



Displacement Textures



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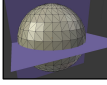


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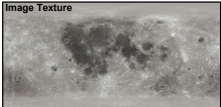
Displacement Textures are a Special Way to Model 3D Geometry

Vertex-described Object




+

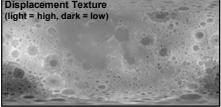
Image Texture




=



Displacement Texture
(light = high, dark = low)



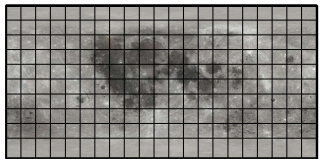


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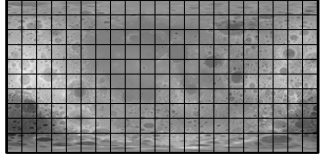
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Think of the Textures as 2D Data Tables: One to Hold RGB Values and One to Hold Height Values

Image Texture



Displacement Texture
(light = high, dark = low)



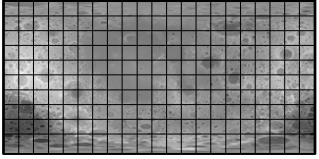


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Why Use a Texture to Hold Height Values?

Displacement Texture
(light = high, dark = low)



Textures:

1. Can be very large.
2. Have been architected for fast lookup.
3. Are capable of bilinear interpolation if you lookup an (s,t) that doesn't fall exactly on a height value. Therefore, you have lots of flexibility with how dense your vertex mesh is.



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```


moondisp.glib
##OpenGL GLIB
Perspective 70
LookAt 0 0 3 0 0 0 1 0

Texture2D 6 frc_color_poles_4k.bmp
Texture2D 7 kdem_16_uint.bmp

Vertex moondisp.vert
Fragment moondisp.frag
Program MoonDisp

    uDoElevations <false> \
    uDoLighting <false> \
    uLightX <-10.0 10.0> \
    uLightY <-10.0 10.0> \
    uLightZ < 1. 10. 10.0> \
    uKa <0. 0.2 1.0> \
    uKd <0. 0.9 1.0> \
    uSeaLevel <0. 0.25 1.0> \
    uHeightScale <0. 0.25 0.50> \
    uNormalScale <-0. 0.04 0.10> \
    uColorUnit 6 \
    uDispUnit 7

Color 1. .3 0.
Sphere 1. 600 600
    
```



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Displacement Textures are a Special Way to Model 3D Geometry

```

moondisp.vert
#version 330 compatibility

uniform float uLightX, uLightY, uLightZ;
uniform float uHeightScale;
uniform float uSeaLevel;
uniform sampler2D uDispUnit;
uniform bool uDoElevations;


out vec2 vST;
out vec3 vN; // normal vector
out vec3 vL; // vector from point to light
vec3 LIGHTPOS = normalize( vec3( uLightX, uLightY, uLightZ ) );

void main()
{
    vec2 st = gl_MultiTexCoord0.st;
    vST = st;

    vec3 norm = normalize( gl_NormalMatrix * gl_Normal ); // normal vector
    vN = norm;
    vec4 ECPosition = gl_ModelViewMatrix * gl_Vertex; // eye coordinate position
    vL = LIGHTPOS - ECPosition.xyz; // vector from the point to the light position

    vec3 vert = gl_Vertex.xyz;
    if( uDoElevations )
    {
        float disp = texture( uDispUnit, st ); // in half-meters, relative to a radius of 1727400 meters
        disp = uSeaLevel;
        disp *= uHeightScale;
        vert += normalize( gl_Normal ) * disp;
    }

    gl_Position = gl_ModelViewProjectionMatrix * vec4( vert, 1. );
}
    
```



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moondisp.frag, I


```

#version 330 compatibility

uniform bool      uDoLighting;
uniform float     uKa, uKd;
uniform float     uHeightScale;
uniform float     uNormalScale;
uniform sampler2D uColorUnit;
uniform sampler2D uDispUnit;

in vec2          vST;
in vec3          vN;
in vec3          vL;
const float DELTA = 0.01;

void main()
{
    vec3 newColor = texture( uColorUnit, vST ).rgb;
    gl_FragColor = vec4( newColor, 1. );
    if( uDoLighting )
    {
        ...
    }
}
    
```



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moondisp.frag, II

```

if( uDoLighting )
{
    vec2 stp0 = vec2( DELTA, 0. );
    vec2 st0p = vec2( 0. , DELTA );
    float west = texture2D( uDispUnit, vST-stp0 ).r;
    float east = texture2D( uDispUnit, vST+stp0 ).r;
    float south = texture2D( uDispUnit, vST-st0p ).r;
    float north = texture2D( uDispUnit, vST+st0p ).r;
    vec3 stangent = vec3( 2.*DELTA, 0., uNormalScale * ( east - west ) );
    vec3 ttangent = vec3( 0., 2.*DELTA, uNormalScale * ( north - south ) );
    vec3 Normal = normalize( cross( stangent, ttangent ) );
    vec3 Light = normalize( vL );

    vec3 ambient = uKa * newColor;
    float d = 0.;
    if( dot( Normal, Light ) > 0. ) // only do diffuse if the light can see the point
    {
        d = dot( Normal, Light );
    }
    vec3 diffuse = uKd * d * newColor;
    gl_FragColor = vec4( ambient+diffuse, 1. );
}
}
    
```




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
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Just the image texture



Lighting only, no displacements
Displacements only, no lighting
Displacements + Lighting

Note: as you can imagine, static images do not do this justice. Being able to dynamically rotate the Moon and change the height exaggeration and light position makes a big difference!



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