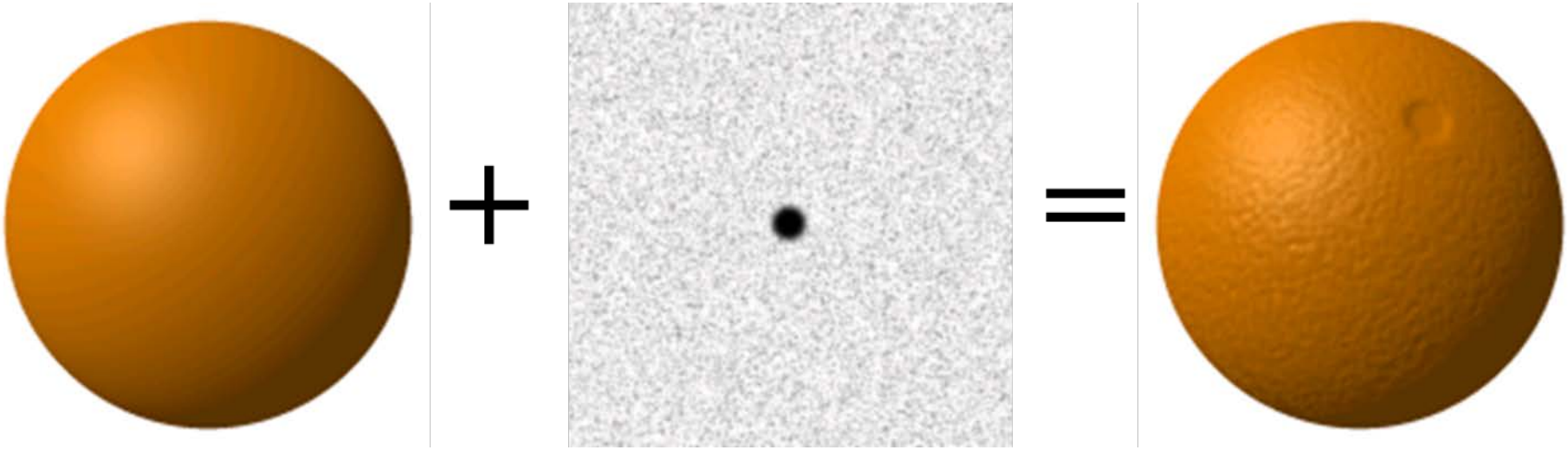
- Normal (Bump) mapping
  - Technique to add details (bumps and dents) to polygon surfaces by using the RGB images where the RGB components correspond to the XYZ coordinates of normal vectors





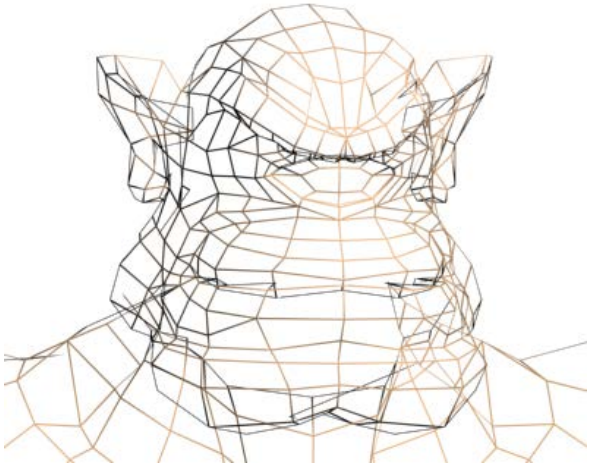
Normal Mapping

- Effects of normal mapping

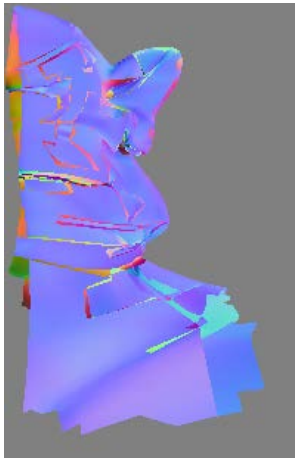


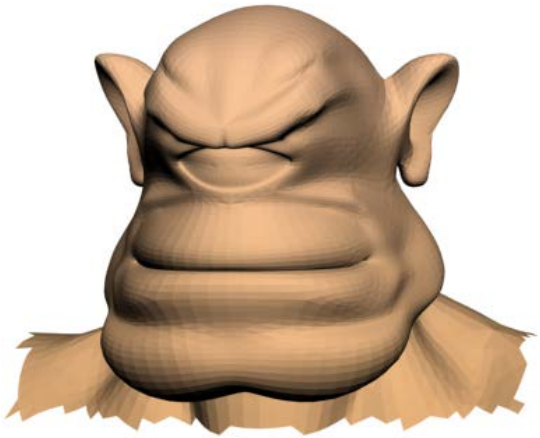
Normal Mapping

- Effects of normal mapping
  - Low-polygon model



  - Normal mapped model





Normal Mapping

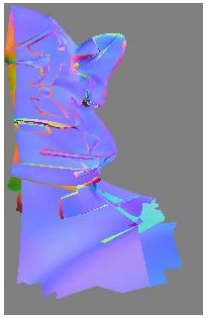
- Normal map → RGB conversion
  - Unit vector $\boldsymbol{v} = (x, y, z)$가 있을 때, 이를 RGB 값으로 변환 가능
    - $\boldsymbol{v}$ 는 normal vector이므로 값은 각각 [-1.0, +1.0] 사이의 값이 됨
  - 변환하려는 결과 값의 범위는 8-bit이므로 [0, 255] 사이의 값이 됨
    - e.g. [-1.0, +1.0] → [0, 255] 변환

      $R = (DWORD)(127.0 \times x + 128.0)$

      $G = (DWORD)(127.0 \times y + 128.0)$

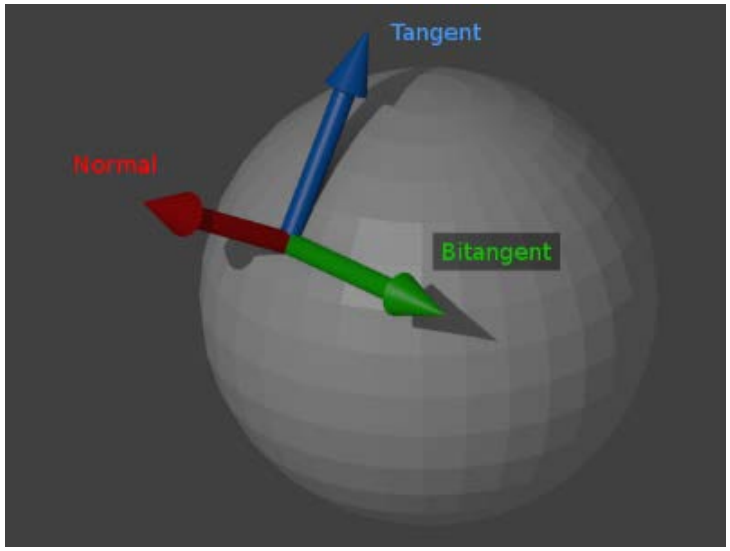
      $B = (DWORD)(127.0 \times z + 128.0)$

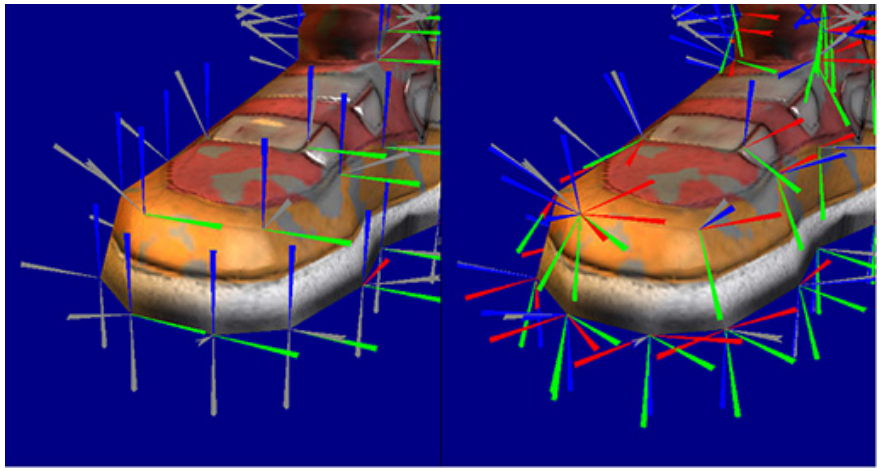
      Color = ((R<<16) | (G<<8) | B) // DWORD ARGB로 변환
    - 이렇게 얻어진 Color 값에는 normal의 정보가 RGB 값으로 변환
  - 일반적으로 normal의 z 값(튀어나온 부분)이 blue 색상으로 변환되기 때문에 RGB 값의 이미지 형태로 저장하면 전체적으로 blue 색상으로 표시됨



Normal Mapping

- Coordinate system of normal map
  - Object space
    - RGB components → XYZ coordinates
    - Cannot be applied to multiple models as the orientation of the surfaces differ among the models unlike color texture maps
  - Tangent space
    - A vector space which is tangent to the surface
    - The coordinate system varies smoothly (based on the derivatives of position with respect to texture coordinates) across the surface

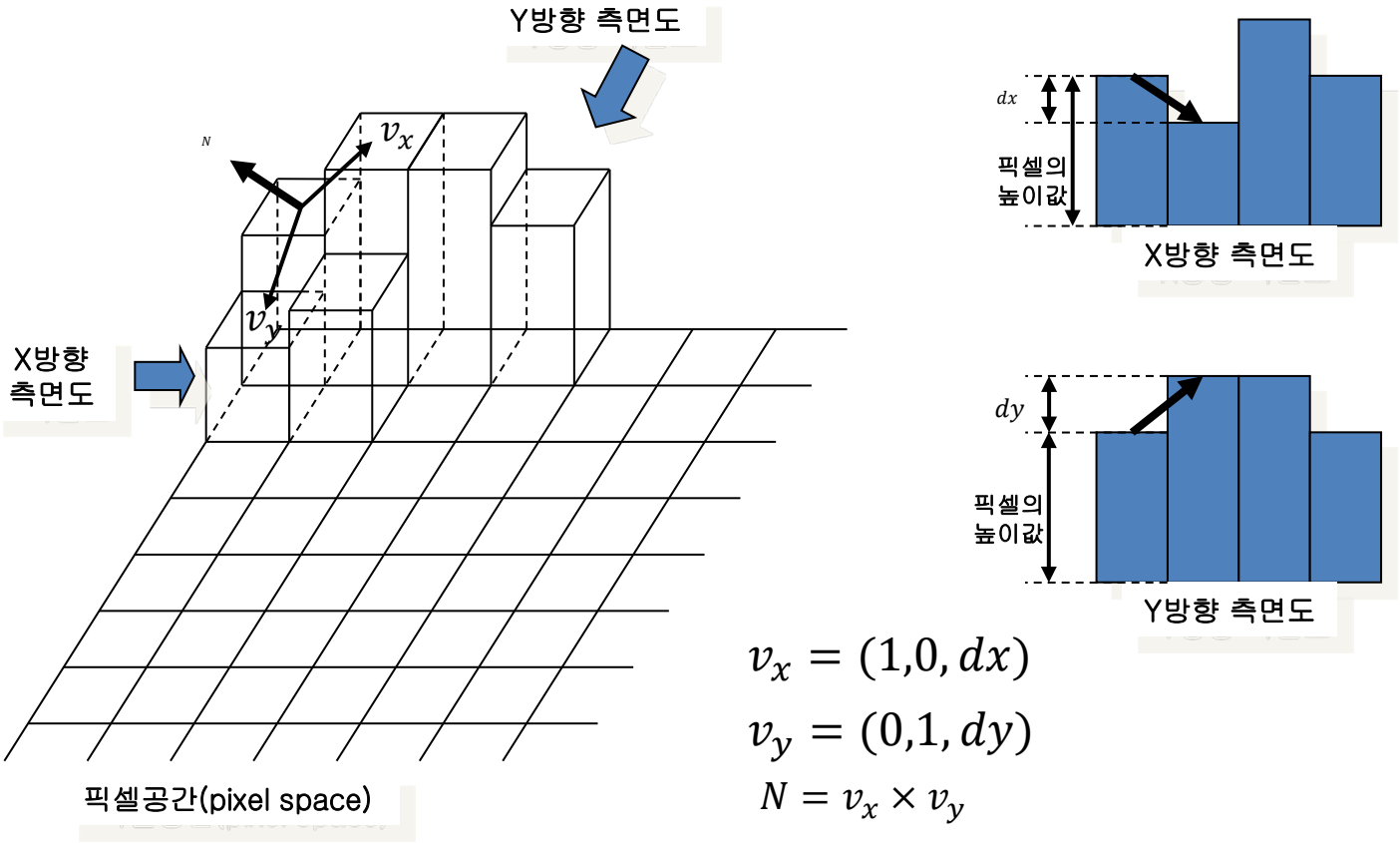




Object vs Tangent

Normal Mapping

- Normal map generation
  - Using height map of texture
    - Texture의 height map에서 texel간의 고저차를 비교하여 미분 vector를 생성
    - 이렇게 만들어진 미분 vector들을 RGB로 변환하여 texel에 저장



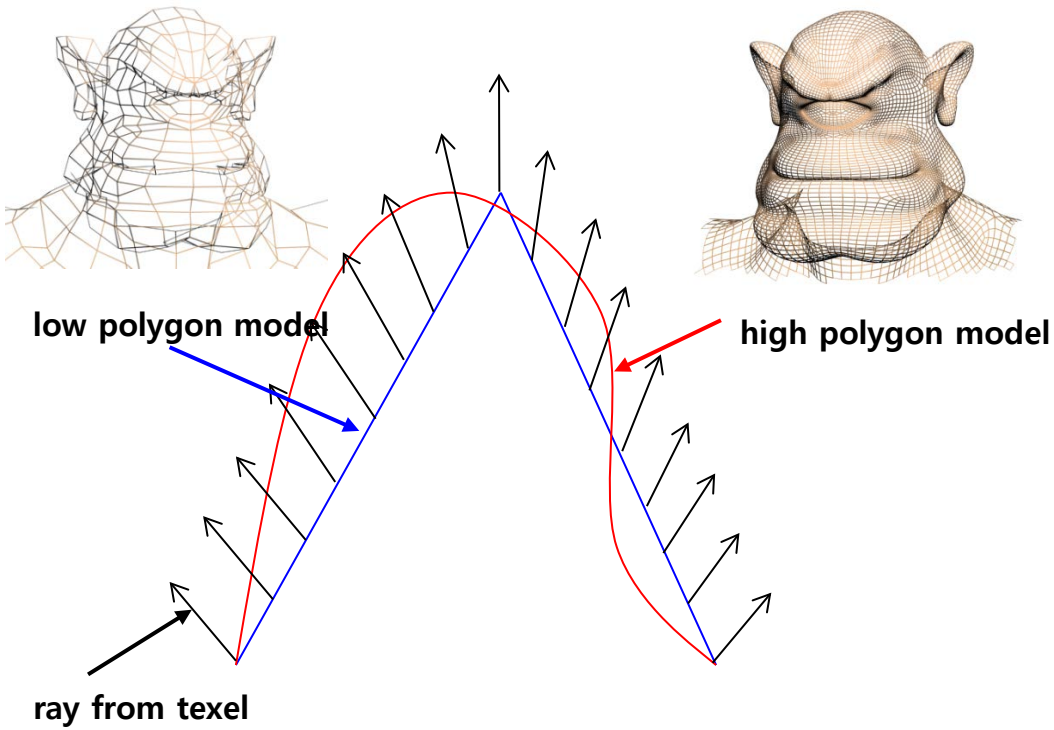
$$v_x = (1,0,dx)$$

$$v_y = (0,1,dy)$$

$$N = v_x \times v_y$$

Normal Mapping

- Normal map generation
  - Comparison between low and high polygonal models: object를 low polygon과 high polygon으로 두 개를 만든 뒤 두 model의 차이를 비교해서 normal map을 생성

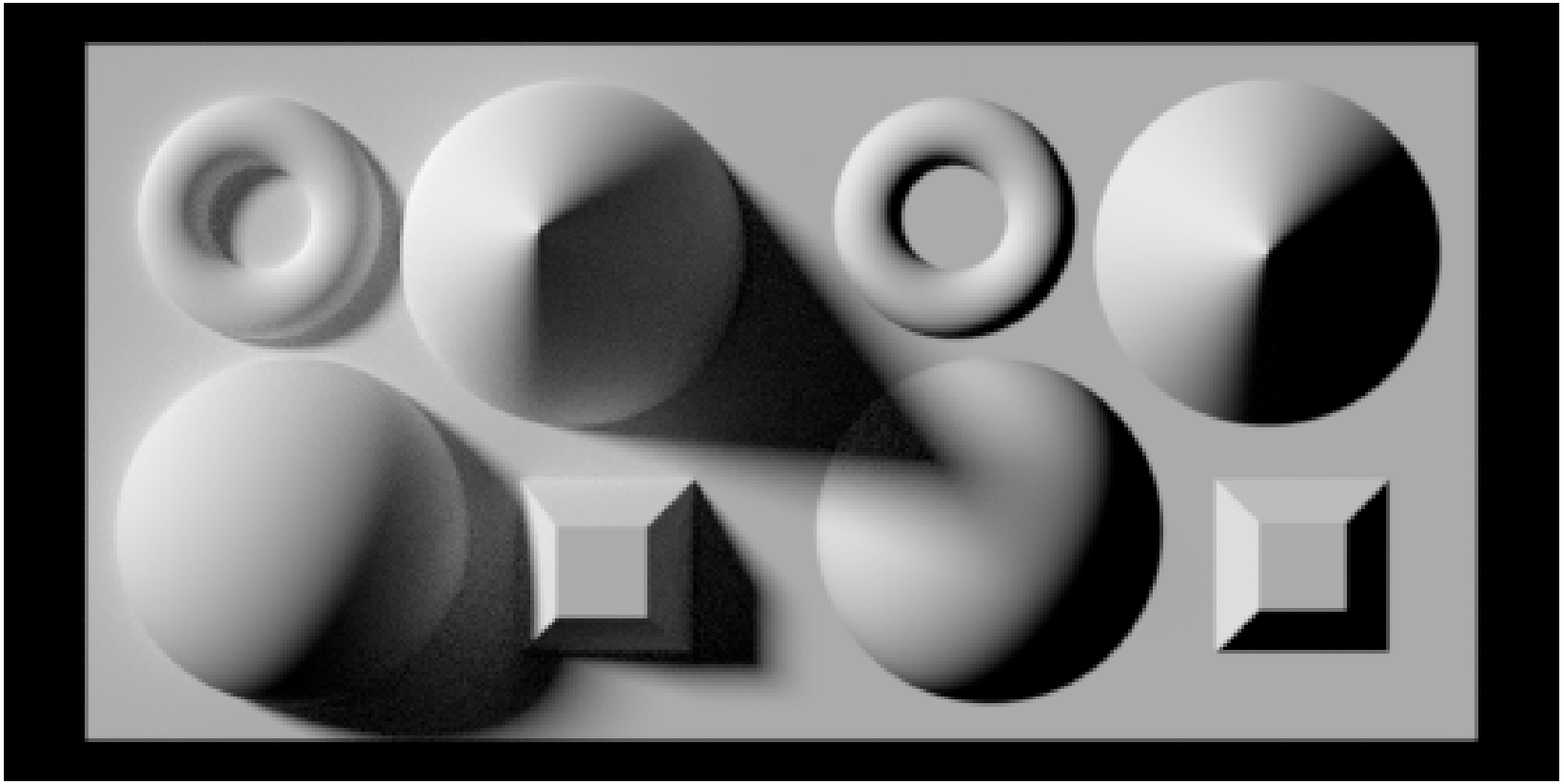


Normal Mapping

- Example of normal mapping

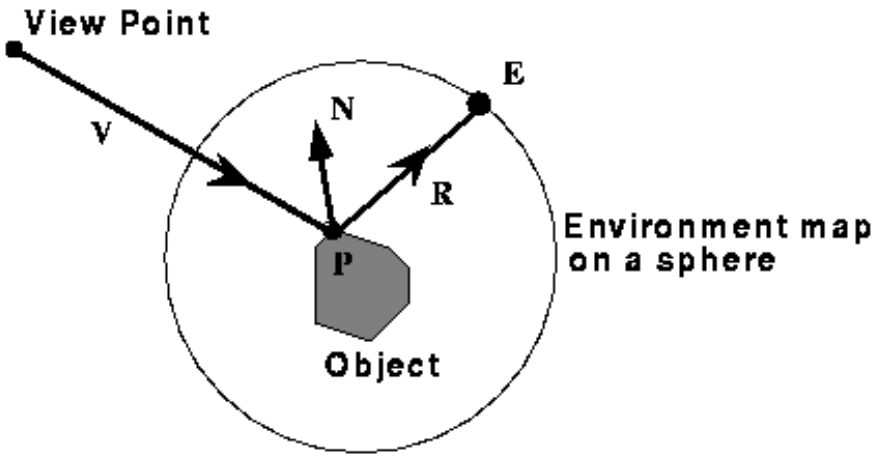
Normal Mapping

- Examples
  - Rendering using the normal mapping technique. On the left, several solid meshes. On the right, a plane surface with the normal map computed from the meshes on the left.



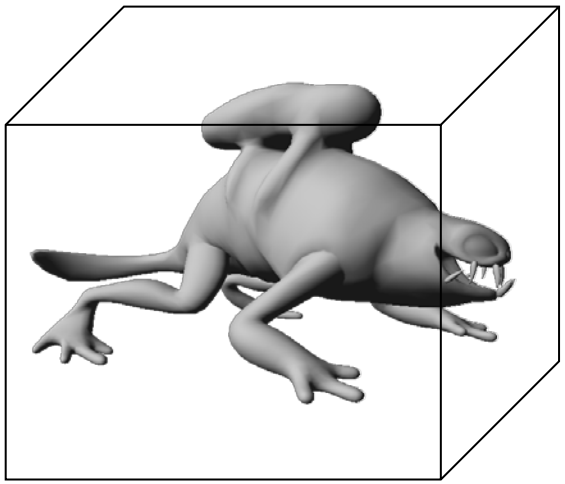
Cube Mapping

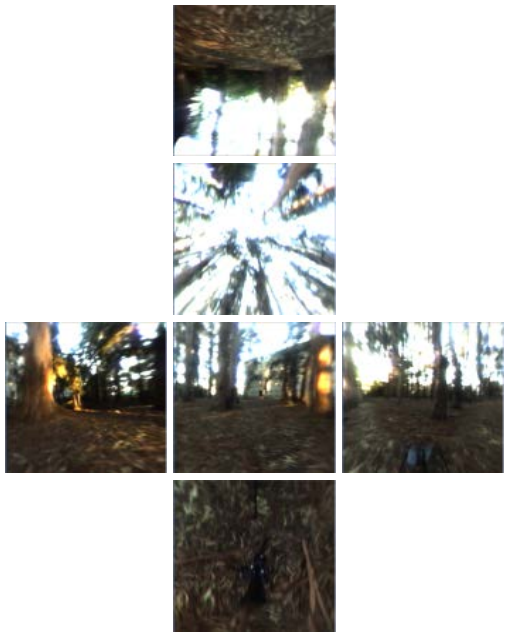
- Environment mapping
  - An efficient technique for simulating the appearance of a reflective surface by using the reflection vector to index a (cubic or spherical) texture map at infinity
  - Assumes that all reflected rays begin from the same point
    - Cubic mapping
    - Spherical mapping
    - Parabolic mapping

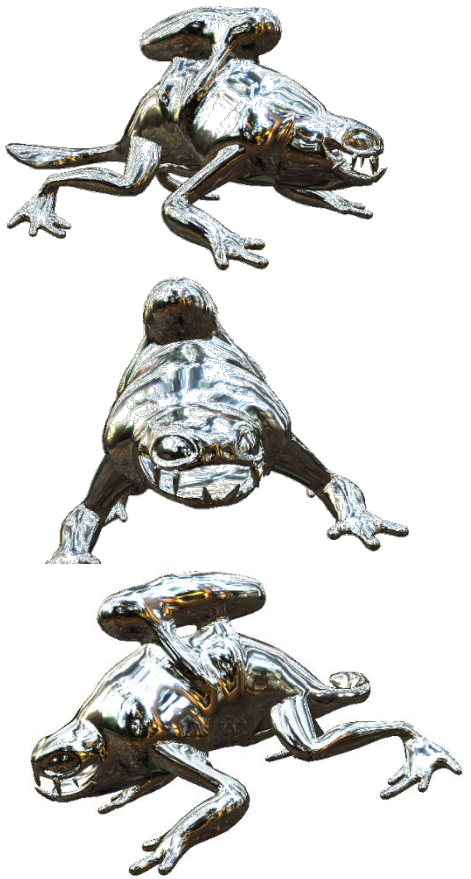


Cube Mapping

- Cube Mapping
  - The map resides on the surfaces of a cube around the object
    - Typically, align the faces of the cube with the coordinate axes
  - Use six textures to model faces of a cube
  - Assume cube faces infinitely far away

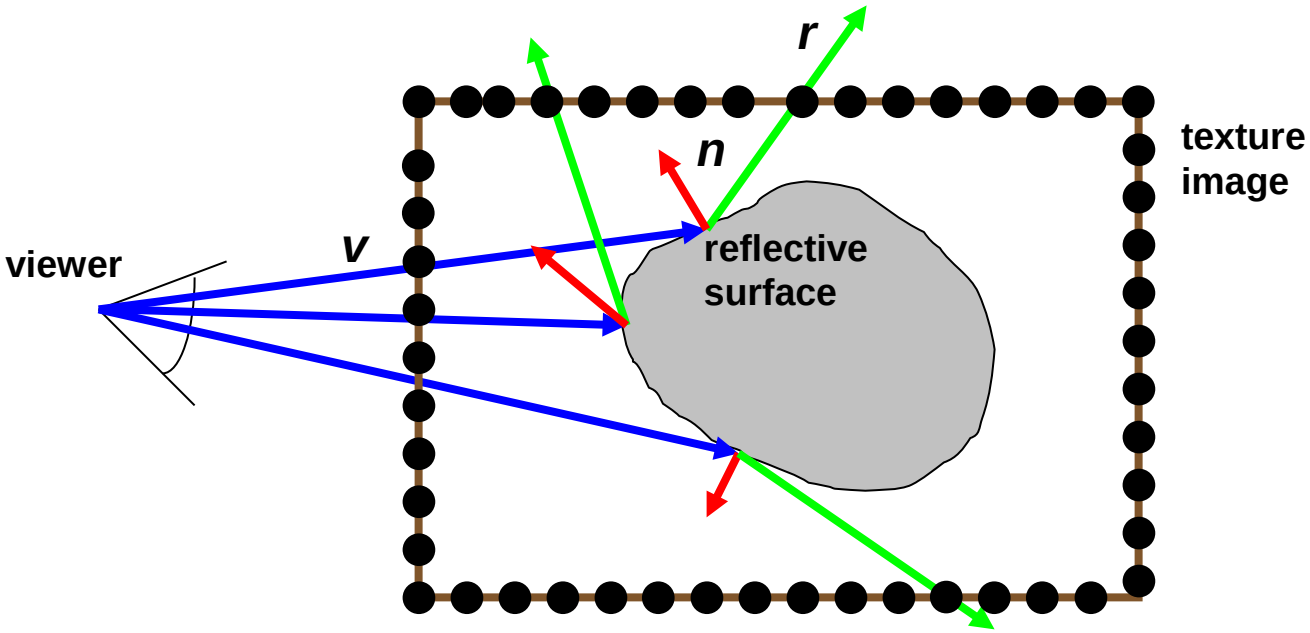






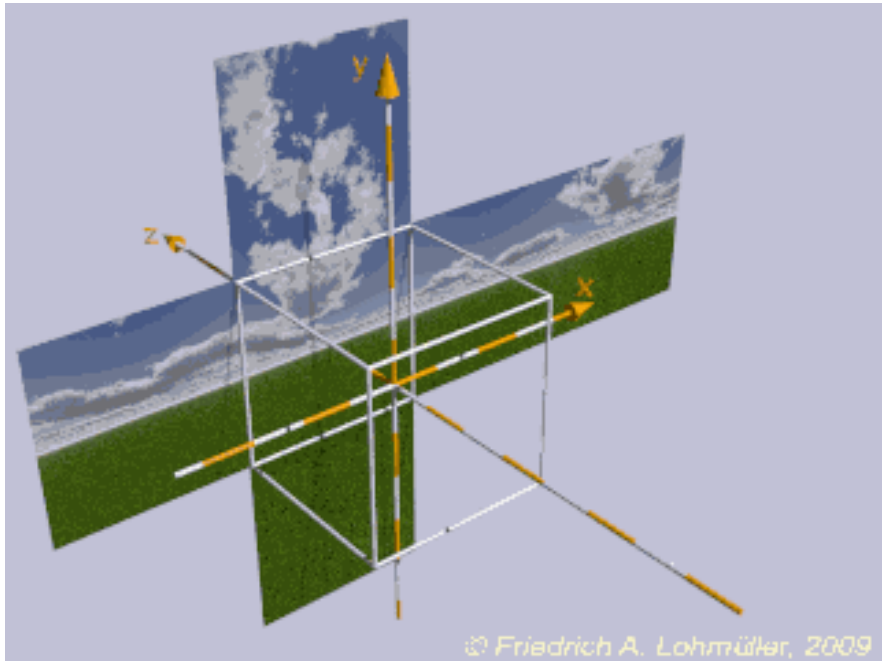
Cube Mapping

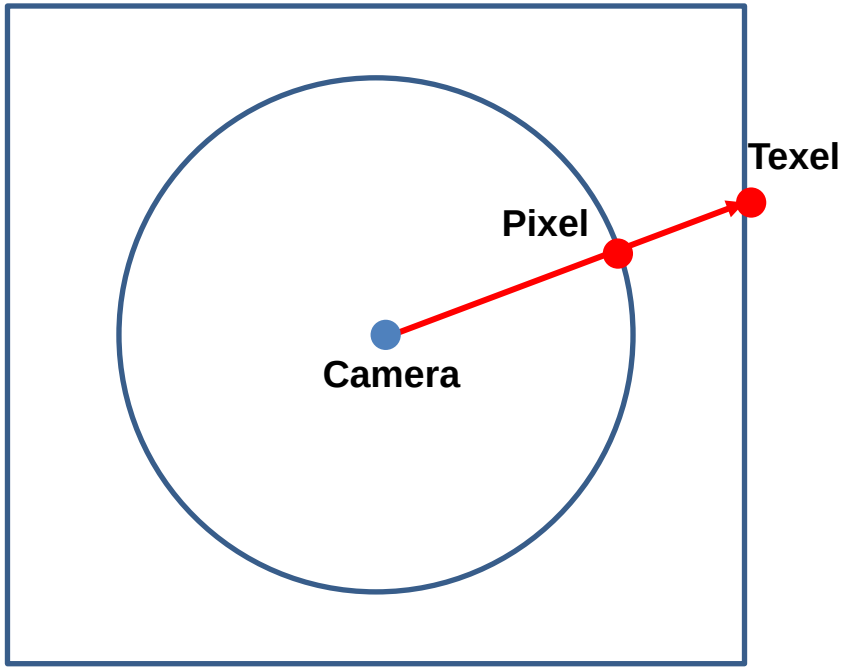
- Cube Mapping
  - Texture is transferred in the direction of the reflected ray ***r*** from the cube map onto the object
    - Reflected ray: $\boldsymbol{r} = 2(\boldsymbol{n}\cdot\boldsymbol{v})\boldsymbol{n} - \boldsymbol{v}$
  - Cube map
    - Store colors of every possible direction in texture maps
    - Look up texture maps based on reflected vector



Cube Mapping

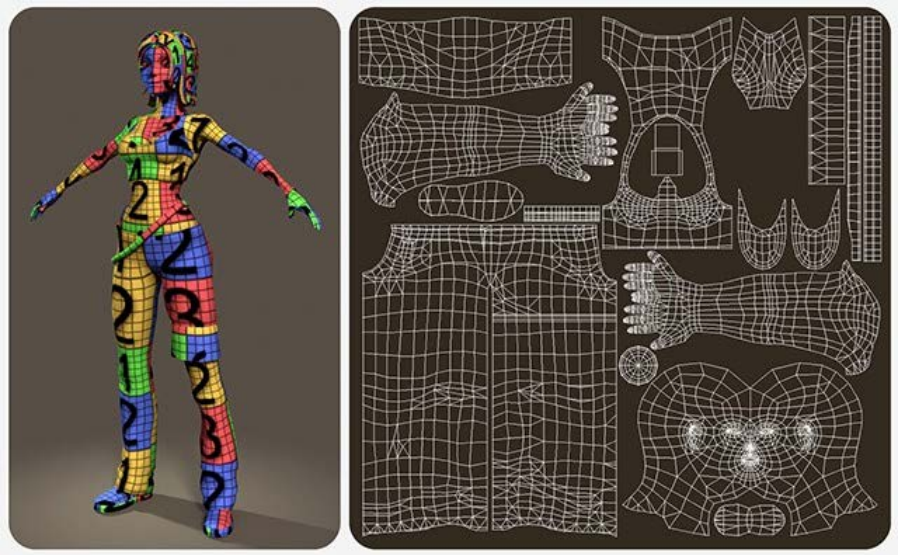
- Skybox(cube map) creation
  - Use a cube map to texture a sphere that surrounds the camera
    - Always center the sky box around the camera → never get closer to the skybox
    - Always back of the depth buffer (e.g. set *z* value to 1)→ everything drawn onto the screen in front of the skybox





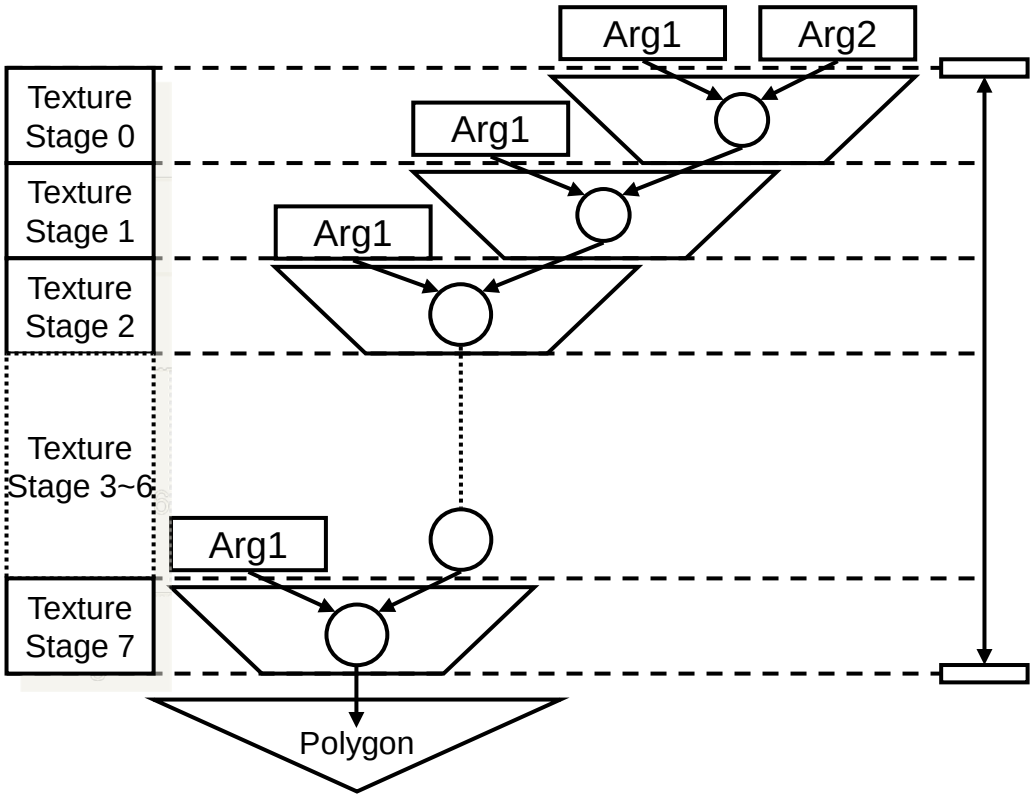
Tutorials

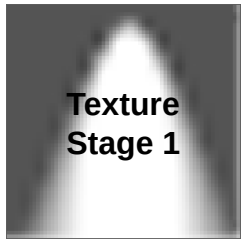
- Diffuse Mapping
- Light Mapping
- Alpha Mapping
- Specular Mapping
- Bump Mapping
- Cube Mapping (Skybox)

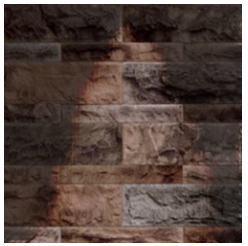


Multiple Textures

- Direct3D multitextures
  - Process of blending two different textures to crate a final texture
  - Texture arrays: contains multiple textures in the GPU memory
  - Blending equation: how to blend two textures in a pixel shader

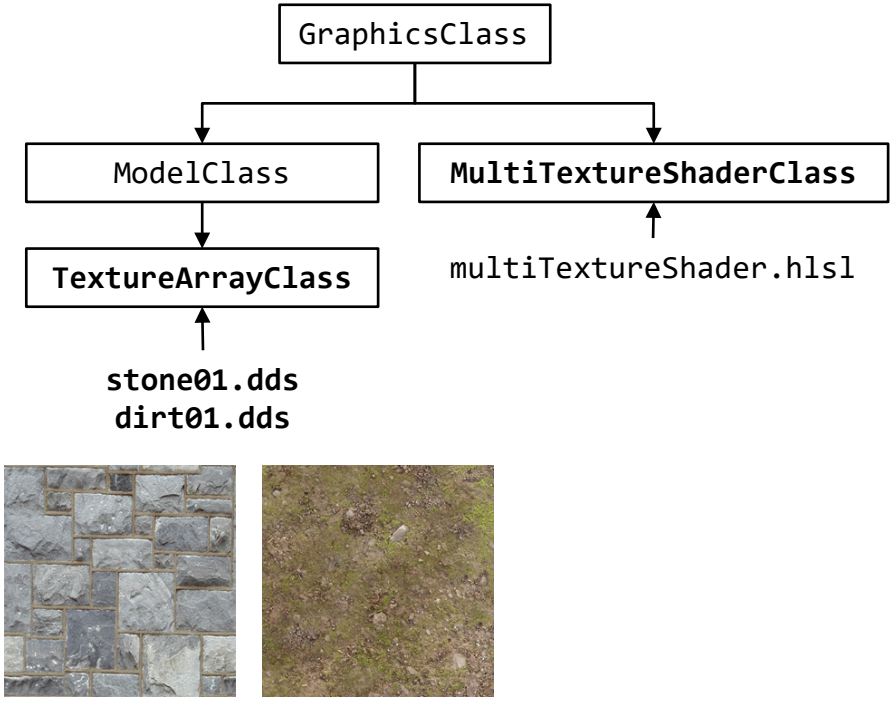






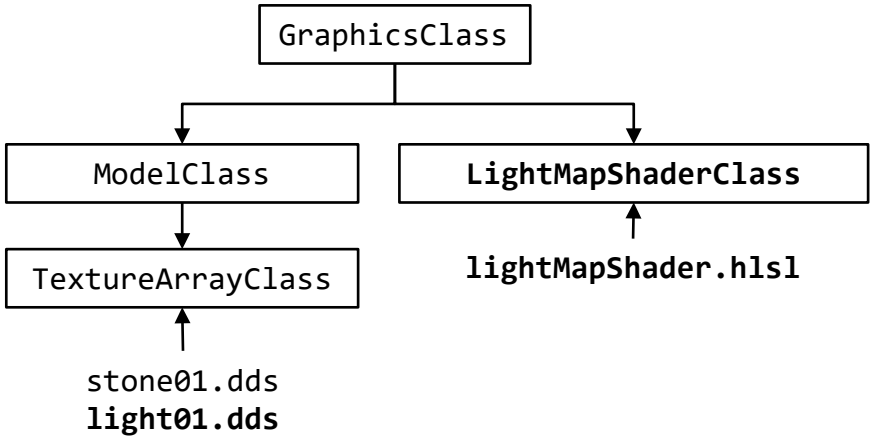
6-1 Diffuse Mapping

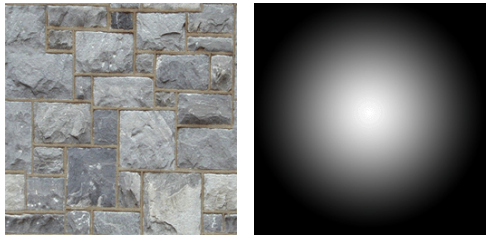
- Blending two diffuse(color) textures
  - MultiTextureShaderClass: handles multiple diffuse(color) textures
  - Shader: using two texture arrays for blending each pixel



6-2 Light Mapping

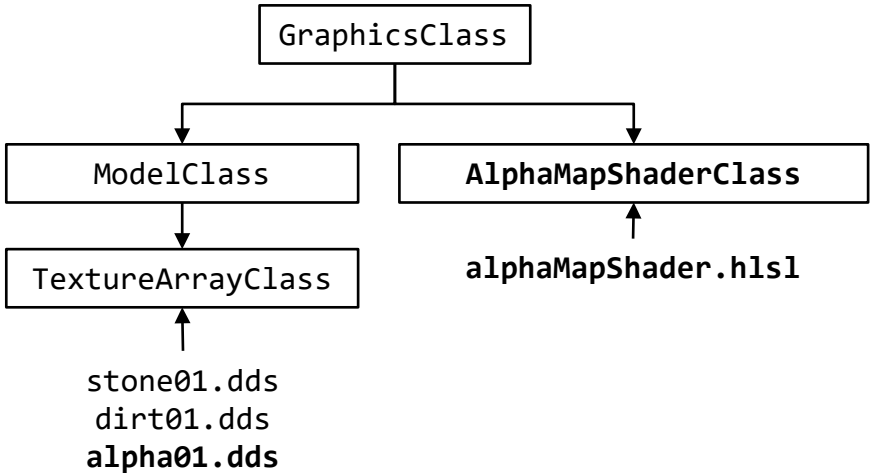
- Blending a diffuse(color) texture and a light map
  - LightMapShaderClass: handles multiple textures
  - Shader: using two texture arrays for blending each pixel based on an intensity value (0~1.0)





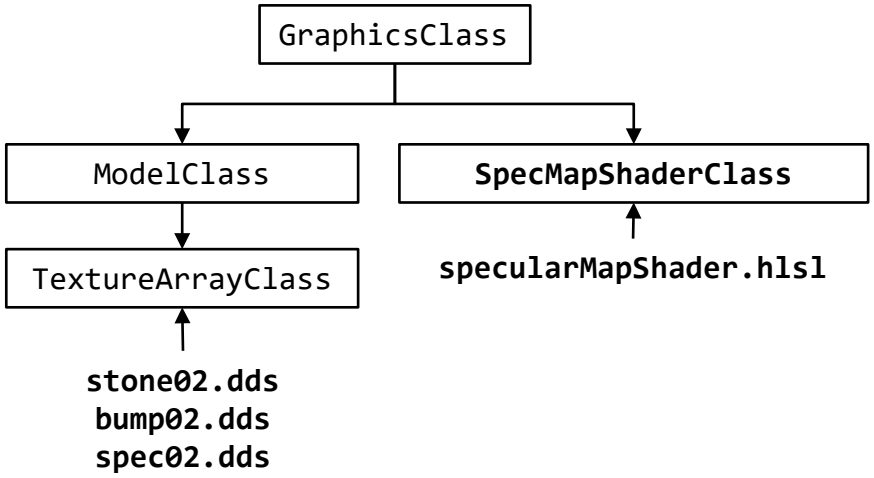
6-3 Alpha Mapping

- Blending two diffuse(color) textures using an alpha map
  - AlphaMapShaderClass: handles multiple textures
  - Shader: using three texture arrays for blending each pixel based on an alpha value (0~1.0)



6-4 Specular Mapping

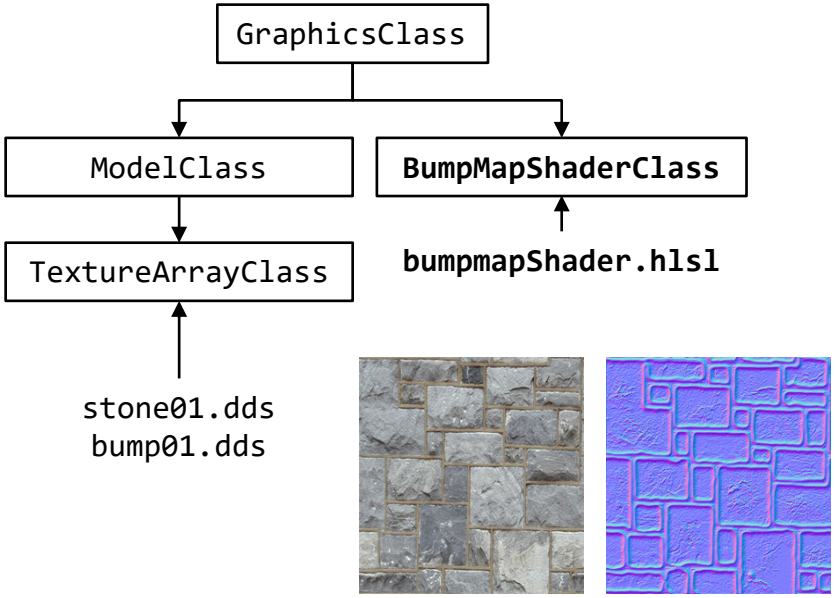
- Blending a diffuse(color) and a normal texture
  - LightMapShaderClass: handles multiple textures
  - Shader: using three texture arrays for blending each pixel based on an intensity value (0~1.0)



6-5 Bump Mapping

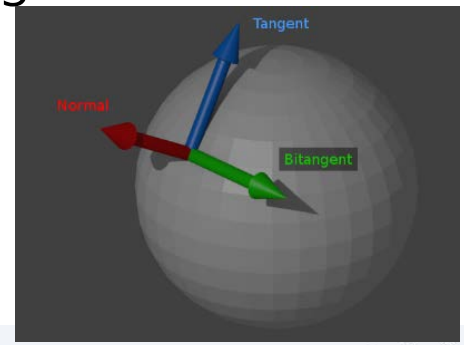
- Adding a normal texture to diffuse(color) texture (*RasterTek)
  - BumpMapShaderClass: handles a normal(bump) texture
  - Shader: calculating the bump normal
    - Normal equation:

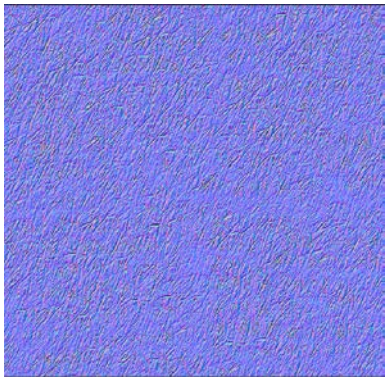
bumpNormal = (bumpMap.x * input.tangent) + (bumpMap.y * input.binormal) + (bumpMap.z * input.normal);



6-5 Bump Mapping

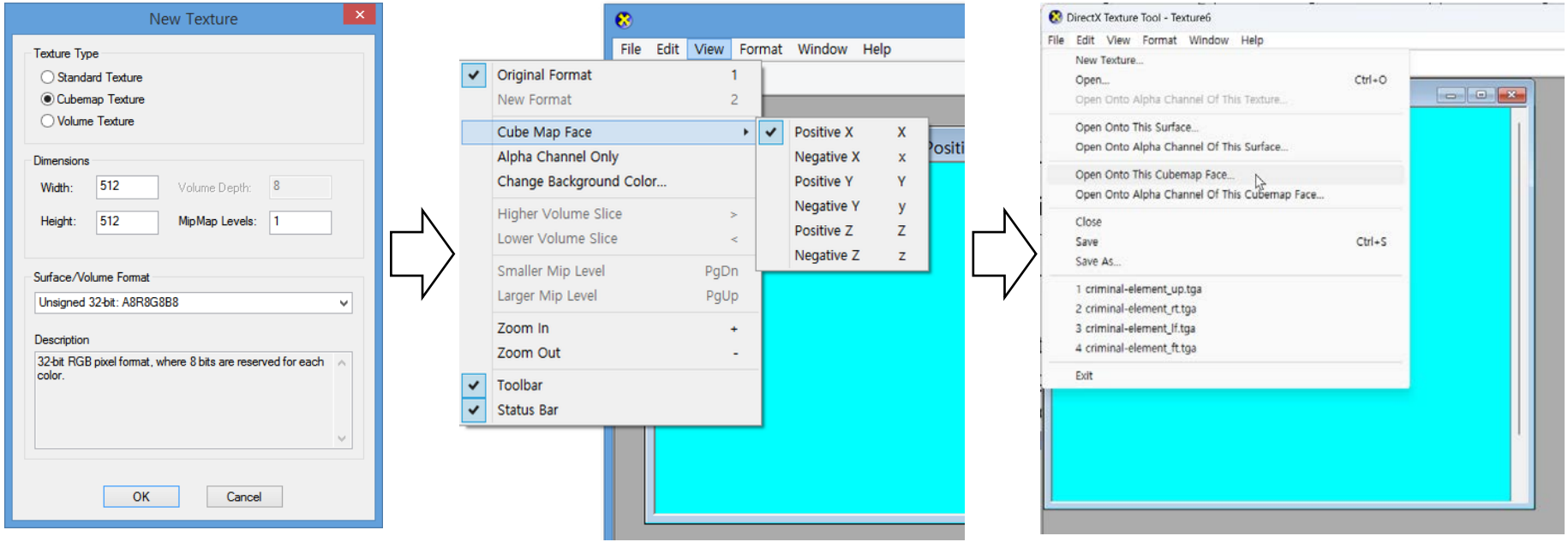
- Adding a normal texture to ground texture (*Braynzar Soft)
  - Using a texture space with Normal, Bitangent, Tangent vectors
    - Normal: the direction of the face
    - Tangent: the V texture coordinates of the face
    - Bitangent: the U texture coordinates of the face





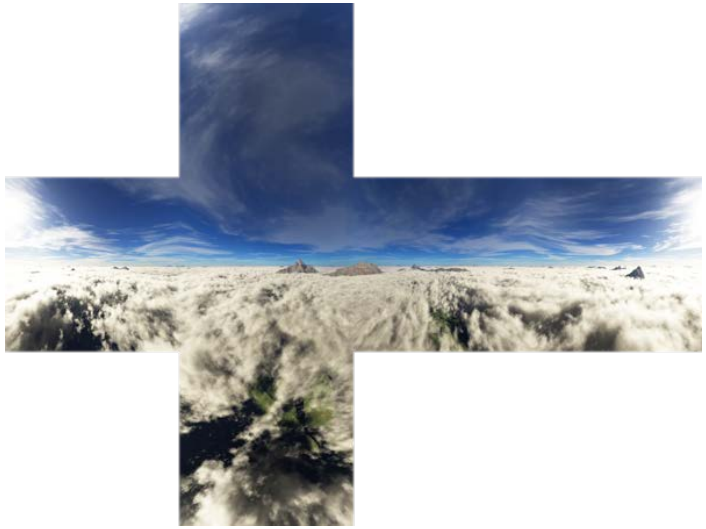
6-6 Cube Mapping (Skybox)

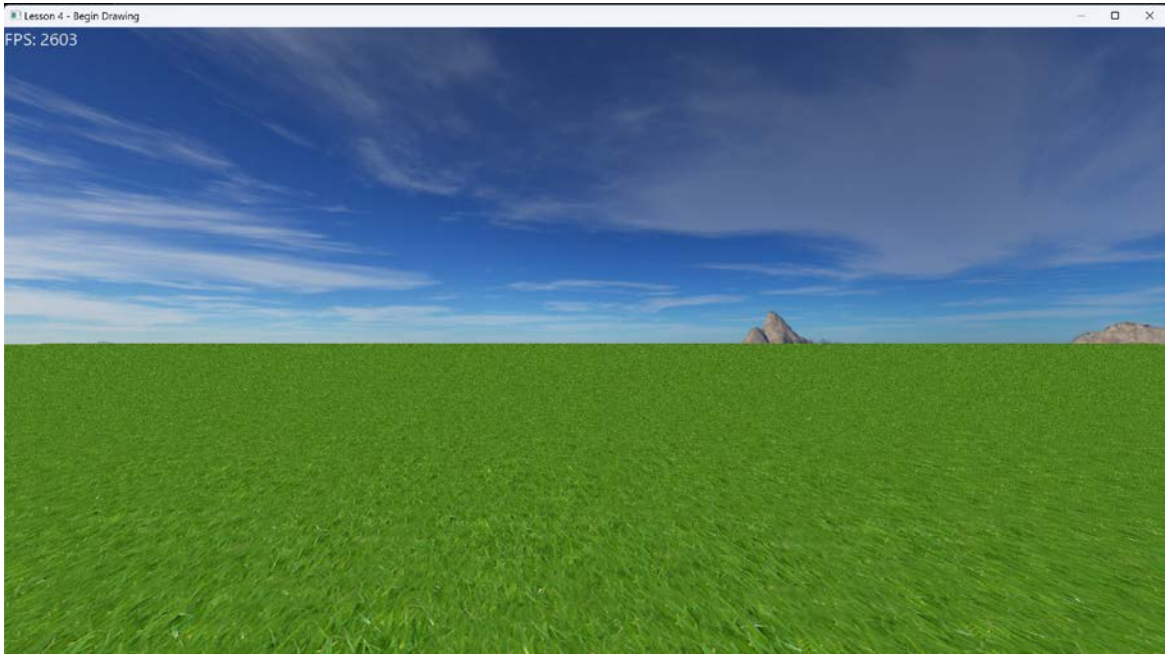
- DirectX texture tool: DxTex.exe (Directx SDK Jun 2010 ver.)
  1. File → New Texture: Set Width & Height, Unsigned 32-bit: A8R8G8B
  2. View → Cube Map Face: Change a face of the cube map
  3. File → Open Onto This Cubemap Face
  - Other image editors: Terragen, E-on Vue, VistaPro, PIcogen, etc.
  - Be careful on DirectX coordinate system



6-6 Cube Mapping (Skybox)

- Skybox sample (*BraynzarSoft)
  - Use six images with same dimensions (e.g. CubeMap-Textures.zip)
  - Use a texture tool for skybox(cubemap) creation (e.g. DxTex)





References

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- Introduction to DirectX 11
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- Raster Tek
  - www.ratertek.com
- Braynzar Soft
  - www.braynzarsoft.net)
- CS 445: Introduction to Computer Graphics *[Aaron Bloomield]*
  - www.cs.virginia.edu/~asb/teaching/cs445-fall06

Q & A