DirectX Programming #3

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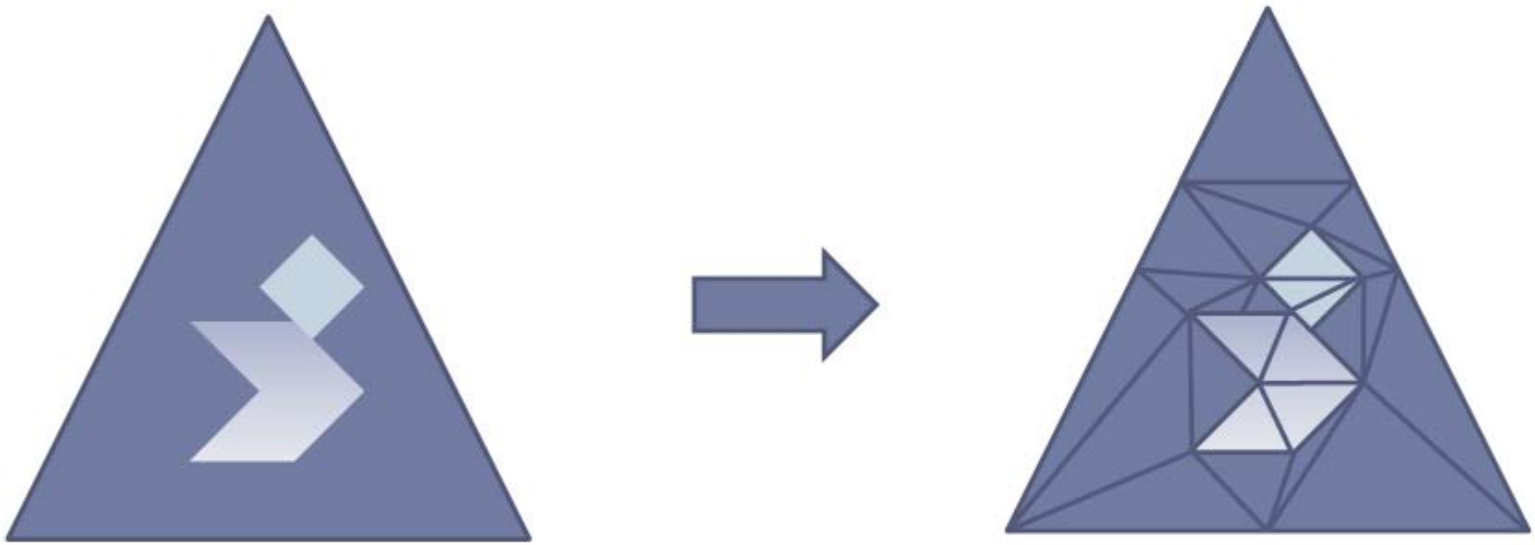
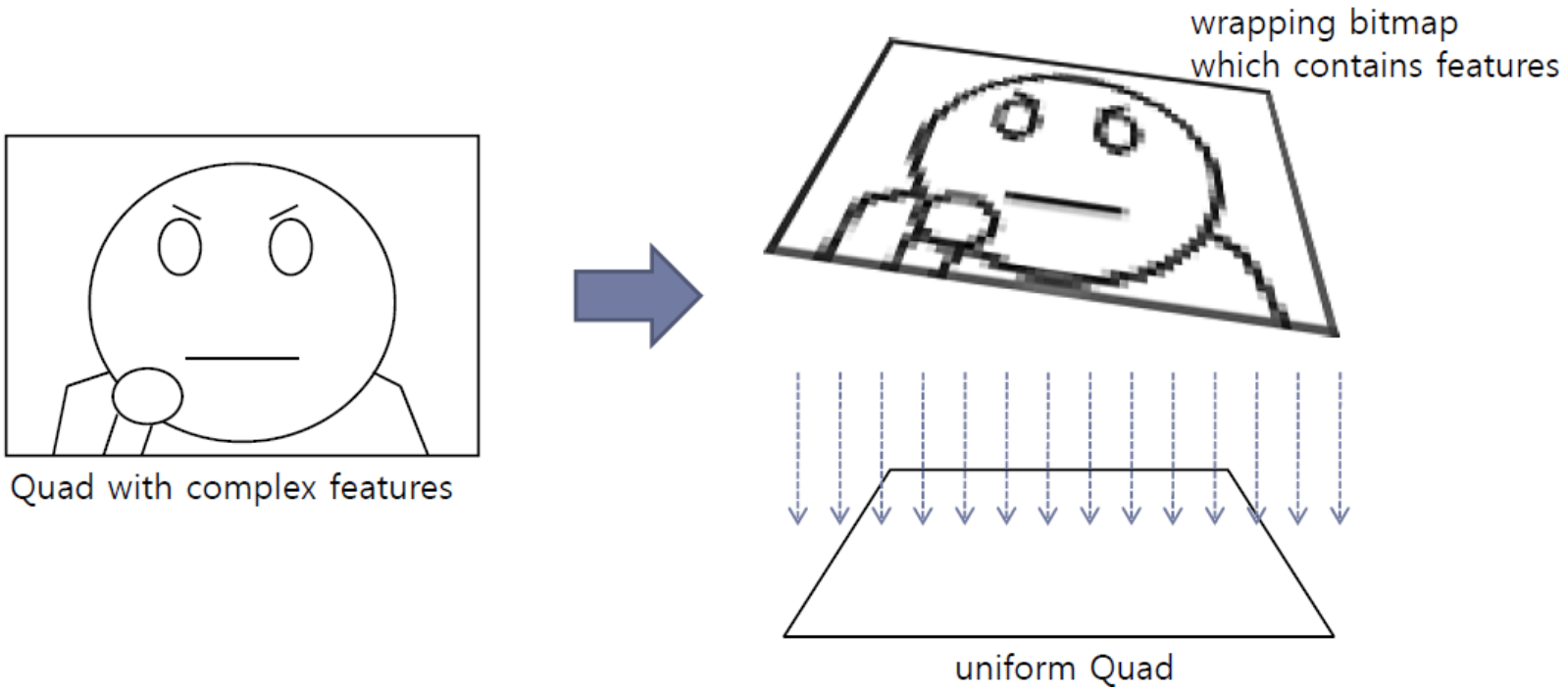
Texture

- In real world, only few surfaces have uniform color
  - How to describe non-uniform surface
- Tesselation
  - Divide a surface into numerous sub-surfaces
  - Too complicated!



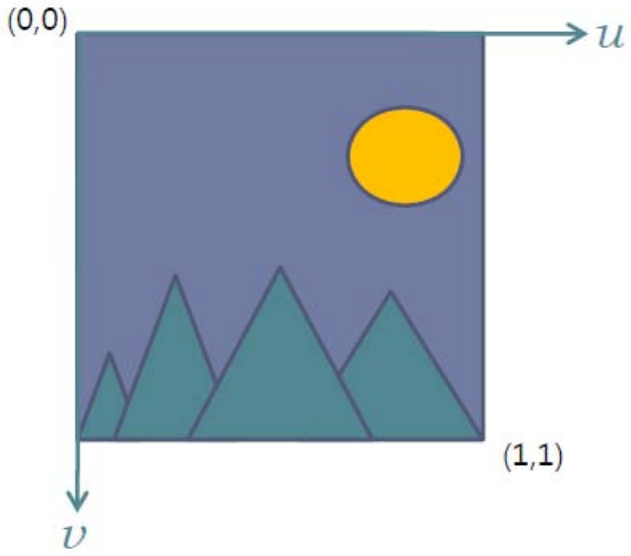
Texture

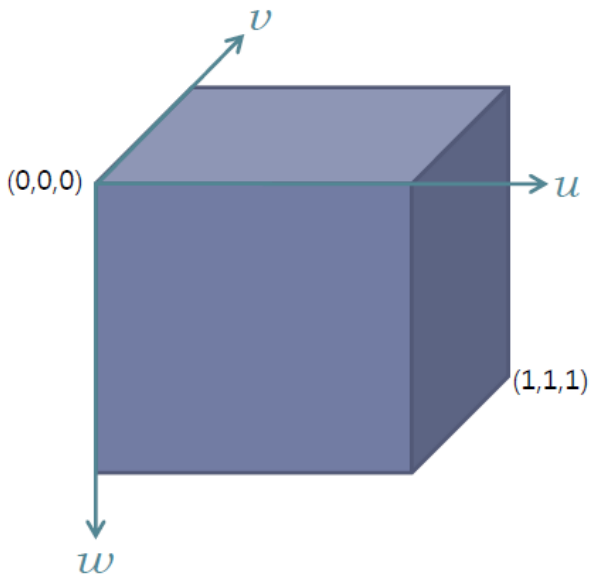
- Texture
  - A bitmap describes detailed surface information
  - Work as a wrapping wallpaper



Texture Coordinate

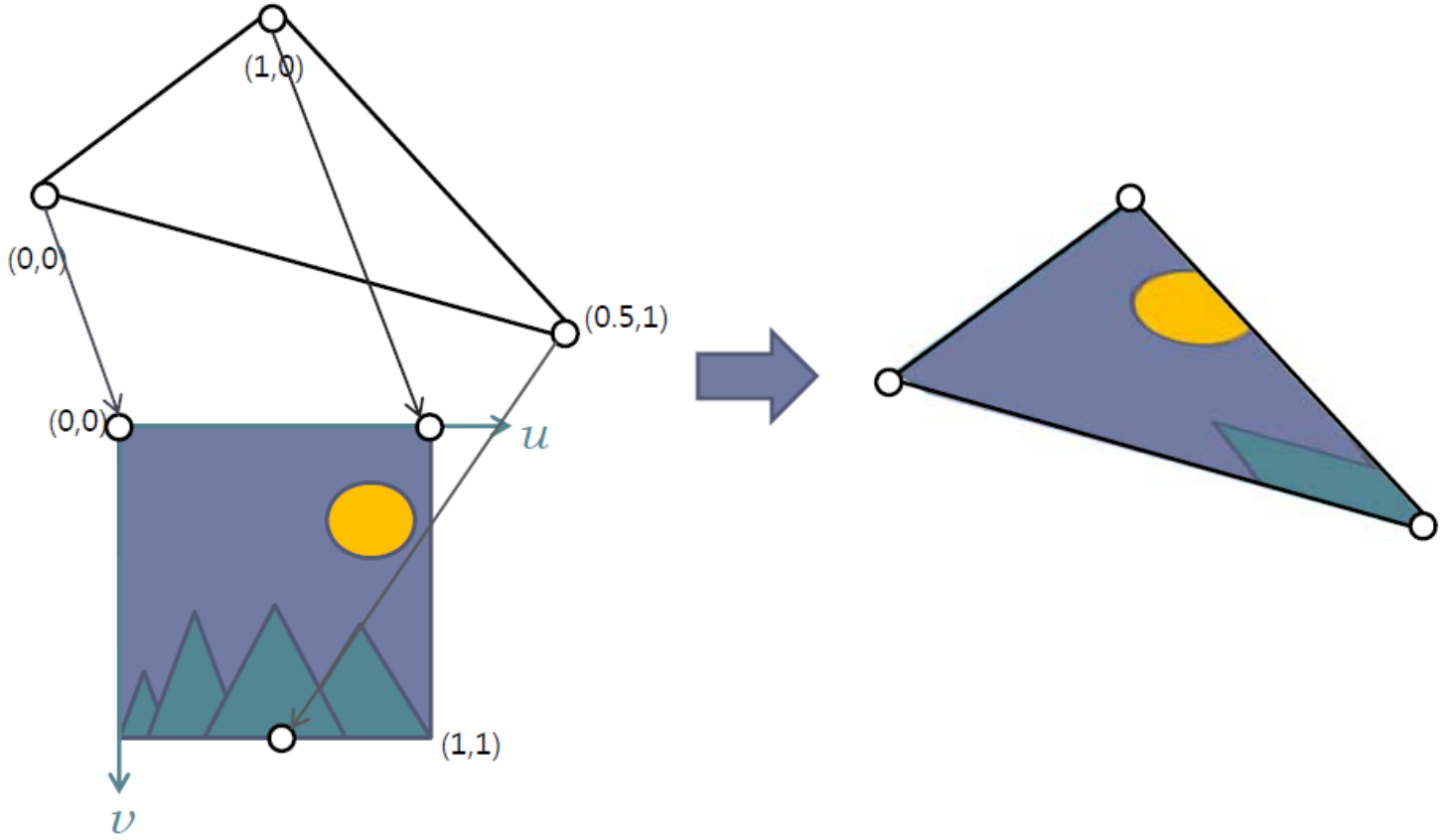
- Independent of the position coordinate
  - [0,1] ranging
  - UV for 2D texture
  - UVW for 3D texture



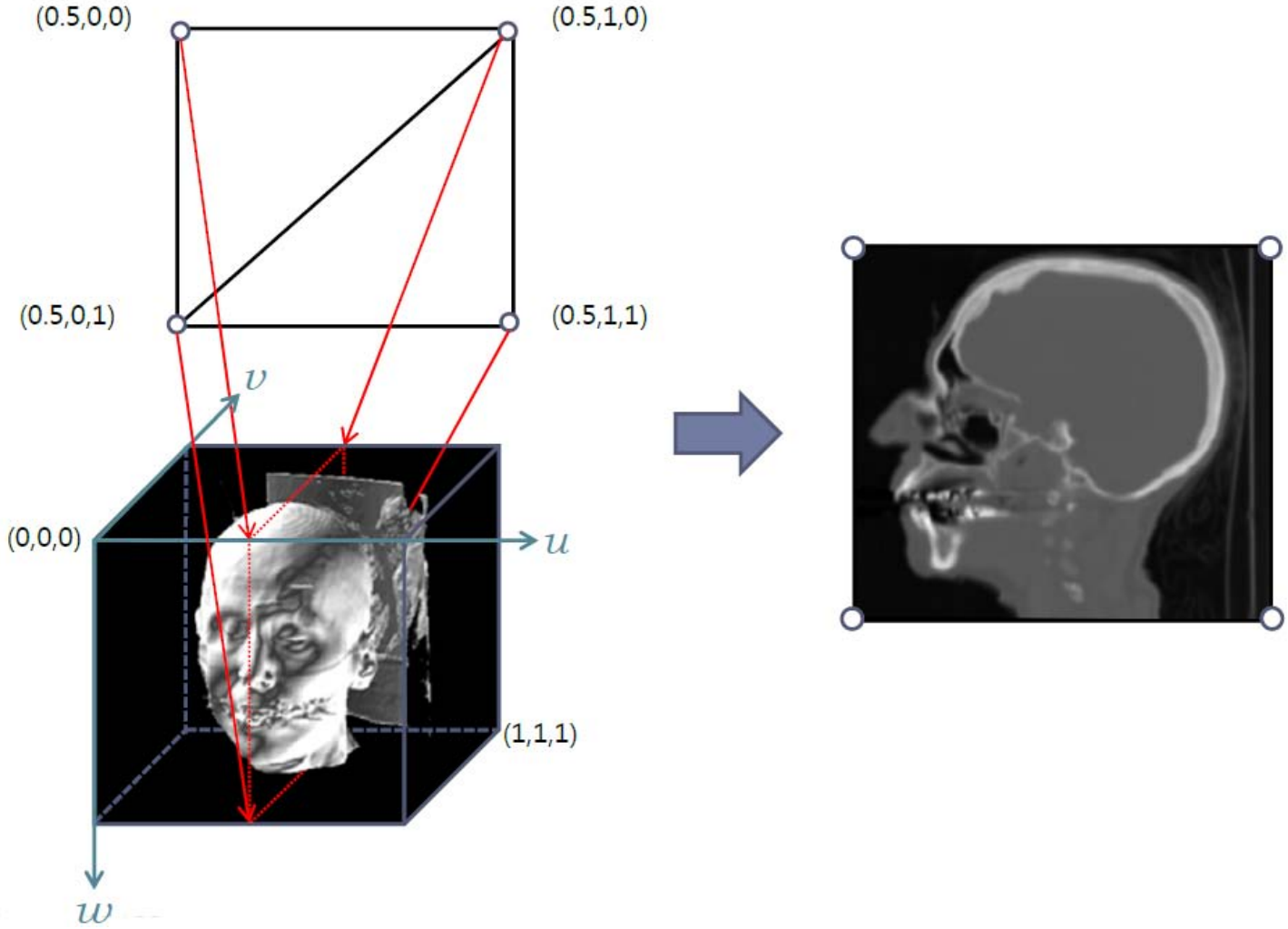


Texture Coordinate

- Texture coordinates indicate mappings between vertices and a texture map



3D Texture

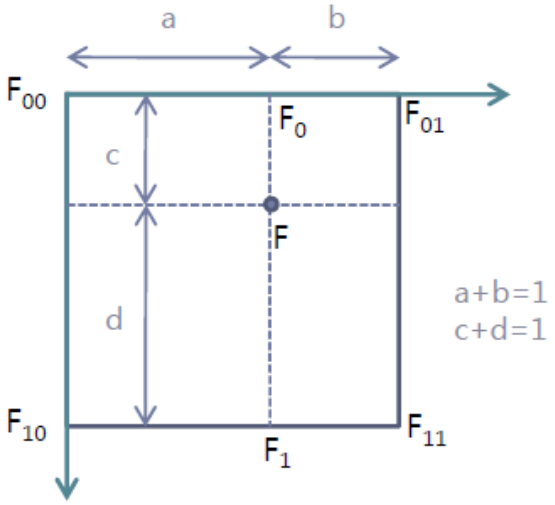


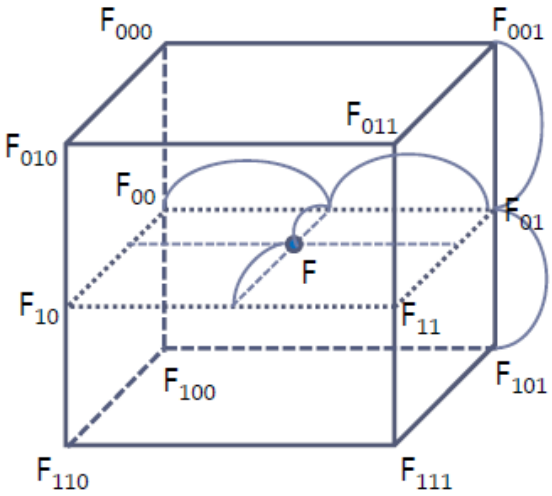
Texture Filtering

- Nearest-point sampling
  - Pick the nearest grid value
  - Jaggy effect
    - When?
- Linear texture filtering
  - Bilinear filtering (2D)

$$F = dF_0 + cF_1$$
$$= d(bF_{00} + aF_{01}) + c(bF_{10} + aF_{11})$$
$$= caF_{11} + cbF_{10} + daF_{01} + dbF_{00}$$

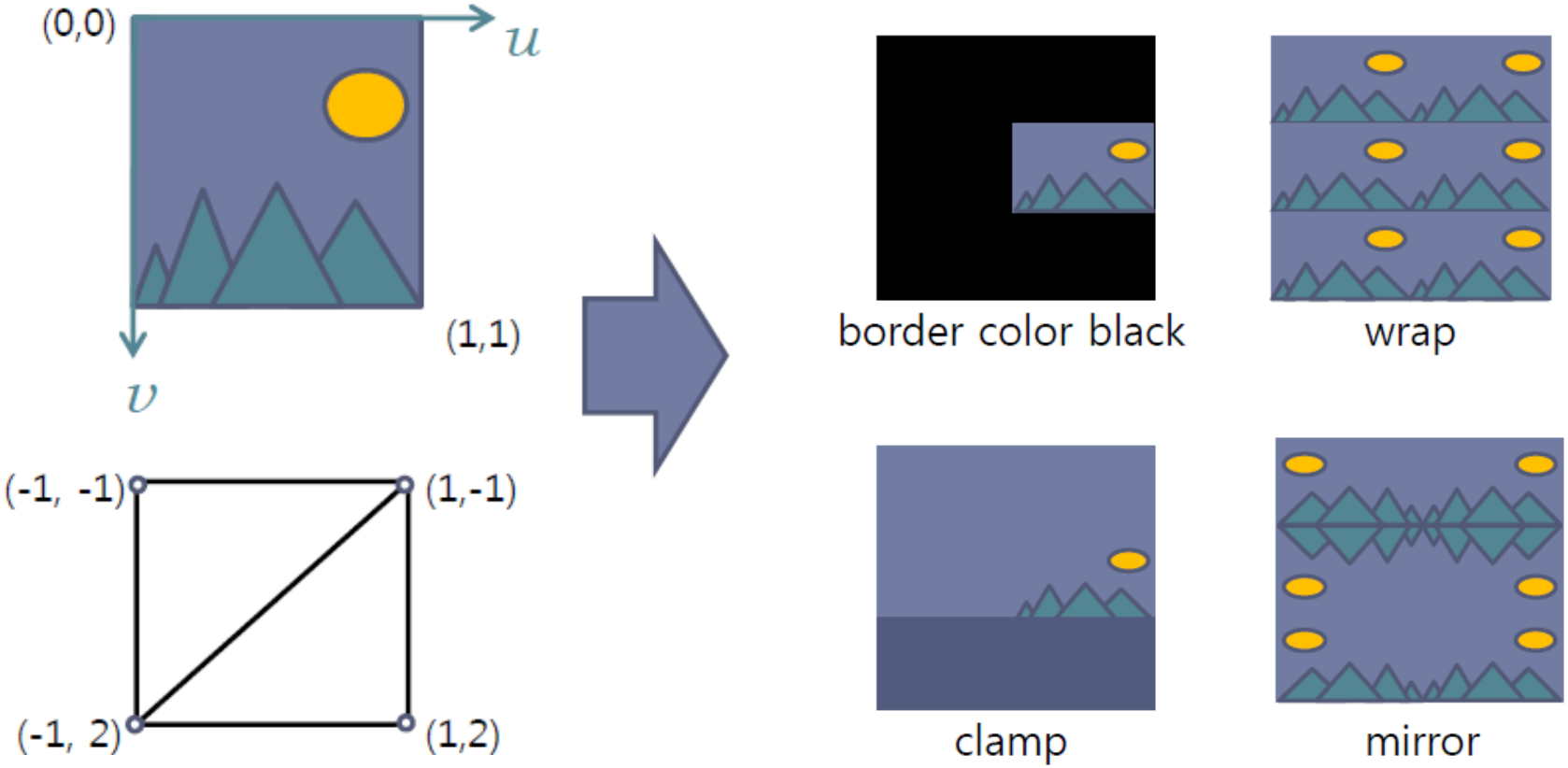
  - Trilinear filtering (3D)
    - Get a plane by bilinear filtering, and bilinear interpolate a pixel in the plane





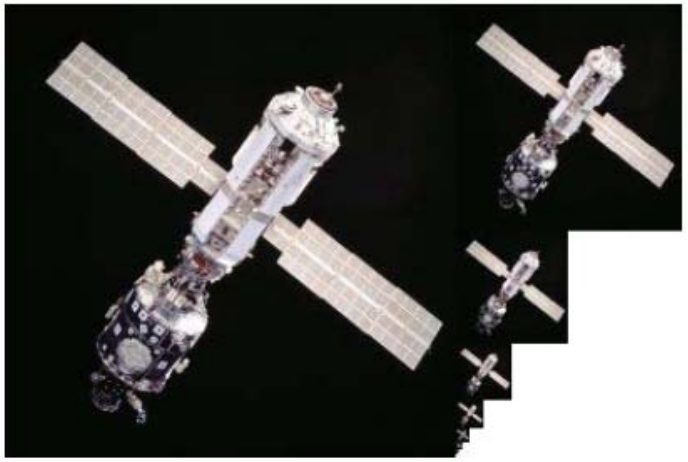
Addressing Convention

- Behavior for out-of-range sampling
  - Border Color, Wrap, Mirror, Clamp



Mipmap Texture

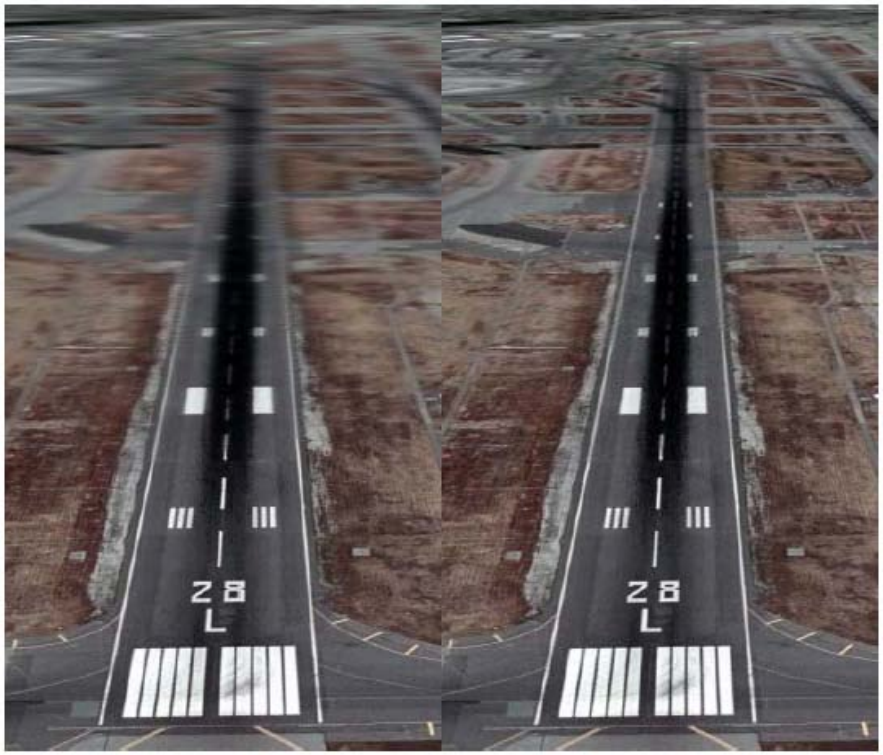
- Mipmap
  - Pre-calculated, optimized collections of bitmap images that accompany a main texture
- Mipmap filtering
  - A high-resolution mipmap image is used for objects that are close to the user
  - A lower-resolution images are used as the object appears farther away
  - Pros
    - Quality improvement
  - Cons
    - Additional memory consumption



Mipmap Filtering

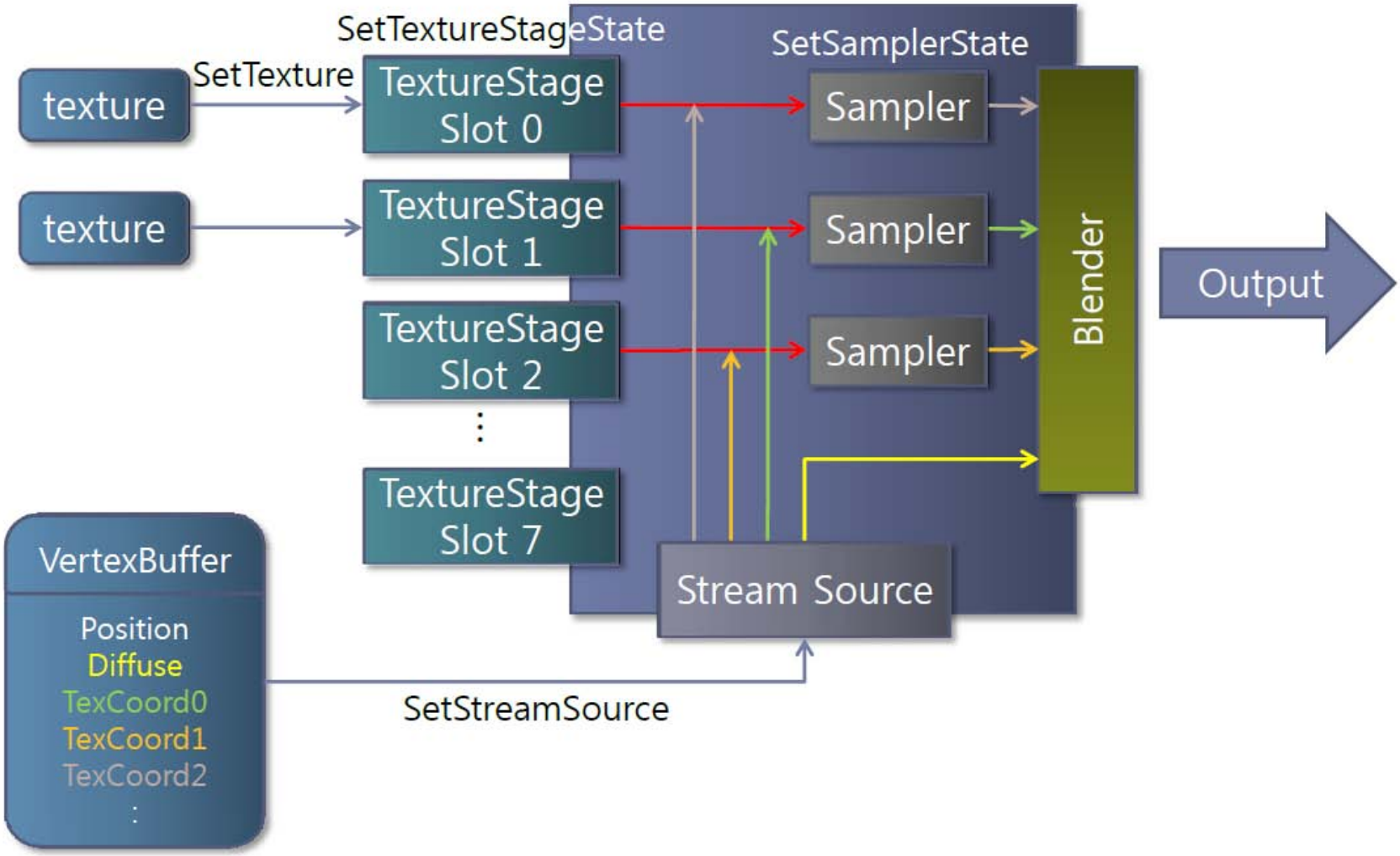
Anisotropic Texture Filtering

- Use adaptive mipmaps on per-pixel level
  - Pros
    - Degrades blurring artifacts of extreme-angle surfaces
  - Cons
    - Expensive operation
- All recent H/Ws support this method



Bilinear filtering Anisotropic filtering

D3D Texture Mapping Overview



Setting Texture Coordinates

- Texture coordinate representation
  - Float or D3DXVECTOR*n*

```
struct CUSTOMVERTEX
{
    D3DXVECTOR3         position;       // The position
    D3DCOLOR            color;          // The color
    FLOAT               tu, tv;         // The texture coordinates
};
```

Setting Texture Coordinates

- D3DFVF
  - D3DFVF_TEX***n*** : ***n*** texture coordinates for a vertex
  - D3DFVF_TEXCOORDSIZE***m***(***k***)
    : ***k***-th texture coordinate is ***m***-dimension

```
D3DFVF_XYZ | D3DFVF_TEX2
        3D position and two 2D texture coordinates
D3DFVF_XYZ | D3DFVF_TEX1 | D3DFVF_TEXCOORDSIZE3(0)
        3D position with one 3D texture coordinate
```

Creating a Texture

- 2D Texture

```
HRESULT IDirect3DDevice9::CreateTexture(UINT Width, UINT Height, UINT Levels,
                                        DWORD Usage, D3DFORMAT Format, D3DPOOL Pool,
                                        IDirect3DTexture9** ppTexture, HANDLE* pSharedHandle);
```

- Width, Height : Size of the texture
- Levels : Number of levels in the texture. 0 for no mipmap
- Usage : Usage of the resource. See D3DUSAGE
- Format : Format of the texture
- Pool : description of the memory class that holds the buffer. See D3DPOOL
- ppTexture : pointer of the texture object
- pSharedHandle : Not used

Creating a Texture

- 3D Texture

```
HRESULT IDirect3DDevice9::CreateTexture
            (UINT Width, UINT Height, UINT Depth, UINT Levels,
             DWORD Usage, D3DFORMAT Format, D3DPOOL Pool,
             IDirect3DTexture9** ppTexture, HANDLE* pSharedHandle);
```

Filling a Texture

- Locking & Unlocking a texture
  - Similar to vertex buffer locking/unlocking
- 2D locking
  - D3DLOCKED_RECT struct & LockRect method

```
typedef struct D3DLOCKED_RECT {
    INT Pitch;                          // # of bytes in one row of the surface
    void * pBits;                       // Pointer to the locked bits
} D3DLOCKED_RECT, *LPD3DLOCKED_RECT;

HRESULT IDirect3DTexture9::LockRect(UINT Level, D3DLOCKED_RECT * pLockedRect,
                                    CONST RECT * pRect, DWORD Flags);
```

- Level : The level of surfaces of the texture to lock
- pLockedRect : Pointer to a D3DLOCKED_RECT structure
- pRect : Pointer to a RECT structure that specifies the region to lock. NULL means the whole area.
- Flags : Locking flags

Filling a Texture

- 3D locking
  - D3DLOCKED_BOX struct & LockBox method

```
typedef struct D3DLOCKED_BOX {
    int RowPitch;                    // # of bytes in one row
    int SlicePitch;                  // # of bytes in one slice
    void * pBits;                    // Pointer to the locked bits
} D3DLOCKED_BOX, *LPD3DLOCKED_BOX;

HRESULT IDirect3DVolumeTexture9::LockBox(UINT Level,
                                         D3DLOCKED_BOX * pLockedBox,
                                         CONST D3DBOX * pBox, DWORD Flags);
```

- Level : The level of surfaces of the texture to lock
- pLockedBox : Pointer to a D3DLOCKED_BOX structure
- pBox : Pointer to a D3DBOX struct that specifies the region to lock. NULL means the whole area.
- Flags : Locking flags

Filling a Texture

- Indirect creation
  - Create a texture object suitable for the source
  - Fill the texture object with source data
  - Build mipmap textures
  - Source
    - File
      - BMP, DDS, DIB, HDR, JPG, PFM, PNG, PPM, TGA
    - Memory
    - Resource

```
If(FAILED(D3DXCreateTextureFromFile(g_pd3dDevice, "Banana.bmp“, &g_pTexture )))
        return E_FAIL;
```

Binding Textures

- Attach the texture to the device
  - TextureStage
    - View in which the device looks the texture resource
    - Up to 8 stages
- Setting texture stage options
  - SetTextureStageState
    - Blending operations
    - Index of the texture coordinate of a vertex to refer

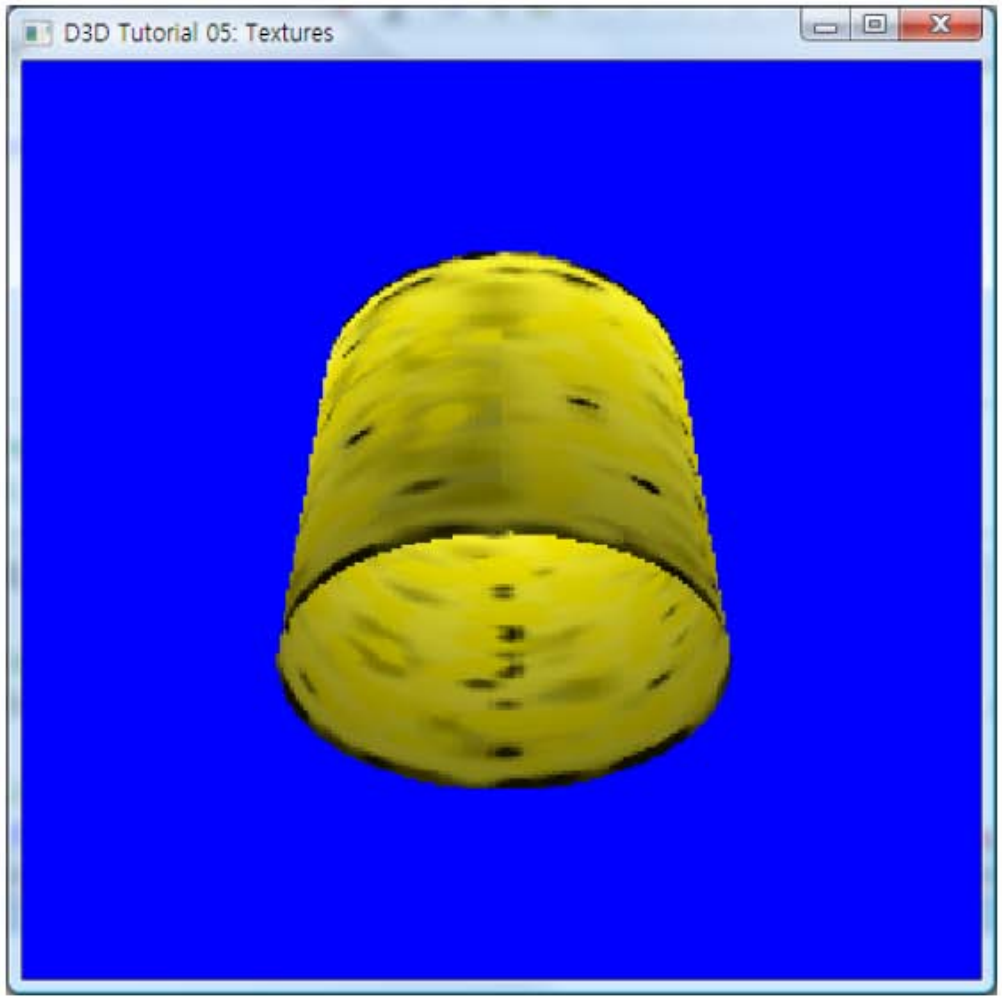
```
g_pd3dDevice->SetTexture( 0, g_pTexture );
g_pd3dDevice->SetTextureStageState( 0, D3DTSS_TEXCOORDINDEX,   1 );
g_pd3dDevice->SetTextureStageState( 0, D3DTSS_COLOROP,   D3DTOP_MODULATE );
g_pd3dDevice->SetTextureStageState( 0, D3DTSS_COLORARG1, D3DTA_TEXTURE );
g_pd3dDevice->SetTextureStageState( 0, D3DTSS_COLORARG2, D3DTA_DIFFUSE );
g_pd3dDevice->SetTextureStageState( 0, D3DTSS_ALPHAOP,   D3DTOP_DISABLE );
```

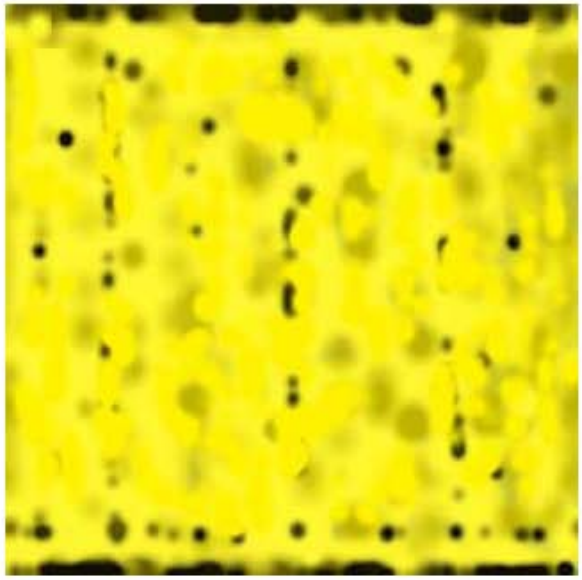
Binding Textures

- Setting sampler options
  - SetSamplerState
    - Boundary conditions
    - Filtering methods

```
g_pd3dDevice->SetSamplerState( 0, D3DSAMP_MAGFILTER, D3DTEXF_LINEAR);
g_pd3dDevice->SetSamplerState( 0, D3DSAMP_MINFILTER, D3DTEXF_ANISOTROPIC);
g_pd3dDevice->SetSamplerState( 0, D3DSAMP_MIPFILTER, D3DTEXF_POINT);
g_pd3dDevice->SetSamplerState( 0, D3DSAMP_ADDRESSU, D3DTADDRESS_WRAP);
g_pd3dDevice->SetSamplerState( 0, D3DSAMP_ADDRESSV, D3DTADDRESS_CLAMP);
```

Result : Tutorial 5





Banana.bmp

Practice Assignments

- Compile and run Tutorial 5
  - Try your own texture patterns using LockRect method