High-Precision Shading and Geometry

Kevin Bjorke

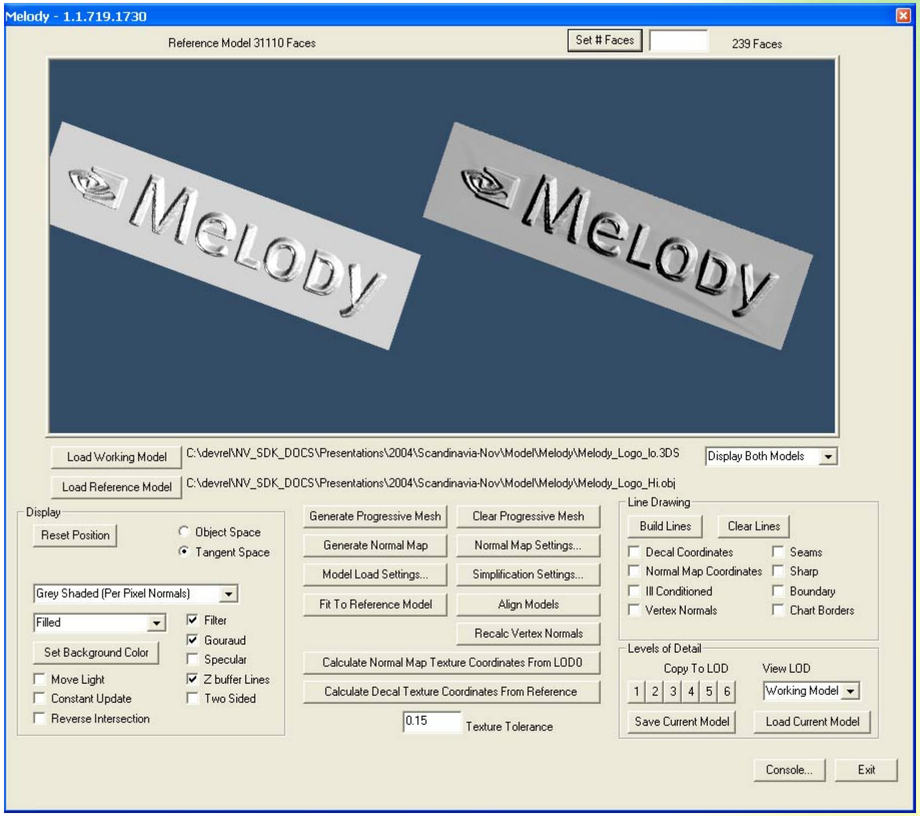
NVIDIA Corporation

CPU Power Drives GPU Tools

- Showing Today: Two NVIDIA Tools
- Melody
  - Simplify Complex Geometry
  - Calculate UV-coord charts
  - Generate high-res Normal Maps for Low-Res models
- FX Composer
  - Create, debug, and tune GPU shaders
  - Generate static data and procedural textures on the CPU

Melody

- Melody’s function is to replace complex geometric complexity with fast, efficient texturing
- Three production challenges:
  - Simplification
  - Mapping
  - Texturing



Melody - 1.1.719.1730

Reference Model 31110 Faces

239 Faces

Load Working Model: C:\devrel\NV_SDK_DOCS\Presentations\2004\Scandinavia-Nov\Model\Melody\Melody_Logo_lo.3DS

Load Reference Model: C:\devrel\NV_SDK_DOCS\Presentations\2004\Scandinavia-Nov\Model\Melody\Melody_Logo_Hi.obj

Display Both Models

Display

○ Object Space
● Tangent Space

Grey Shaded (Per Pixel Normals)

Filled

☑ Filter
☑ Gouraud
☐ Specular
☑ Z buffer Lines
☐ Two Sided
☐ Move Light
☐ Constant Update
☐ Reverse Intersection

0.15 Texture Tolerance

Line Drawing

☐ Decal Coordinates
☐ Normal Map Coordinates
☐ Ill Conditioned
☐ Vertex Normals
☐ Seams
☐ Sharp
☐ Boundary
☐ Chart Borders

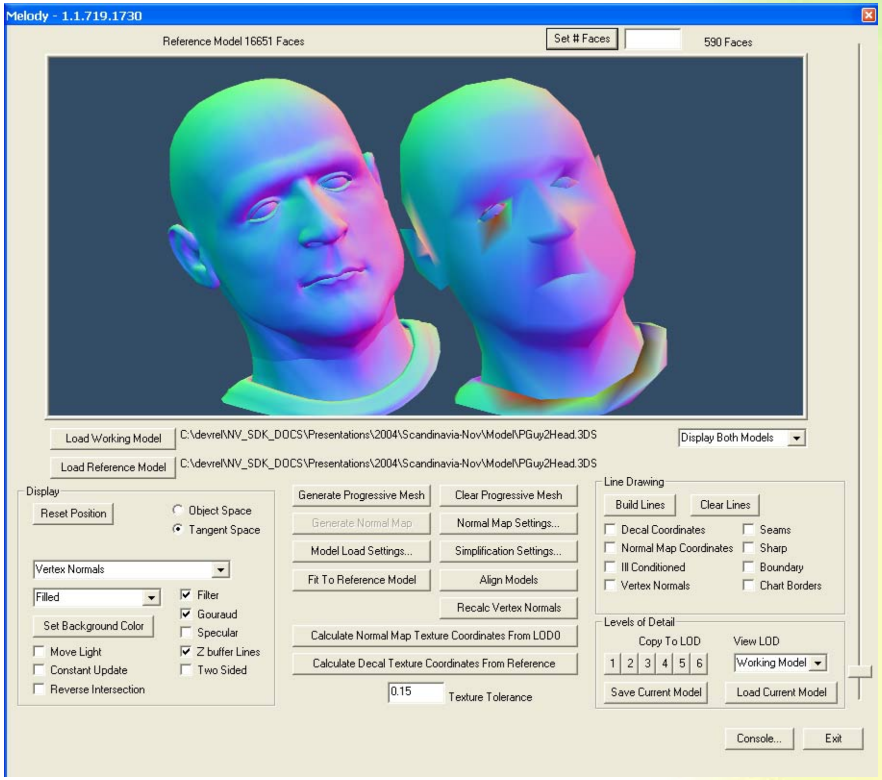
Levels of Detail

Copy To LOD

View LOD: Working Model

Geometric Simplification

- Many times, models are simplified by hand. Or…
- Melody provides automatically simplified geometry
- “Dial a poly count”
- Complete with monotonic UVs if not available in the model



Melody - 1.1.719.1730

Reference Model 16651 Faces

590 Faces

Load Working Model: C:\devrel\NV_SDK_DOCS\Presentations\2004\Scandinavia-Nov\Model\PGuy2Head.3DS

Load Reference Model: C:\devrel\NV_SDK_DOCS\Presentations\2004\Scandinavia-Nov\Model\PGuy2Head.3DS

Display Both Models

Display

○ Object Space
● Tangent Space

Vertex Normals

Filled

☑ Filter
☑ Gouraud
☐ Specular
☑ Z buffer Lines
☐ Two Sided
☐ Move Light
☐ Constant Update
☐ Reverse Intersection

0.15 Texture Tolerance

Line Drawing

☐ Decal Coordinates
☐ Normal Map Coordinates
☐ Ill Conditioned
☐ Vertex Normals
☐ Seams
☐ Sharp
☐ Boundary
☐ Chart Borders

Levels of Detail

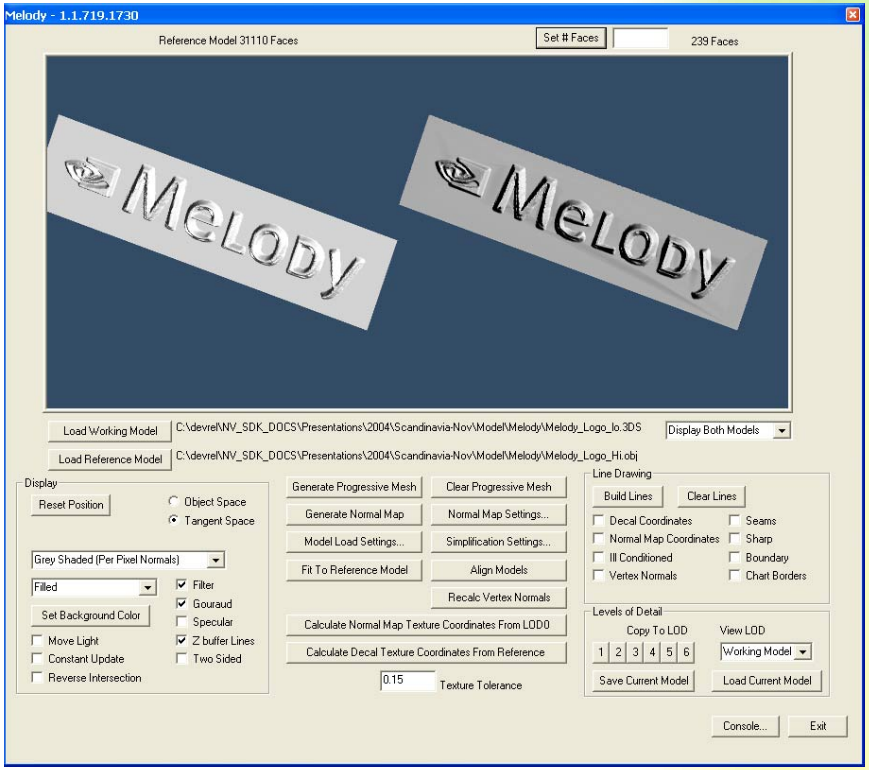
View LOD: Working Model

Simplification is a Memory Hog

- For complex models, 2GB is often not enough!
- Each vertex, and each edge, carries a suite of connectivity, prioritization, and texture-mapping info
- High-complexity reference models already sometimes fail to allocate adequate memory blocks
- 64-bit computing breaks this bottleneck

Normal Map Generation

- Using the high-res geometry as a reference, Melody generates a normal map for use on low-poly models
- *New:* Now compatible with Epic's Unreal Engine



Melody - 1.1.719.1730

Reference Model 31110 Faces

239 Faces

C:\devrel\NV_SDK_DOCS\Presentations\2004\Scandinavia-Nov\Model\Melody\Melody_Logo_lo.3DS

C:\devrel\NV_SDK_DOCS\Presentations\2004\Scandinavia-Nov\Model\Melody\Melody_Logo_Hi.obj

Display Both Models

Display

○ Object Space

● Tangent Space

Grey Shaded (Per Pixel Normals)

Filled

☑ Filter

☑ Gouraud

□ Specular

☑ Z buffer Lines

□ Two Sided

□ Move Light

□ Constant Update

□ Reverse Intersection

0.15 Texture Tolerance

Line Drawing

□ Decal Coordinates

□ Normal Map Coordinates

□ Ill Conditioned

□ Vertex Normals

□ Seams

□ Sharp

□ Boundary

□ Chart Borders

Levels of Detail

Copy To LOD

View LOD

Working Model

Huge Worlds Need Huge Data

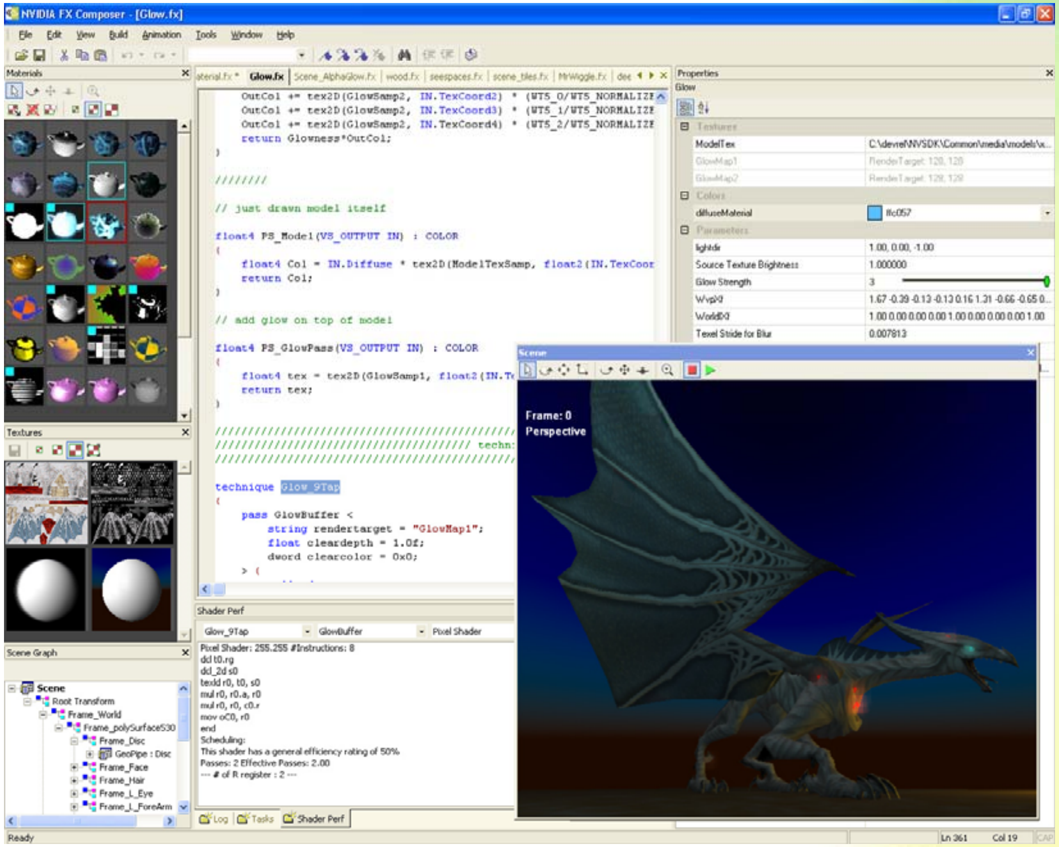
- The trend in tools is toward high production complexity
- 64-bit computing has impact:
  - How much you can do
  - How fast you can do it
  - Without large memory blocks, data flow slows as large chunks of data are broken up
- Full 64-bit Melody version available soon on http://developer.nvidia.com/

Rich Media use *All* Resources

- Intensive Tools for Production
  - Geometric simplification (Melody)
  - Global illumination lightmap generation
  - Volume-texture model creation
  - Compare the complexity of a sound studio mixing board to a car stereo
- Growing Audience Appetite for Complexity
  - Developers need tools to help them maximize run-time synergy between CPU and GPU capabilities

FX Composer

- IDE for DirectX shaders with integrated performance analysis and preview
  - – CREATE
  - – DEBUG
  - – TUNE



```
    OutCol += tex2D(GlowSamp2, IN.TexCoord2) * (WT5_0/WT5_NORMALIZE
    OutCol += tex2D(GlowSamp2, IN.TexCoord3) * (WT5_1/WT5_NORMALIZE
    OutCol += tex2D(GlowSamp2, IN.TexCoord4) * (WT5_2/WT5_NORMALIZE
    return Glowness*OutCol;
}

////////

// just drawn model itself

float4 PS_Model(VS_OUTPUT IN) : COLOR
{
    float4 Col = IN.Diffuse * tex2D(ModelTexSamp, float2(IN.TexCoor
    return Col;
}

// add glow on top of model

float4 PS_GlowPass(VS_OUTPUT IN) : COLOR
{
    float4 tex = tex2D(GlowSamp1, float2(IN.Te
    return tex;
}

////////////////////////////////////////////////
/////////////////////////////////////// techn:
////////////////////////////////////////////////

technique Glow_9Tap
{
    pass GlowBuffer <
        string rendertarget = "GlowMap1";
        float cleardepth = 1.0f;
        dword clearcolor = 0x0;
    > {
```

Textures	
ModelTex	C:\devrel\NVSDK\Common\media\models\x...
GlowMap1	RenderTarget: 128, 128
GlowMap2	RenderTarget: 128, 128
Colors	
diffuseMaterial	ffc057
Parameters	
lightdir	1.00, 0.00, -1.00
Source Texture Brightness	1.000000
Glow Strength	3
WvpXf	1.67 -0.39 -0.13 -0.13 0.16 1.31 -0.66 -0.65 0...
WorldXf	1.00 0.00 0.00 0.00 1.00 0.00 0.00 0.00 1.00
Texel Stride for Blur	0.007813

Glow_9Tap — GlowBuffer — Pixel Shader

```
Pixel Shader: 255.255 #Instructions: 8
dcl t0.rg
dcl_2d s0
texld r0, t0, s0
mul r0, r0.a, r0
mul r0, r0, c0.r
mov oC0, r0
end
Scheduling:
This shader has a general efficiency rating of 50%
Passes: 2 Effective Passes: 2.00
--- # of R register : 2 ---
```

```
Scene
  Root Transform
    Frame_World
      Frame_polySurface530
        Frame_Disc
          GeoPipe : Disc
        Frame_Face
        Frame_Hair
        Frame_L_Eye
        Frame_L_ForeArm
```

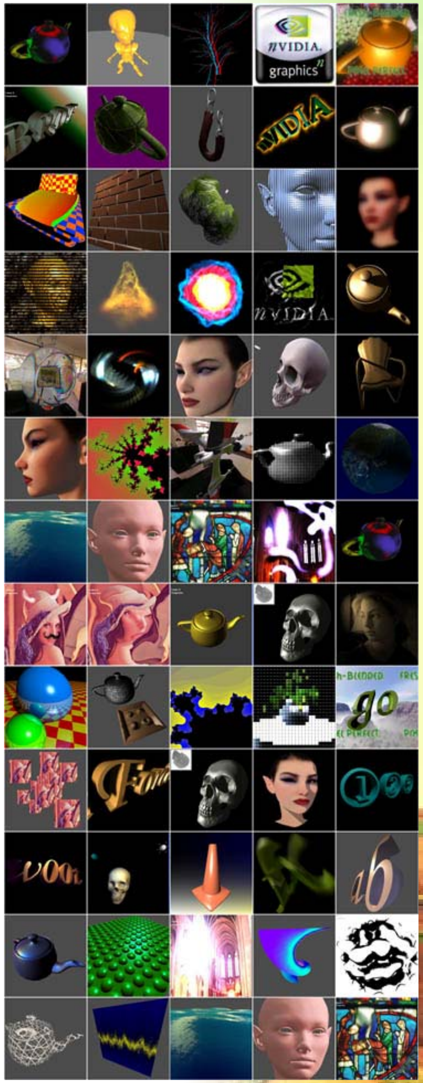
Everquest 2 character © Sony Computer Entertainment

HLSL for both Artists and Programmers

- Examples of what you can do in FX Composer
  - Code details in these slides, available at http://developer.nvidia.com along with complete source code
- Your Models, Your Game Engine...
- Using FX Composer with DCC tools
  - Alias Maya
  - 3DS Max 7
  - RTZen Ginza

Dozens of Effects Projects

- Your Models, Your Game Engine...
- Using FX Composer with DCC tools
  - Alias Maya
  - 3DS Max 7
  - RTZen Ginza
- What's in there: more than we can show in the next few minutes!
- Projects show shaders set-up, and sometimes show shaders interacting



Some SDK Projects

Programmers: HLSL Beyond the Manual

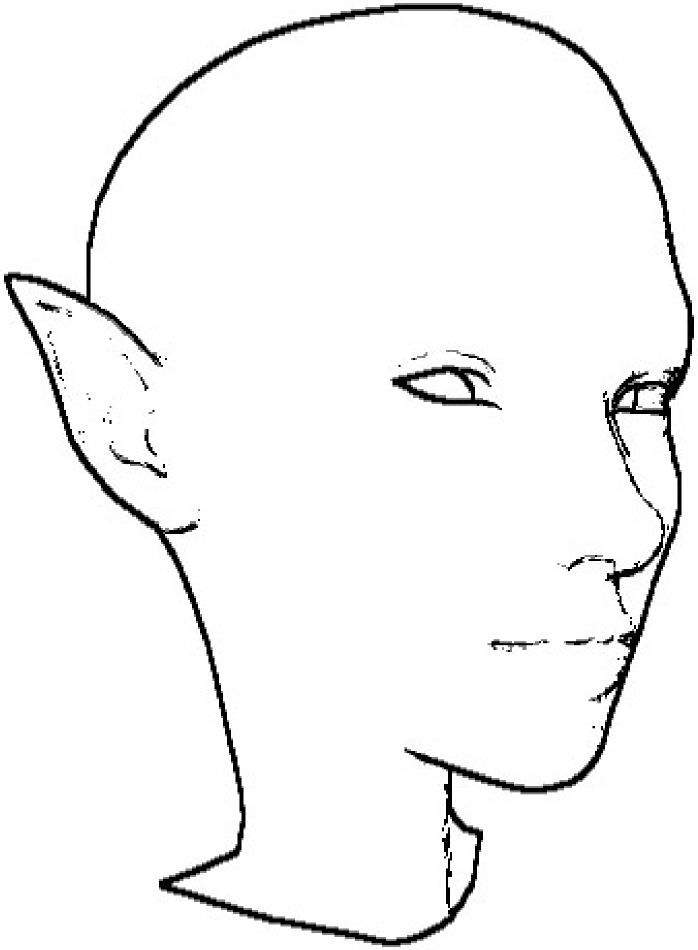
- **This talk will include examples that show how to:**
  - Use the CPU to generate textures etc
  - Use DirectX/XNA's CPU-side DXSAS scripting
  - Write shaders for use in both DCC apps and FX Composer
  - Call on macros and functions from the NVIDIA #include files (.fxh) with FX Composer:
    - `Quad.fxh, shadowMaps.fxh, Noise_3d.fxh, noise_2d.fxh, Spot_tex.fxh, nvMatrix.fxh`
- **Get at new NV4x Features**

DXSAS Scripting

- These examples include techniques for:
  - MRTs
  - Loops of Passes
  - Looping on Booleans
  - FXCOMPOSER_RESET
  - Re-Using Texture Samplers
  - Using the GPU for Texture Creation

Example Shader: scene_lineDraw.fx

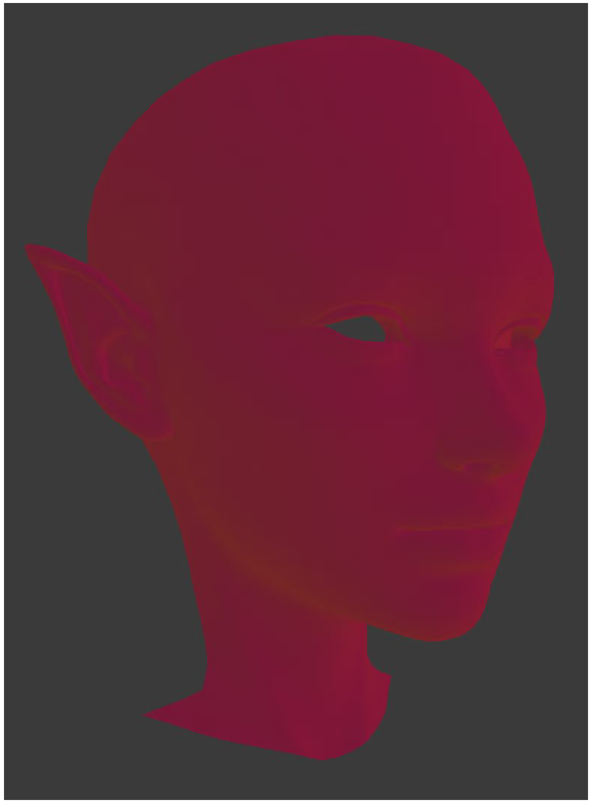
- Uses #include
- Uses MRT
- Uses “half” data
- Uses DXSAS scene commands
- Uses static data



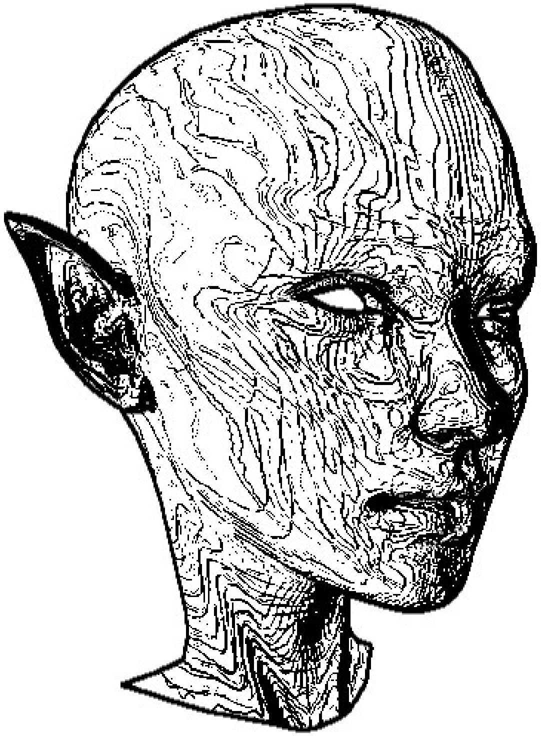
Sample from scene_lineDraw.fx

Edge Detect Based on Normals

- **Potential, but Has Artifacts**



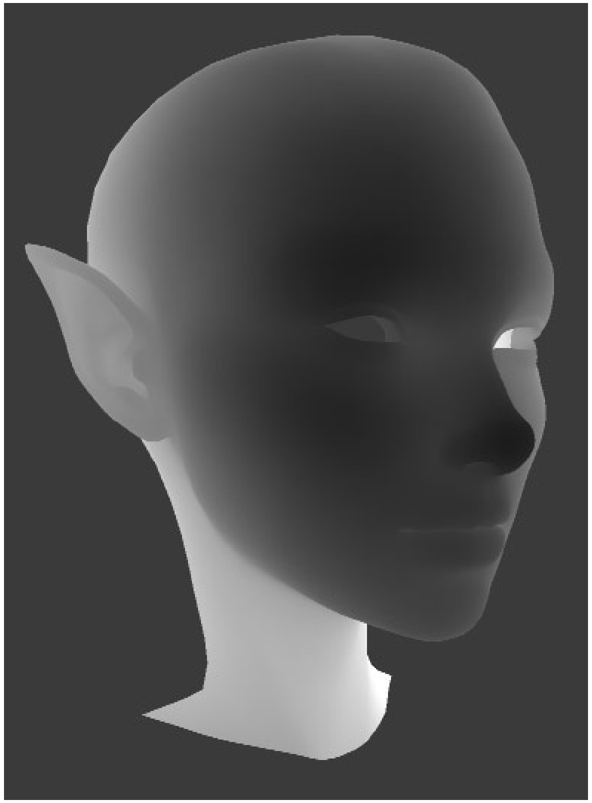
Worldspace Normals



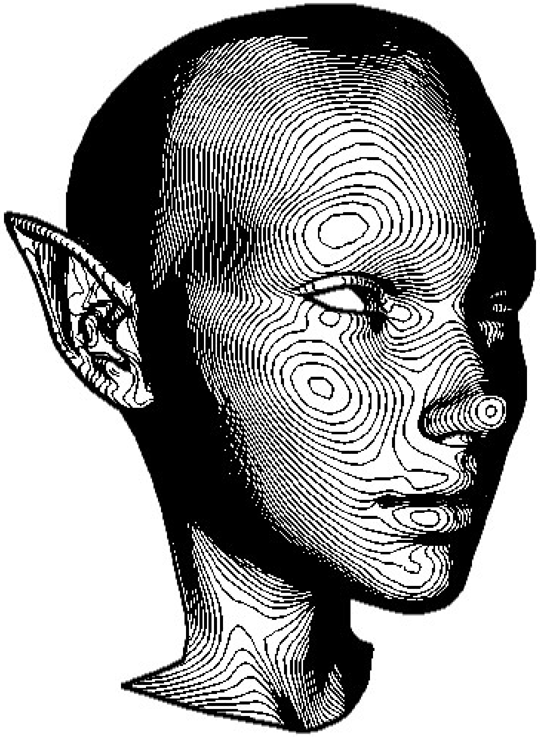
Edges

Edge Detect Based on Depth

- **Has Different Artifacts**



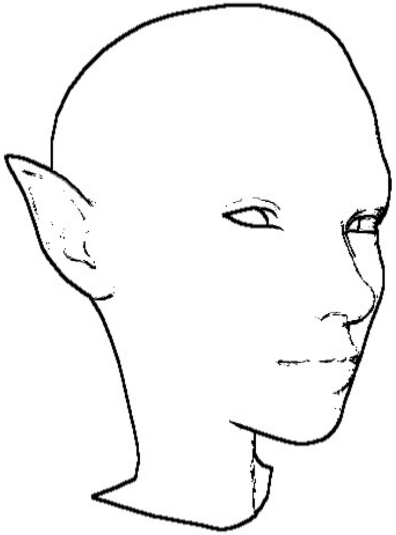
Depth



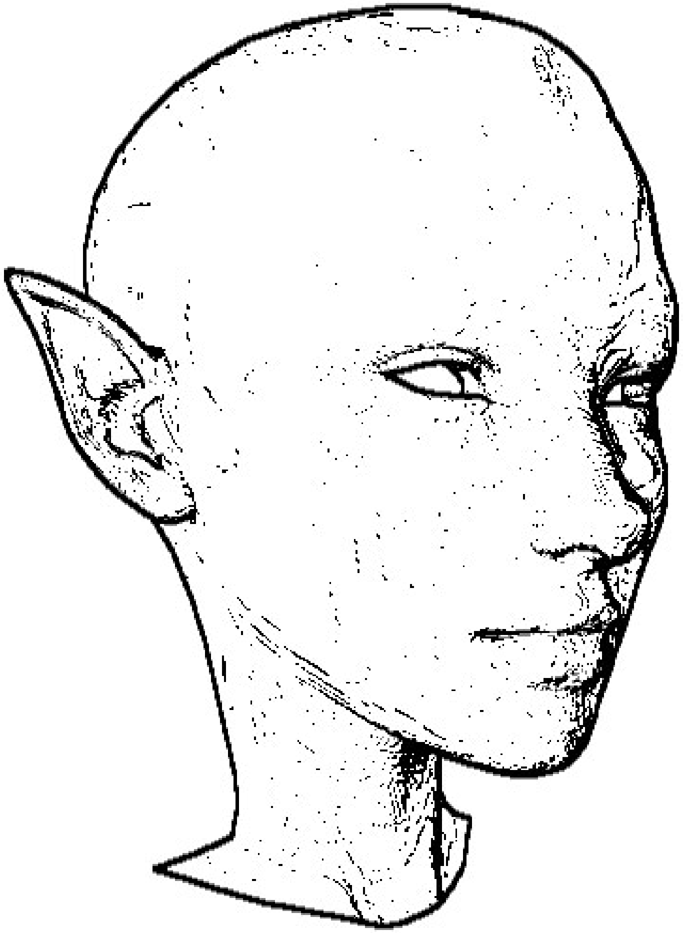
Edges

Combining Results

- Much Smoother, Artifacts tend to cancel even in bad cases



Artist-tweaked



Intersection of (Poor) Edges

Parameters We Will Need

- The parameters we borrow from the original shaders:
  - Two edge-detect threshholds
  - Hither/Far values for depth image
- For scene commands:
  - Color for screen-clear
  - Value for depth-clear (hidden)

lineDraw - beginning

- We include “Quad.fxh” for macros, types, and shader functions
- QUAD_REAL defaults to “half”
  - We can override it by #defining QUAD_FLOAT before #including Quad.fxh
- We will use Quad.fxh Render-to-Texture Declaration Macros
- Quad.fxh also provides vertex and pixel shader functions for simplest screen-aligned-quad cases: writing “straight” textures.

```
#include "Quad.fxh"
```

lineDraw – starting DXSAS

- This shader is a “scene” effect
- We provide mutliple techniques, for different HW profiles
- Two extra techniques for artist tuning

```
float Script : STANDARDSGLOBAL <
   string UIWidget = "none";
   string ScriptClass = "scene";
   string ScriptOrder = "standard";
   string ScriptOutput = "color";
   string Script =
   "Technique=Technique?NV3X:NV4X:NormsOnly:DepthOnly;";
> = 0.8; // version #
```

ScriptClass

Dedicated “Artist” Techniques

lineDraw "untweakables"

- Tracked automatically by app - no user override
- UIWidget = "none" improves performance

No Widget Display

```
float4x4 WorldITXf : WorldInverseTranspose <
                           string UIWidget="None"; >;
float4x4 WorldViewProjectionXf : WorldViewProjection <
                           string UIWidget="None"; >;
float4x4 WorldViewXf : WorldView <
                           string UIWidget="None"; >;
float4x4 WorldXf : World <
                           string UIWidget="None"; >;
float4x4 ViewIXf : ViewInverse <
                           string UIWidget="None"; >;
```

lineDraw static parameters

- Static values are “invisible” to the UI
- Calculated by the CPU
- Can call most HLSL functions, intrinsic or user-defined
- QUAD_REAL type declared by Quad.fxh
- QuadTexOffset and QuadScreenSize are hidden parameters declared by Quad.fxh

static

```
static float EdgeT2 = (Threshhold * Threshhold);
static float DeepT2 = (ThreshholdD * ThreshholdD);

static QUAD_REAL2 TexelCornerOffset =
      QUAD_REAL2(QuadTexOffset/(QuadScreenSize.x),
                 QuadTexOffset/(QuadScreenSize.y));
```

lineDraw Texture Declarations

- Macros from “Quad.fxh” for common RTT texturing
- Standard declarations (like these) match screen size exactly (so resizing the window will re-allocate them)

```
DECLARE_QUAD_TEX(NormTexture,NormSampler,"X8R8G8B8")
DECLARE_QUAD_TEX(DeepTexture,DeepSampler,"X8R8G8B8")
DECLARE_QUAD_DEPTH_BUFFER(DepthBuffer, "D24S8")
```

lineDraw Template

- QUAD_REAL data
- We perform both edge detects and multiply the results
- :COLOR semantic on function itself

Function Output Semantic

```
QUAD_REAL4 edgeDetect2PS(EdgeVertexOutput IN) : COLOR {
  QUAD_REAL n = edgeDetectGray(IN,NormSampler,EdgeT2);
  QUAD_REAL d = edgeDetectR(IN,DeepSampler,DeepT2);
  QUAD_REAL line = 1 - (n*d);
  return line.xxxx;
}
```

Complete Technique

- **Looks Complex but Just 4 (or 3) Chunks:**
  - **Script; Normal, Depth, & Edge Passes**

```
technique NV3X <
           string Script = "Pass=Norms;”
                              "Pass=Depth;"
                              "Pass=ImageProc;";
>  {
           pass Norms <
                 string Script = "RenderColorTarget0=NormTexture;"
                              "RenderDepthStencilTarget=DepthBuffer;"
                              "ClearSetColor=BlackColor;"
                              "ClearSetDepth=ClearDepth;"
                              "Clear=Color;"
                              "Clear=Depth;"
                              "Draw=Geometry;";
           > {
                              VertexShader = compile vs_2_0 simpleVS();
                              ZEnable = true;
                              ZWriteEnable = true;
                              CullMode = None;
                              AlphaBlendEnable = false;
                              PixelShader = compile ps_2_a normPS();
           }
           pass Depth <
                string Script = "RenderColorTarget0=DeepTexture;"
                              "RenderDepthStencilTarget=DepthBuffer;"
                              "ClearSetColor=BlackColor;"
                              "ClearSetDepth=ClearDepth;"
                              "Clear=Color;"
                              "Clear=Depth;"
                              "Draw=Geometry;";
           > {
                              VertexShader = compile vs_2_0 simpleVS();
                              ZEnable = true;
                              ZWriteEnable = true;
                              CullMode = None;
                              AlphaBlendEnable = false;
                              PixelShader = compile ps_2_a deepPS();
           }
           pass ImageProc <
               string Script = "RenderColorTarget0=;"        // re-use
                              "RenderDepthStencilTarget=;"
                              "Draw=Buffer;";
           > {
                              cullmode = none;
                              ZEnable = false;
                              ZWriteEnable = false;
                              AlphaBlendEnable = false;
                              VertexShader = compile vs_1_1 edgeVS();
                              PixelShader = compile ps_2_0 edgeDetect2PS();
           }
}
```

Technique: Chunk 1 of 4

- DXSAS scripts at each step
- The “Technique” script is optional for this case (one pass after another)

```
technique NV3X <
   string Script = "Pass=Norms;"
                    "Pass=Depth;"
                    "Pass=ImageProc;";
>  {
   // . . .
```

Technique: Chunk 2 of 4

- **We redirect color output to “NormTexture” & Draw the Model Geometry**

```
pass Norms <
    string Script = "RenderColorTarget0=NormTexture;"
                    "RenderDepthStencilTarget=DepthBuffer;"
                    "ClearSetColor=BlackColor;"
                    "ClearSetDepth=ClearDepth;"
                    "Clear=Color;"
                    "Clear=Depth;"
                    "Draw=Geometry;";
> {
    VertexShader = compile vs_2_0 simpleVS();
    ZEnable = true;
    ZWriteEnable = true;
    CullMode = None;
    AlphaBlendEnable = false;
    PixelShader = compile ps_2_a normPS();
}
```

Render to Texture

Offscreen Depth Buffer

All Current Models

Technique: Chunk 3 of 4

- **Redirect Color Output to "DeepTexture" & Draw Model Again**

```
pass Depth <
    string Script = "RenderColorTarget0=DeepTexture;"
                    "RenderDepthStencilTarget=DepthBuffer;"
                    "ClearSetColor=BlackColor;"
                    "ClearSetDepth=ClearDepth;"
                    "Clear=Color;"
                    "Clear=Depth;"
                    "Draw=Geometry;";
> {
    VertexShader = compile vs_2_0 simpleVS();
    ZEnable = true;
    ZWriteEnable = true;
    CullMode = None;
    AlphaBlendEnable = false;
    PixelShader = compile ps_2_a deepPS();
}
```

New Render Target

Re-use Depth Buffer

All Current Models

Technique: Chunk 4 of 4

- **Combine, Edge Detect, write result to Frame Buffer**
- *Ignore scene geometry*

```
pass ImageProc <
    string Script = "RenderColorTarget0=;"
                    "RenderDepthStencilTarget=;"
                    "Draw=Buffer;";
> {
    cullmode = none;
    ZEnable = false;
    ZWriteEnable = false;
    AlphaBlendEnable = false;
    VertexShader = compile vs_1_1 edgeVS();
    PixelShader = compile ps_2_0 edgeDetect2PS();
}
```

Reset Render Target

Reset Depth Target

Screen-Aligned Quad

lineDraw MRT Technique

- **We can collapse the first two passes**
- **Remember to reset *all* outputs!**

```
pass NormsAndDepth <
    string Script = "RenderColorTarget0=NormTexture;"
                     "RenderColorTarget1=DeepTexture;"
                     "RenderDepthStencilTarget=DepthBuffer;"
                     "ClearSetColor=BlackColor;"
                     "ClearSetDepth=ClearDepth;"
                     "Clear=Color;"
                     "Clear=Depth;"
                     "Draw=Geometry;";
> {
    VertexShader = compile vs_2_0 simpleVS();
    ZEnable = true;
    ZWriteEnable = true;
    CullMode = None;
    AlphaBlendEnable = false;
    PixelShader = compile ps_2_a geomMRT_PS();
}
```

Target 0

Target 1

Offscreen Depth Buffer

All Current Models

lineDraw MRT shader

- Use “out” to specify multiple return values
- Func can be “void” or return a value via function semantic

```
QUAD_REAL4 vecColorN(QUAD_REAL3 V) {
    QUAD_REAL3 Nc = 0.5*(normalize(V)+((1.0).xxx));
    return QUAD_REAL4(Nc,1);
}

void geomMRT_PS(
          vertexOutput IN,
          out QUAD_REAL4 normColor : COLOR0,
          out QUAD_REAL4 deepColor : COLOR1
) {
    normColor = vecColorN(IN.WorldNormal);
    QUAD_REAL d = (IN.EyePos.z-Near)/(Far-Near);
    deepColor = QUAD_REAL4(d.xxx,1);
}
```

Target 0

Target 1

MRT shader alternative form

- Shader function can be “void” or return a value via function semantic
- :COLOR0 is the same as :COLOR

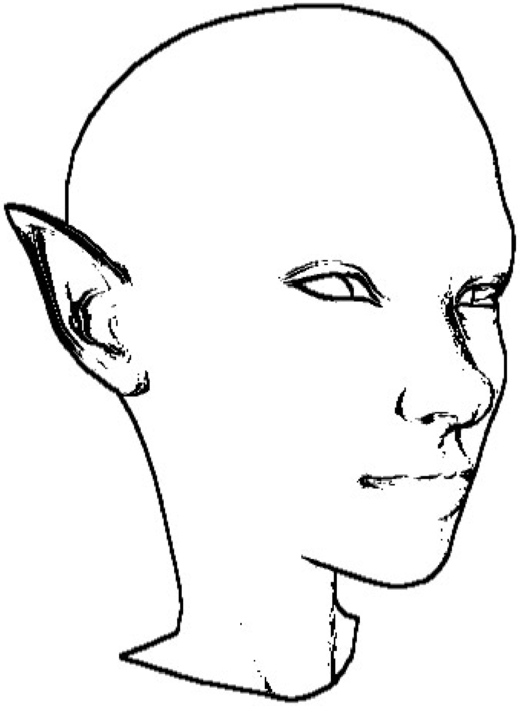
Function Output Semantic

```
QUAD_REAL4 geomMRT_PS(
        vertexOutput IN,
        out QUAD_REAL4 deepColor : COLOR1) : COLOR0
{
   QUAD_REAL d = (IN.EyePos.z-Near)/(Far-Near);
   deepColor = QUAD_REAL4(d.xxx,1);
   return vecColorN(IN.WorldNormal);
}
```

lineDraw Tuning Technique 1

- **Provide a visualization for artists to tune params for edgeNorms**

```
technique NormsOnly {
   pass Norms <
        // . . .
```

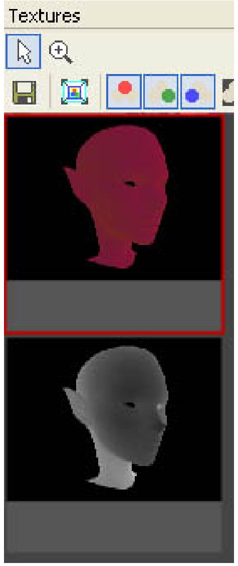


Tuned Normals Edges

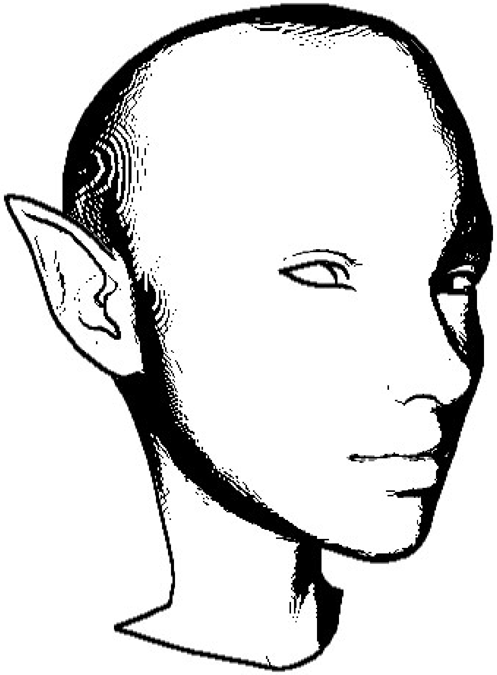
lineDraw Tuning Technique 2

- **Likewise for Depth and edge parameters**

```
technique DepthOnly {
  pass Depth <
      // . . .
```



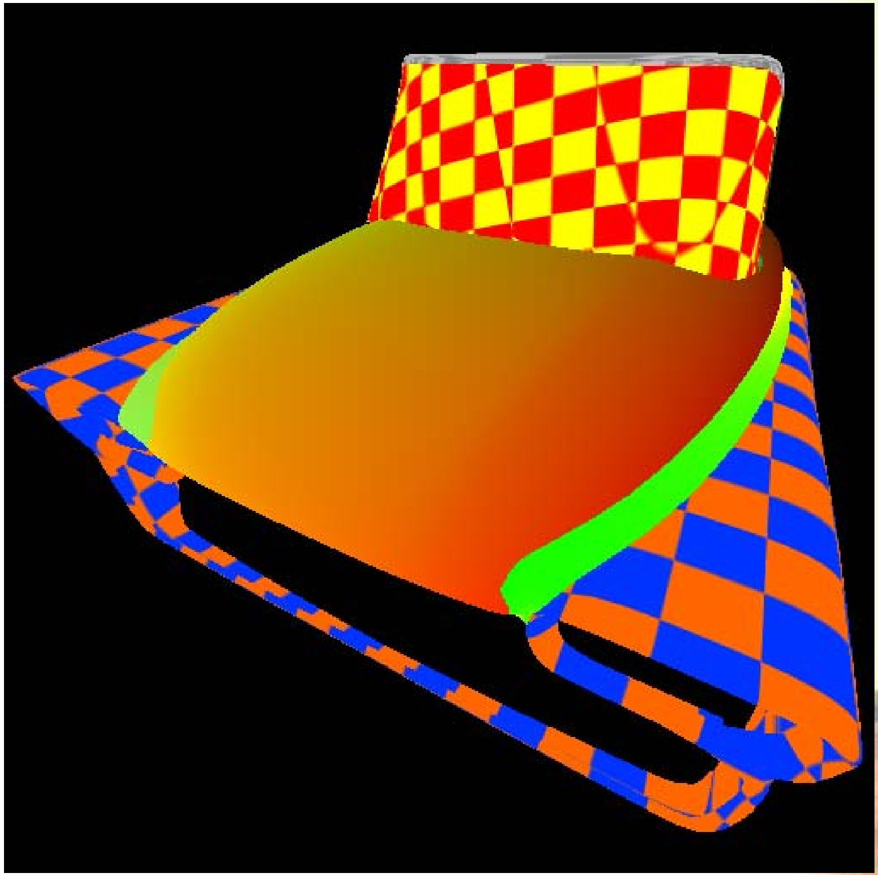
Live Texture Display
in FX Composer



Tuned Depth Edges

Example Shader: SeeSpaces.fx

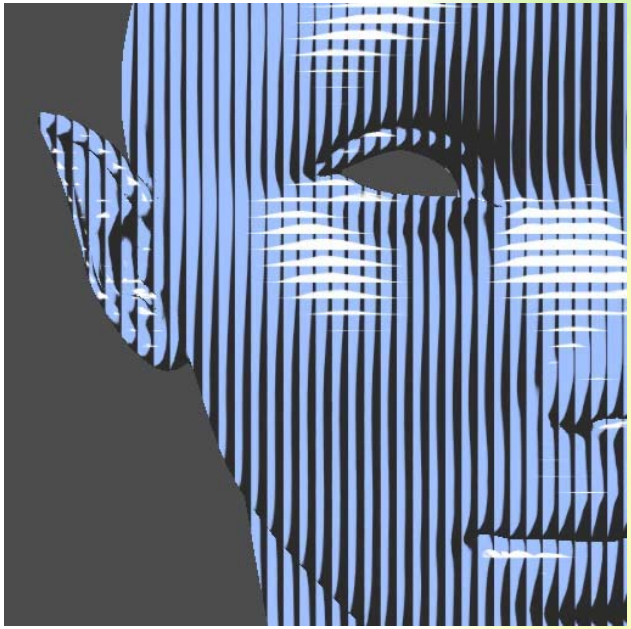
- Artist Visualization
- Uses texture generation and texture derivatives on CPU for fast AA
- Debugging



Sample from "DebugCab.fxproj"

Checks, Stripes, Antialiasing

- Using CPU pre-calculation results in higher quality and faster performance than math in the pixel shader
- In shading, any number can potentially be a texture
- Likewise many functions (like some BRDFs) can be represented by one or more textures



"Durer" shader from NVIDIA SDK

HLSL Procedural Textures

- :COLOR sematic like a pixel shader
- :PSIZE input semantic gives texel size as function is called for *each* MIP level
- This is the *only* way to get at the HLSL noise() intrinsic

```
float4 MakeStripe(float2 Pos : POSITION,float ps : PSIZE) : COLOR
{
   float v = 0;
   float nx = Pos.x+ps; // keep the last column full-on, always
   v = nx > Pos.y;
   return float4(v.xxxx);
}

#define TEX_SIZE 128
texture stripeTex <
    string function = "MakeStripe";
    string UIWidget = "None";
    float2 Dimensions = { TEX_SIZE, TEX_SIZE };
>;
sampler2D StripeSampler = sampler_state {
    Texture = <stripeTex>;
    MinFilter = LINEAR; MagFilter = LINEAR; MipFilter = LINEAR;
    AddressU = WRAP;
    AddressV = CLAMP;
};
```

Output Semantic

Input Semantic

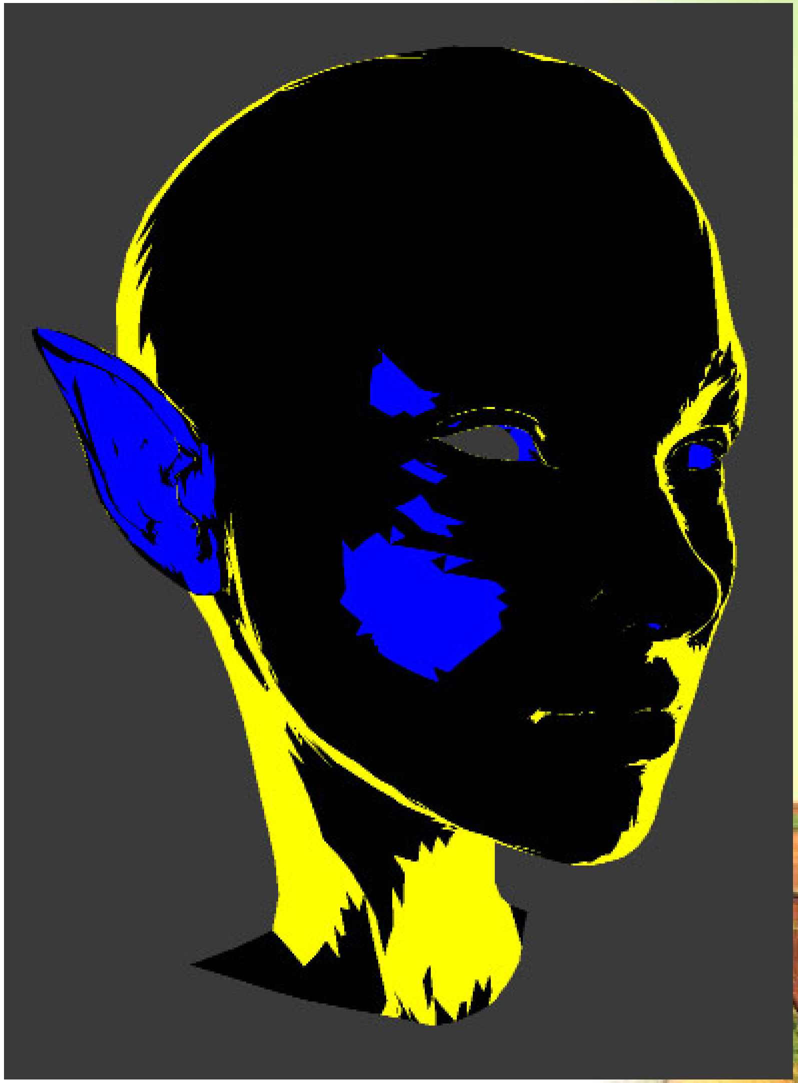
Call generator function

No user interface needed

Be sure to set address modes appropriate for individual texture and algorithm

Example Shader: uvDetective

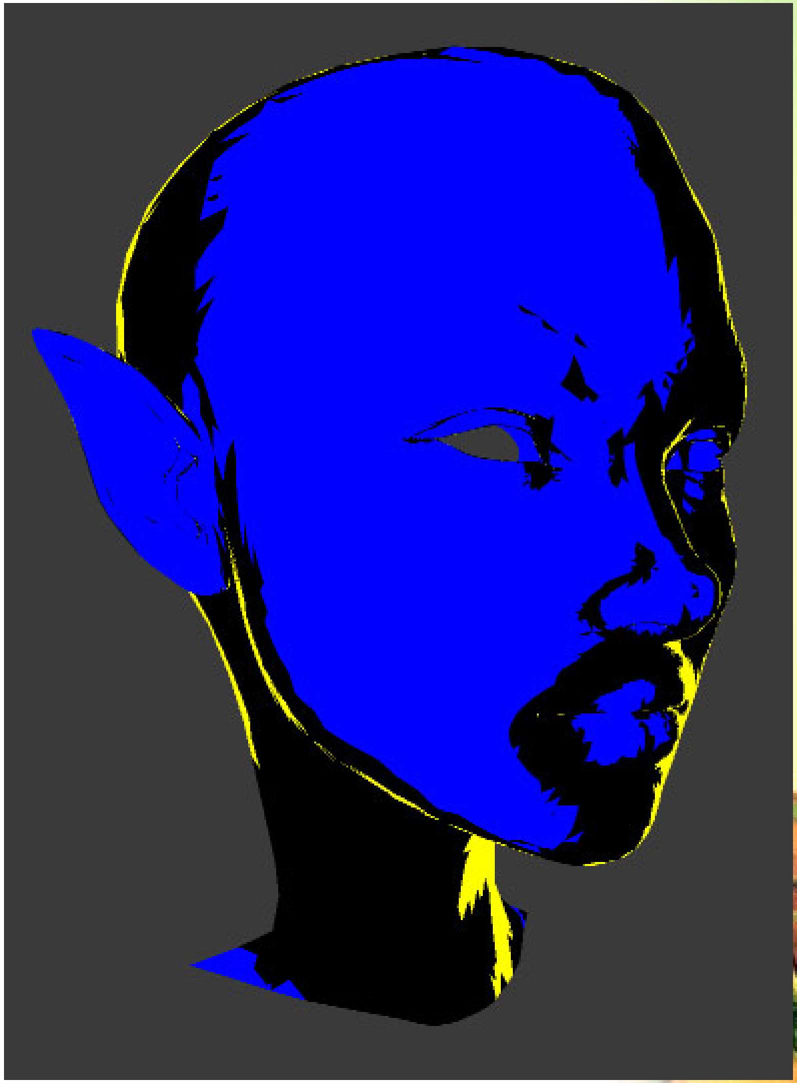
- Visualization for Artists Tuning Models
- Black – texture should be around 512x512 for close-to-texel-sized pixels



Black areas for 512x512 texture

Can be set to any size

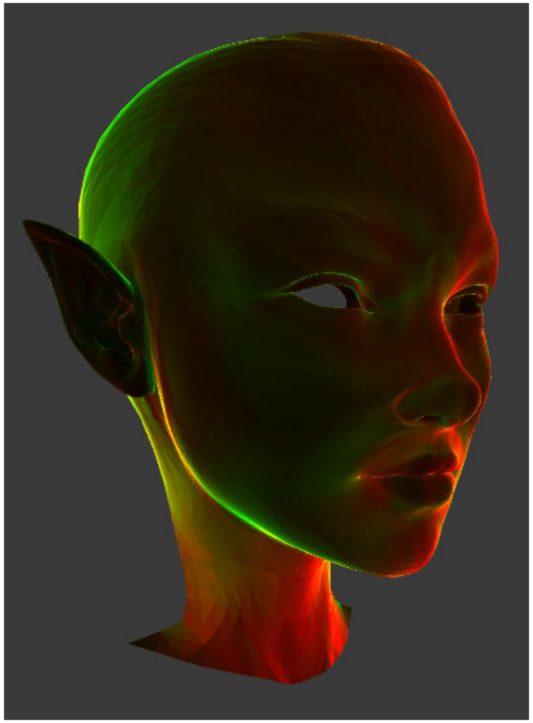
- **Now black is for 256 res**
- **Blue shows area where a higher-res texture *could* be useful**



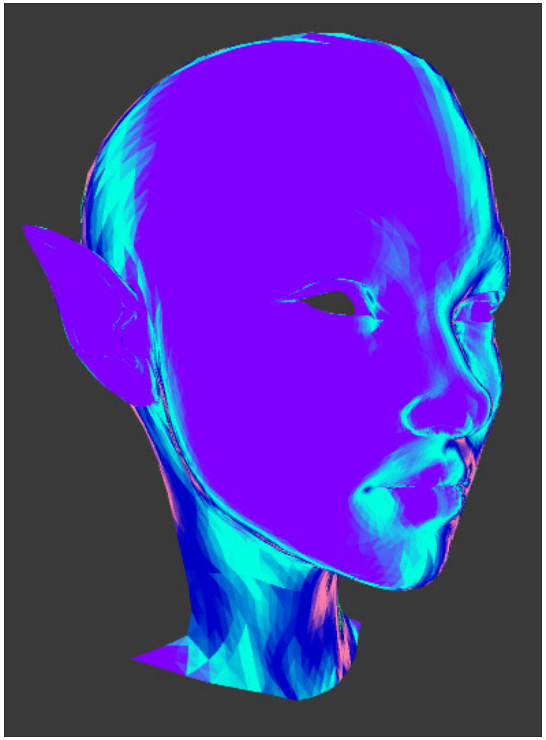
Black areas for 256x256 texture

Show Related Visualizations Too

- Direct Derivatives and (CPU-generated) false MIP coloring



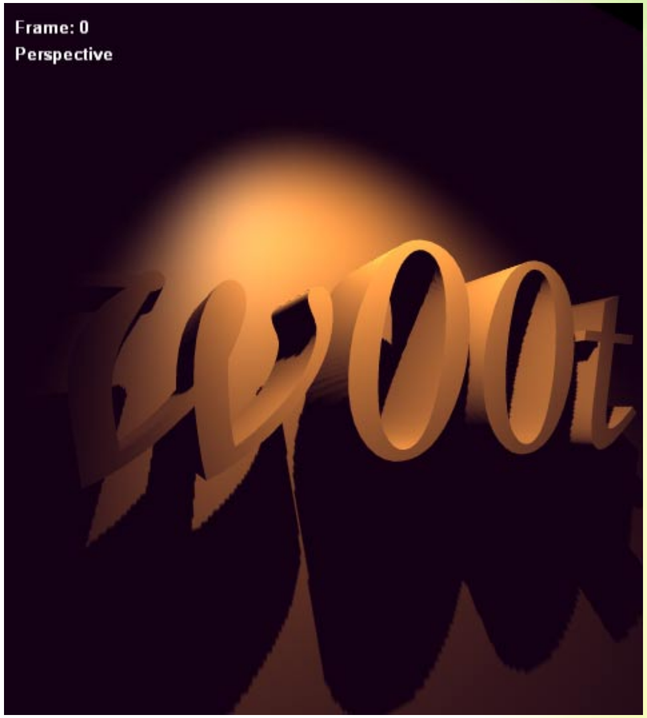
Direct Visualization of Texture Derivatives (Amount of texture stretching)



"False Color MIP Texture" Display (texture generated by uvDetective.fx)

Example Shader: shadowSpot2.fx

- Special shadow format
- DXSAS:
  - "sceneorobject" ScriptClass
  - Script/No Script
- Uses RenderPort
- Uses CPU intrinsics
- Include files:
  - shadowMap.fxh
  - spot_tex.fxh



HW shadow mapping

shadowSpot2 - shadow texture

- Shadow texture format
- We throw away color portion
- Vertex shader declared for us

Found in …\MEDIA\HLSL\

```
#include “shadowMap.fxh”

DECLARE_SHADOW_XFORMS("light0",LampViewXf,
      LampProjXf,ShadowViewProjXf)
DECLARE_SHADOW_BIAS
DECLARE_SHADOW_MAPS(ColorShadMap,ColorShadSampler,
      ShadDepthTarget,ShadDepthSampler)
```

Inside shadowMap.fxh - Maps

- DECLARE_SHADOW_MAPS will set up two map and sampler pairs
- Default Size is 512
- We can override by pre-#defining SHADOW_SIZE
- Uses format "D24S8_SHADOWMAP“ which will provide HW-accelerated multisample PCF filtering

```
DECLARE_SHADOW_MAPS(ColorShadMap,ColorShadSampler,
          ShadDepthTarget,ShadDepthSampler)
```

Inside shadowMap.fxh - Transforms

- DECLARE_SHADOW_XFORMS declares attachable transforms using special “frustum” annotation and an additional “static” declaration:

```
// DECLARE_SHADOW_XFORMS("light0",LampViewXf,
//                 LampProjXf,ShadowViewProjXf)
// expands to:

float4x4 LampViewXf : View < string frustum = “light0”; >;
float4x4 LampProjXf : Projection < string frustum = “light0”; >;
static float4x4 ShadowViewProj = mul(LampViewXf,LampProjXf);
```

“frustum” annotation

“static” declaration executes HLSL code on CPU each frame

Inside shadowMap.fxh - Bias

- DECLARE_SHADOW_BIAS will set up a user parameter “ShadBias”
- We can override range for small or large models by pre-#defining MAX_SHADOW_BIAS

```
DECLARE_SHADOW_BIAS
```

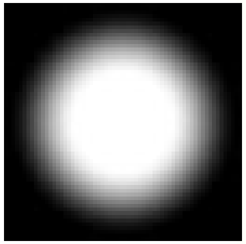
Inside shadowMap.fxh - Shaders

- Vertex shader for creating shadow maps: “shadCamVS”
- No pixel shader needed for shadow-creation passes
- Vertex shader for using shadow maps: “shadowUseVS”
  - Shadow projection TexCoords (UVs) passed in “LProj”
- Code sample in .fxh for usage in Pixel shaders

shadowSpot2 - spotlight pattern

- “SpotSamp” sampler will be declared for you and filled by CPU
- Compile-time shaping options

```
#include “spot_tex.fxh”
```



Default “spot_tex” texture

- Call “SpotSamp” using light projection UVs like so:

```
float cone = tex2Dproj(SpotSamp,IN.LProj);
```

shadowSpot2 - pixel shader

- Just shadow portion
- “LProj” provided by vertex shader “shadowUseVS”

```
float4 useShadowPS(ShadowingVertexOutput IN) : COLOR
{
   float3 litPart, ambiPart;
   lightingCalc(IN,litPart,ambiPart);
   float4 shadowed =  tex2Dproj(ShadDepthSampler,IN.LProj);
   return float4((shadowed.x*litPart)+ambiPart,1);
}
```

shadowSpot2 - pixel shader

- Compare to a completely unshadowed version:
  - We supply an *unshadowed* version for apps with limited DXSAS scripting, like 3DStudio Max
    - And declare ScriptClass = "sceneorobject";

```
float4 unshadowedPS(ShadowingVertexOutput IN) : COLOR
{
    float3 litPart, ambiPart;
    lightingCalc(IN,litPart,ambiPart);
    return float4(litPart+ambiPart,1);
}
```

shadowSpot2 - shadow technique

- Vertex shader from .fxh file:
- Note assign of “RenderPort”

```
technique Shadowed <
    string Script = "Pass=MakeShadow;”
           “Pass=UseShadow;";
> {
 pass MakeShadow <
     string Script = "RenderColorTarget0=ColorShadMap;"
          "RenderDepthStencilTarget=ShadDepthTarget;"
          "RenderPort=light0;"
          "ClearSetColor=ShadowClearColor;"
          "ClearSetDepth=ClearDepth;"
          "Clear=Color;"
          "Clear=Depth;"
          "Draw=geometry;";
 > {
    VertexShader = compile vs_2_0 shadowGenVS(WorldXf,WorldITXf,ShadowViewProjXf);
    ZEnable = true;
    ZWriteEnable = true;
    ZFunc = LessEqual;
    CullMode = None;
    // no pixel shader!
  }
  // . . . Continued . . .
```

“RenderPort” sets clipping etc correctly for this viw

Provided by shadowMap.fxh

shadowSpot2 - technique (cont’d)

- **Vertex Shader provided from .fxh**
- **Remember, Reset “RenderPort”**

Reset Renderport to scene camera

Provided by shadowMap.fxh

```
    // . . .
    pass UseShadow <
    string Script = "RenderColorTarget0=;"
                    "RenderDepthStencilTarget=;"
                    "RenderPort=;"
                    "ClearSetColor=ClearColor;"
                    "ClearSetDepth=ClearDepth;"
                    "Clear=Color;"
                    "Clear=Depth;"
                    "Draw=geometry;";
   > {
    VertexShader = compile vs_2_0 shadowUseVS(WorldXf,WorldITXf,
                    WorldViewProjXf,ShadowViewProjXf,
                    ViewIXf,ShadBiasXf, SpotLightPos);
    ZEnable = true;
    ZWriteEnable = true;
    ZFunc = LessEqual;
    CullMode = None;
    PixelShader = compile ps_2_a useShadowPS();
    }
}
```

shadowSpot2 – unshadowed technique

Frame: 0
Perspective

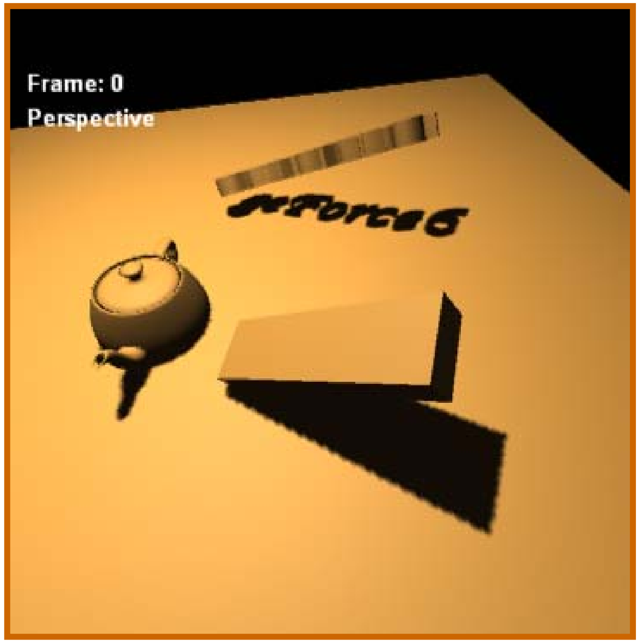
Scene w/o shadow

- Provided for apps like 3DS Max
- Just one pass, shared code
- DXSAS Script optional
- Declare ScriptClass “sceneorobject”

Provided by shadowMap.fxh

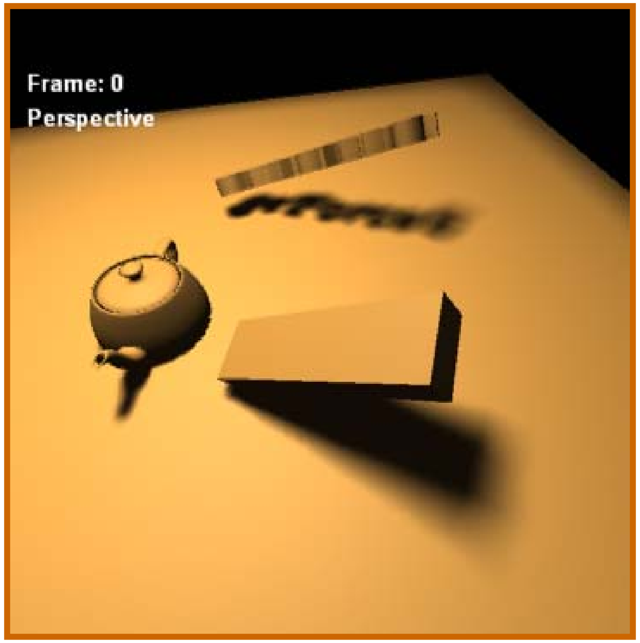
```
technique Unshadowed {
  pass NoShadow {
    VertexShader = compile vs_2_0 shadowUseVS(WorldXf, WorldITXf, WorldViewProjXf,
                                    ShadowViewProjXf, ViewIXf,
                                    ShadBiasXf, SpotLightPos);
    ZEnable = true;
    ZWriteEnable = true;
    ZFunc = LessEqual;
    CullMode = None;
    PixelShader = compile ps_2_a unshadowedPS();
  }
}
```

Differing Shadow Formats & Algorithms



D24S8 Shadow Maps

- Fast, good quality
- Antialiased on NVIDIA hardware
- sharp edges
- Trivial to use

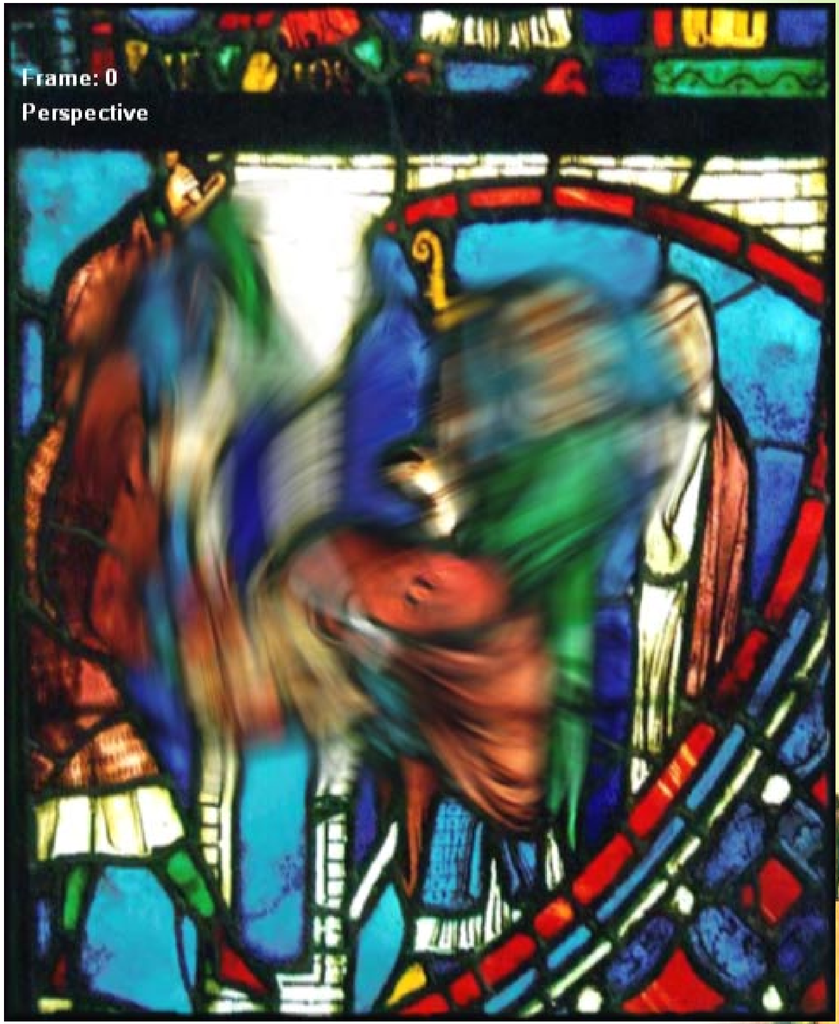


Floating Point

- Most flexible
- AA calculated in shader, so anything is possible
- Can be mixed with RGB in one texture

Example Shader: paint_blur

- Uses FP16 Blending
- Uses DXSAS accumulation loops
- Uses “bool loops”
- Uses CPU funcs and static vars for mouse tracking



Painted Accumulation-Buffer Motion Blur

Paint_blur - Three key params

- **Loop counter & limit**
- **RESET pulse boolean**
  - **Can also be toggled manually**

```
float passnumber <string UIWidget = "none";>;
float npasses <
   float UIStep = 1.0;
   string UIName = “# of blur passes";
> = 8.0f;
bool bReset : FXCOMPOSER_RESETPULSE
<
   string UIName="Clear Canvas?";
>;
```

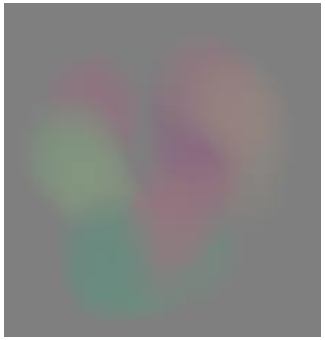
Hidden loop counter

Dedicated Semantic

Declaring Floating Point Textures

- **Just like any other texture**
- **Our paint strokes are added using Alpha Blending - works fine on FP16 formats**
- **Caution: FXC will still compile if a format is not available - it will switch to 8bit int**

```
DECLARE_QUAD_TEX(PaintTex,PaintSamp,"A16B16G16R16F")
```



A sample "live" displacement texture

Paint_blur - DXSAS looping

- **Loop value from parameter in technique script**
  - **Change value to change blur quality**

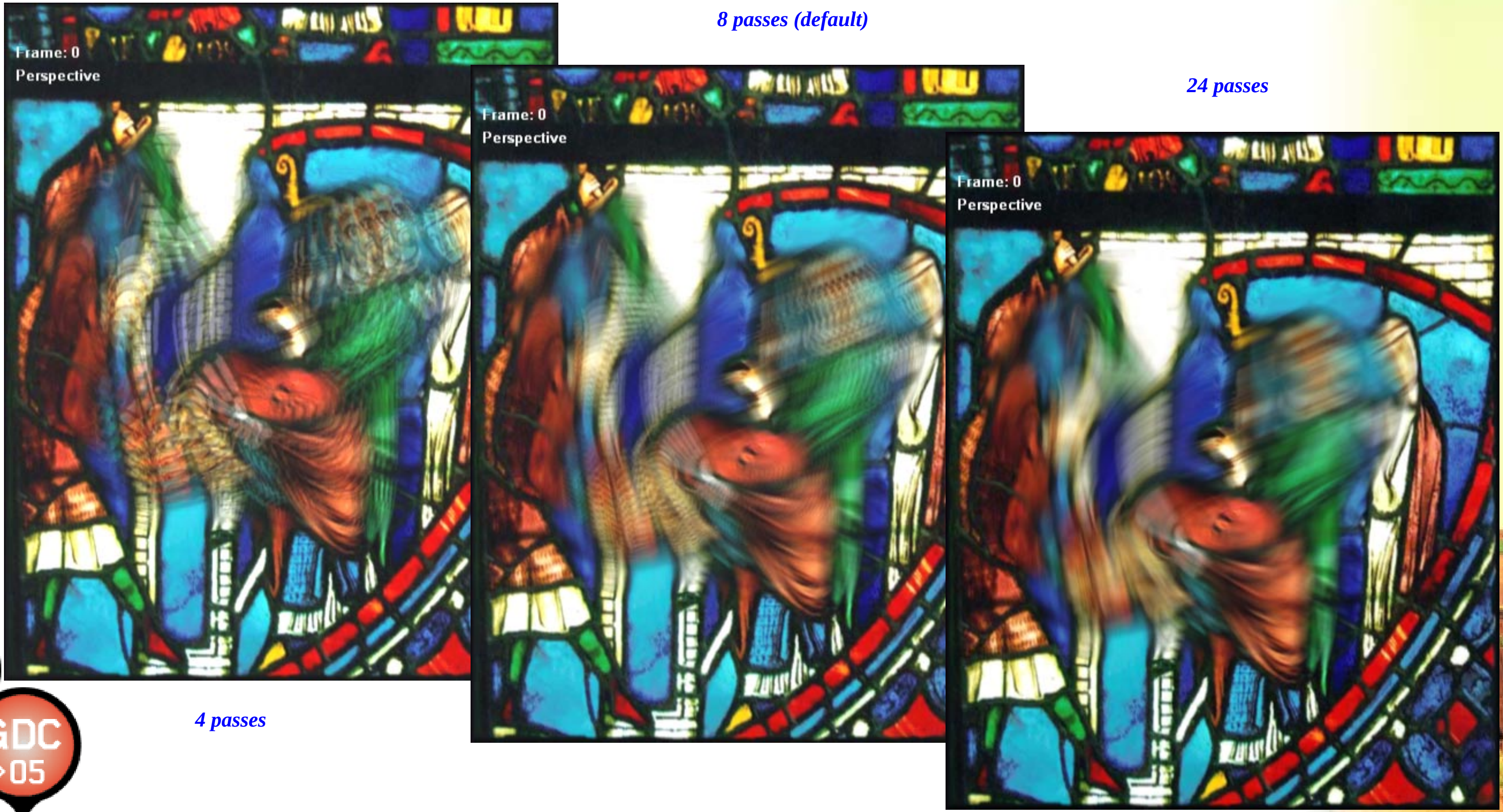
```
string Script =
   // Clear Accum Buffer
   "RenderColorTarget0=AccumBuffer;"
   "ClearSetColor=ClearColor;"
   "Clear=Color;"
   // paint into blur-dir buffer...
   "Pass=paint;"
   // accumulate
   "LoopByCount=npasses;"
        "LoopGetIndex=passnumber;"
        "Pass=Accumulate;"
   "LoopEnd;"
   // draw accum buffer to framebuffer
   "Pass=FinalPass;";
```

User-defined loop limit

Script counter assignment

Effects of Changing Pass Count

- **Tune for Quality versus Performance**



4 passes

8 passes (default)

24 passes

Paint_blur - DXSAS “bool” looping

- Loop value from RESET, inside script for “Paint” pass
  - Painting clears itself as needed
  - Otherwise “PaintTex” persists from frame to frame

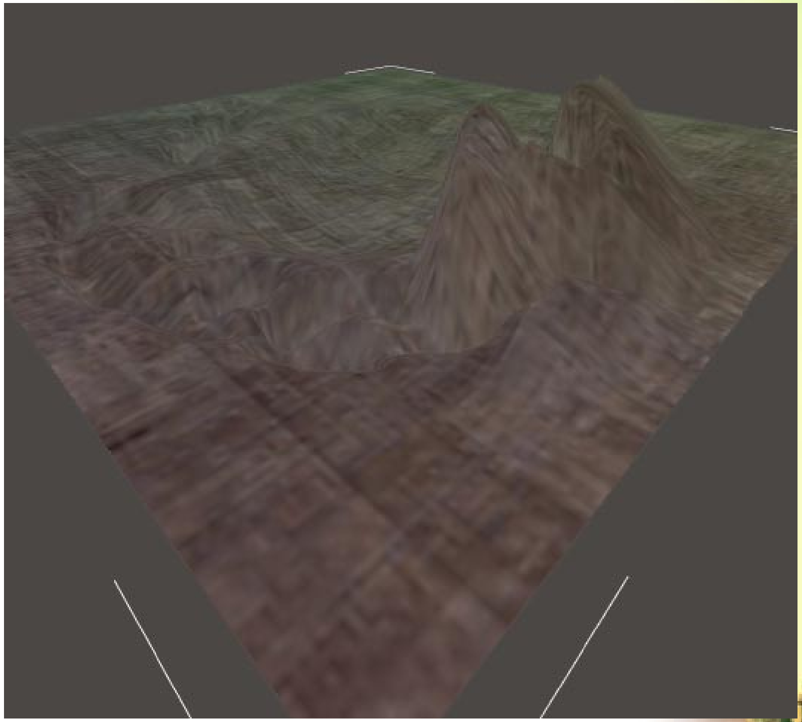
```
string Script =
   "RenderColorTarget0=PaintTex;"
   "RenderDepthStencilTarget=;"
   "LoopByCount=bReset;"
             "ClearSetColor=ClearColor;"
             "Clear=Color0;"
             "LoopEnd=;"
   "Draw=Buffer;";
```

With “bool” value, acts like “if()”

“PaintTex” display

Example shader: paint_sculpt

- Uses FP blending
- Converts to FP32
- Uses FP32 VTF



Live texture sculpting on static plane

Paint_sculpt - mixing data

- **FP16 blending for paint, as before**
- **Extra copy pass for VTF FP32**
- **Use Quad.fxh utility shaders**

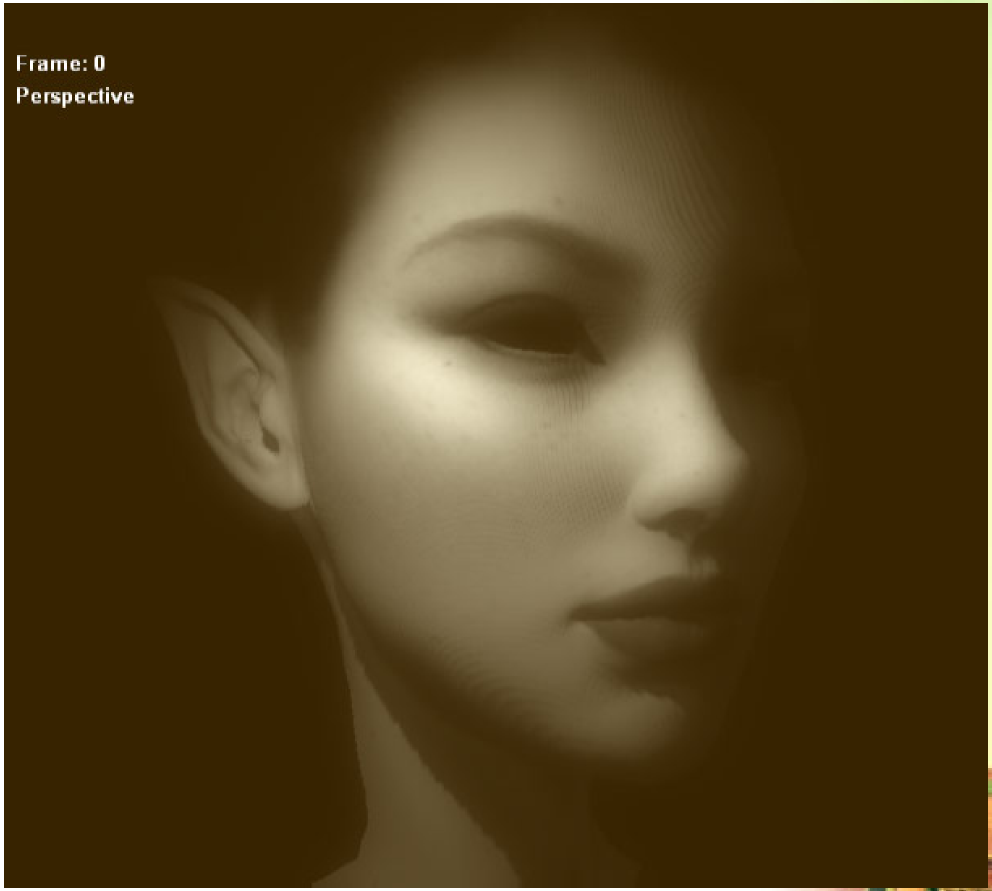
```
pass boost <
   string Script =    "RenderColorTarget0=DisplaceMap;"
                      "Draw=Buffer;";
> {
   VertexShader = compile vs_3_0 ScreenQuadVS();
   ZEnable = false;
   ZWriteEnable = false;
   CullMode = None;
   PixelShader = compile ps_3_0 TexQuadPS(PaintStrokeSampler);
}
```

Provided by Quad.fxh

Provided by Quad.fxh

Example shader(s): post_holga & friends

- Uses noise_2d, spot_tex, Quad.fxh,
- FP16 if you have it
- DXSAS Effect stacking

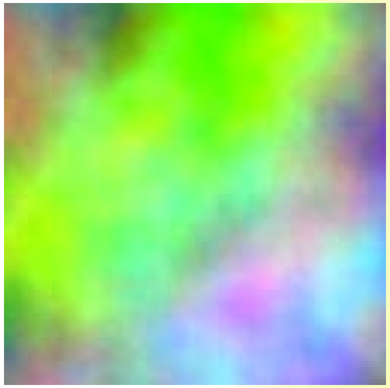


Dusk's 1935 Debut

Post_holga - noise textures

- **Textures are still the fastest way to get noise in pixel shading**
  - **This noise, at low scales, will also be pretty continuous at a variety of visible sizes**
- **Emulate Optical Distortion by Offseting screen U,V with 2D Noise**
- **Default NOISE2D_SCALE was 500 - we want *much* smoother noise for this application**

```
#define NOISE2D_SCALE 1
#define NOISE2D_FORMAT "A16B16G16R16F"
#include "noise_2d.fxh"
```

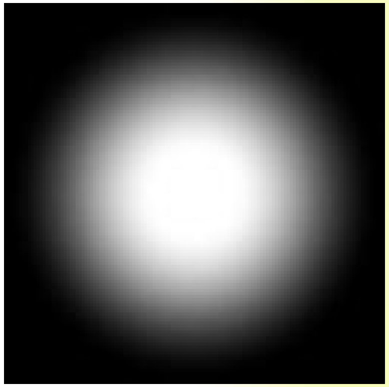


2D Noise

Post_holga - spot_tex

- Using this texture for a different purpose – to isolate distortion to the edges of the frame, and to control the vignetting effect
- Change a couple of defaults to get a different shape

```
#define SPOT_TEX_SIZE 128
#define SPOT_TEX_INSIDE 0.2
#include "spot_tex.fxh"
```



Tweaked spot_tex image

Post_holga - buffering the scene

- **Post_holga (and other postprocess effects) are declared ScriptOrder=“postprocess”**
- **We use “ScriptExternal=” to hand-off scene rendering to FX Composer, while using our own texture (“SceneMap”) as the scene render target, rather than the framebuffer**

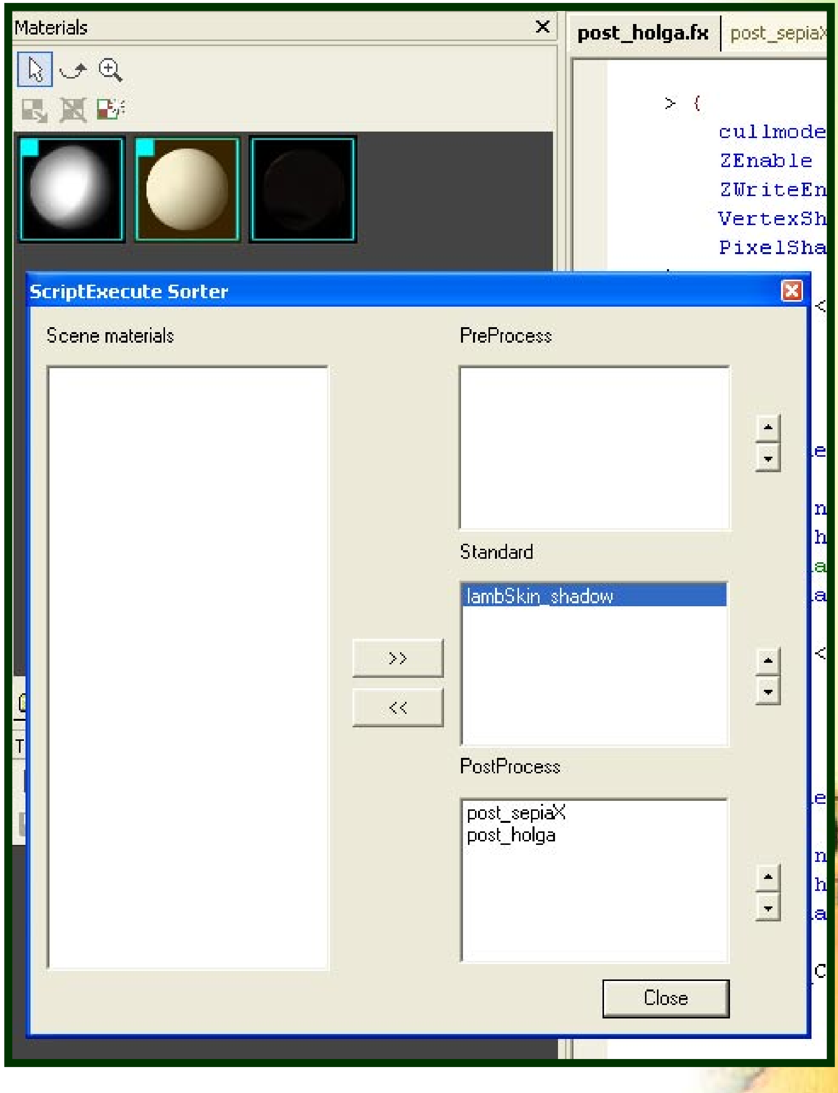
```
string Script = "ClearSetDepth=ClearDepth;"
        "RenderColorTarget=SceneMap;"
        "RenderDepthStencilTarget=DepthMap;"
        "ClearSetColor=ClearColor;“
        "ClearSetDepth=ClearDepth;"
               "Clear=Color;"
        "Clear=Depth;"
        "ScriptSignature=color;"
        "ScriptExternal=;"
        "Pass=DownSample;"
        "Pass=GlowH;"
        "Pass=GlowV;"
        // . . .
```

What do I output?

Render all “below” me

Adding More Shaders to the Scene

- Use the ScriptExecute Sorter, found in the menu of the Materials Pane
- Build up the look you like
- Maybe reduce to one shader later (maybe not)



```
> {
    cullmode
    ZEnable
    ZWriteEn
    VertexSh
    PixelSha
```

Standard: lambSkin_shadow

PostProcess: post_sepiaX, post_holga

The ScriptExecute Sorter

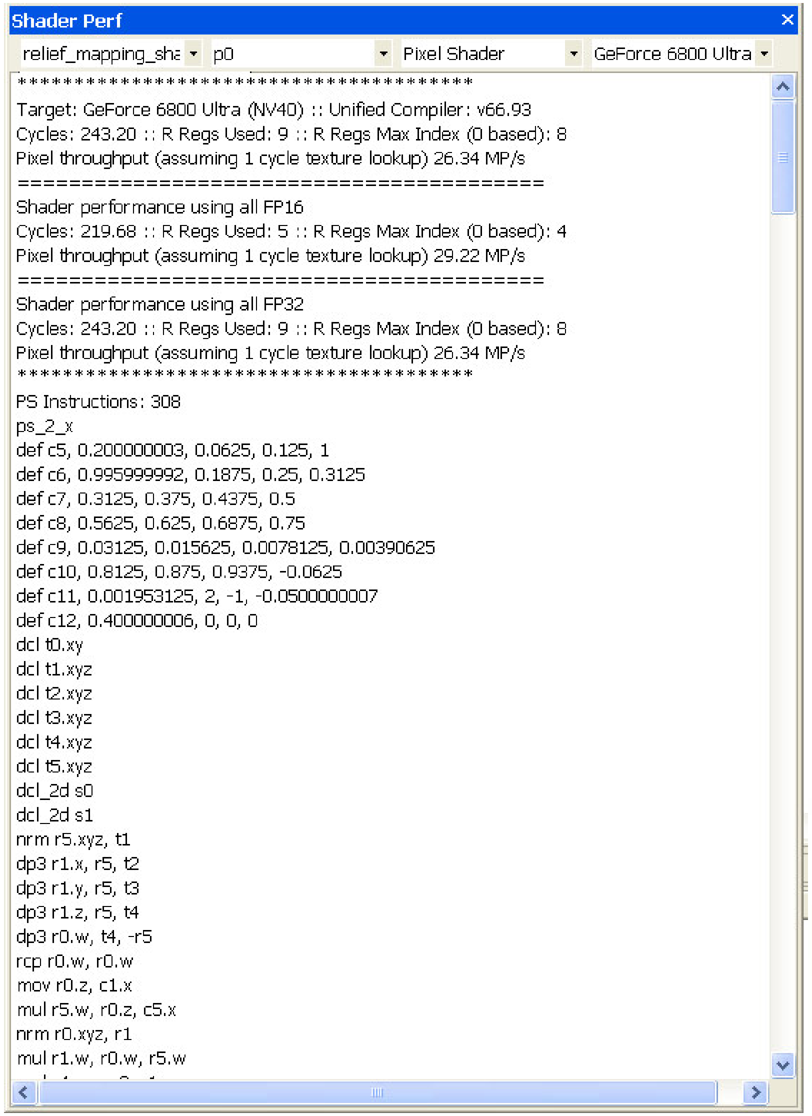
Fast Exploration of Algorithms

- Shading Algorithms can be quickly explored without having to rewrite your game engine just to try things out

Relief Mapping Shaders
By Fabio Policarpo

CPU-guided Performance Analysis

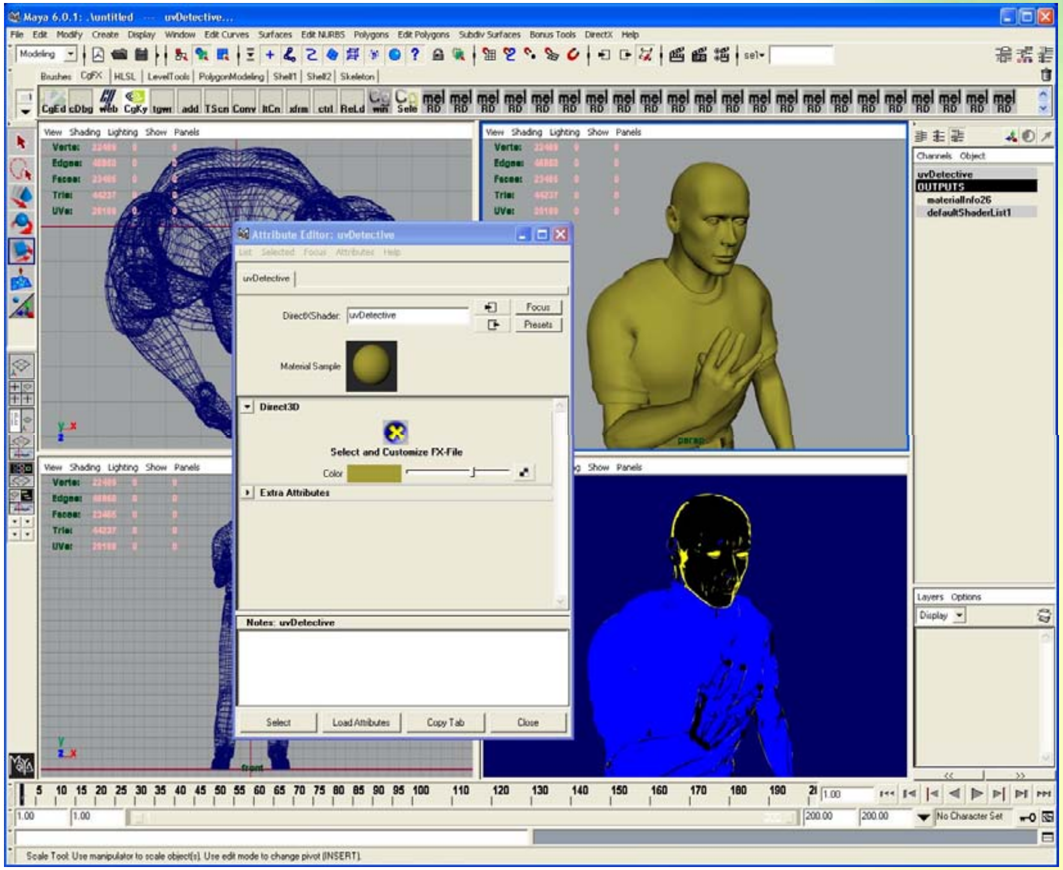
- **“Shader Perf” panel can analyze performance for chips you don’t even have!**
  - **This sample image of NV40 pixel shader analysis from my nv36M laptop**



```
****************************************
Target: GeForce 6800 Ultra (NV40) :: Unified Compiler: v66.93
Cycles: 243.20 :: R Regs Used: 9 :: R Regs Max Index (0 based): 8
Pixel throughput (assuming 1 cycle texture lookup) 26.34 MP/s
==========================================
Shader performance using all FP16
Cycles: 219.68 :: R Regs Used: 5 :: R Regs Max Index (0 based): 4
Pixel throughput (assuming 1 cycle texture lookup) 29.22 MP/s
==========================================
Shader performance using all FP32
Cycles: 243.20 :: R Regs Used: 9 :: R Regs Max Index (0 based): 8
Pixel throughput (assuming 1 cycle texture lookup) 26.34 MP/s
****************************************
PS Instructions: 308
ps_2_x
def c5, 0.200000003, 0.0625, 0.125, 1
def c6, 0.995999992, 0.1875, 0.25, 0.3125
def c7, 0.3125, 0.375, 0.4375, 0.5
def c8, 0.5625, 0.625, 0.6875, 0.75
def c9, 0.03125, 0.015625, 0.0078125, 0.00390625
def c10, 0.8125, 0.875, 0.9375, -0.0625
def c11, 0.001953125, 2, -1, -0.0500000007
def c12, 0.400000006, 0, 0, 0
dcl t0.xy
dcl t1.xyz
dcl t2.xyz
dcl t3.xyz
dcl t4.xyz
dcl t5.xyz
dcl_2d s0
dcl_2d s1
nrm r5.xyz, t1
dp3 r1.x, r5, t2
dp3 r1.y, r5, t3
dp3 r1.z, r5, t4
dp3 r0.w, t4, -r5
rcp r0.w, r0.w
mov r0.z, c1.x
mul r5.w, r0.z, c5.x
nrm r0.xyz, r1
mul r1.w, r0.w, r5.w
```

FX Composer & Maya

- **Microsoft DX9 Viewer**
  - Newest in February 2005 DirectX SDK Update
  - Special sub-dialog from Attribute Editor
  - Maya 6 or Maya 5
  - DirectX in Maya window or “floater”
  - Integrates .X exporter


Maya 6.0.1: .\untitled --- uvDetective...
File Edit Modify Create Display Window Edit Curves Surfaces Edit NURBS Polygons Edit Polygons Subdiv Surfaces Bonus Tools DirectX Help
Modeling
Brushes CgFX HLSL LevelTools PolygonModeling Shelf1 Shelf2 Skeleton
View Shading Lighting Show Panels
Verts: Edges: Faces: Tris: UVs:
Channels Object
uvDetective
OUTPUTS
materialInfo26
defaultShaderList1
Layers Options
Display
front
Attribute Editor: uvDetective
List Selected Focus Attributes Help
uvDetective
Focus
Presets
Material Sample
Direct3D
Select and Customize FX-File
Color
Extra Attributes
Notes: uvDetective
Select
Load Attributes
Copy Tab
Close
No Character Set

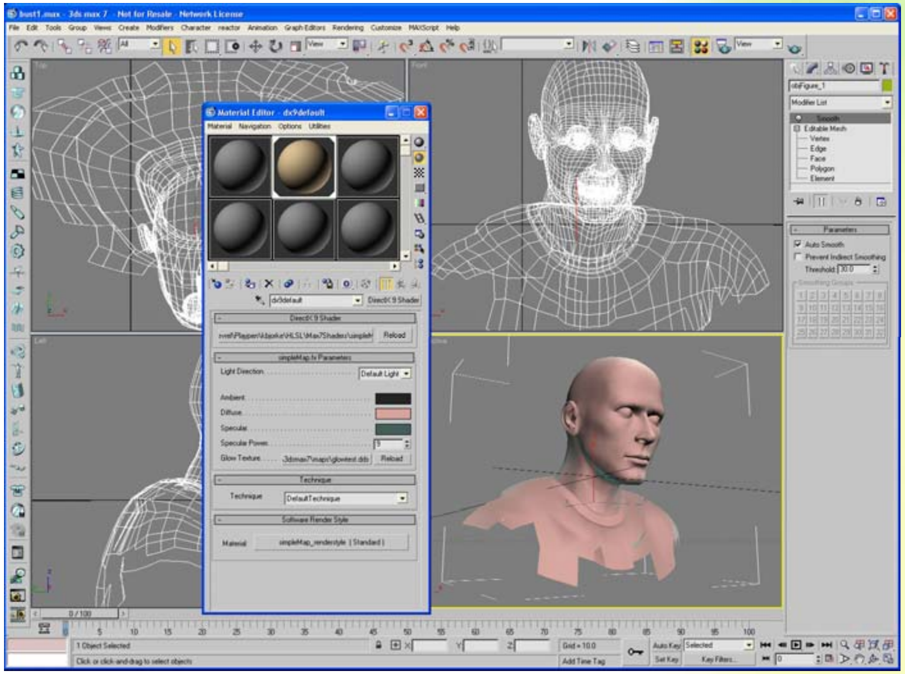
DirectXShader: uvDetective

Scale Tool: Use manipulator to scale object(s). Use edit mode to change pivot (INSERT).

Maya 6.0.1 Model showing “uvDetective”

FX Composer & 3DS Max 7

- **3DStudio Max support for DX9 built-in**
  - Define shaders in Max Materials Pane
  - Limited DXSAS support so far
  - Which is why we make shadow scripts “smart”
  - New NVB exporter from 3DS Max will carry all FX Composer attributes too.



dx9default | DirectX 9 Shader

Light Direction: Default Light

Ambient

Diffuse

Specular

Specular Power: 9

Glow Texture: 3dsmax7\maps\glowtest.dds

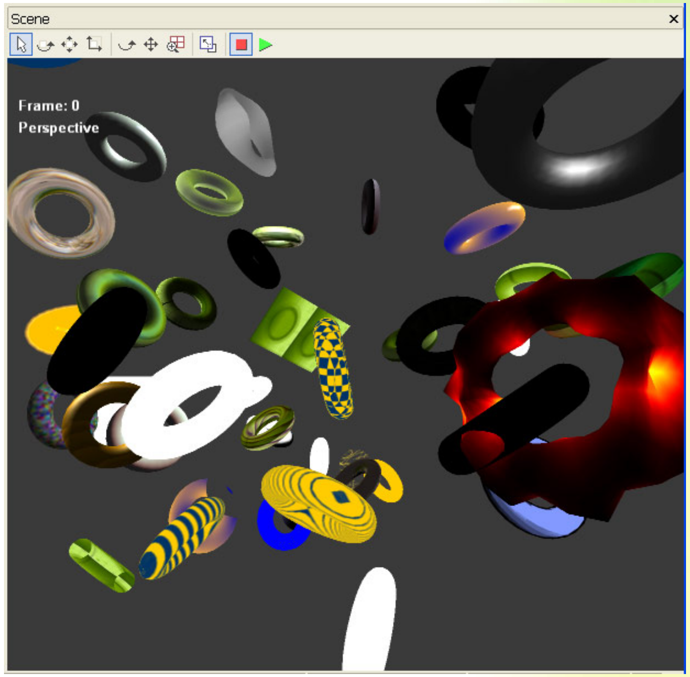
Technique: DefaultTechnique

Material: simpleMap_renderstyle (Standard)

HLSL Shader in 3DS Max 7

C# Scripting

- Can use C# or Visual Basic, with full text-edit intellisense etc
  - Works off .NET “CLR” so others could work too
- Setting Animation Keys
  - From Programs or External Files
- Creating Objects
  - From Primitives or External Files
  - Can call C++ plugins or work directly
- Cycling Through Shaders and Projects
  - Preview examples like “Scatter_scene.cs”
- Exporting
  - See example “export_material_keys.cs” to access and export all properties of the current scene to XML
- Most FX Composer Internals Are Exposed
  - Use the OLE Viewer in Visual Studio, expand library “nvsys”
    - Data types, structures, and methods are all there



Sample Animated Display from “scatter_scene.cs”

Sample C# Script: “rtzImport.cs”

- Translates app-specific semantics from RTZen Ginza (http://www.rtzen.com/) FX export files into forms most-friendly to FX Composer.
- Creates a tweaked copy of your Ginza shader, then opens it.
- Be sure to include the RTZen path “...\RTShaderGinza\media\images\” in your FX Composer Settings... dialog

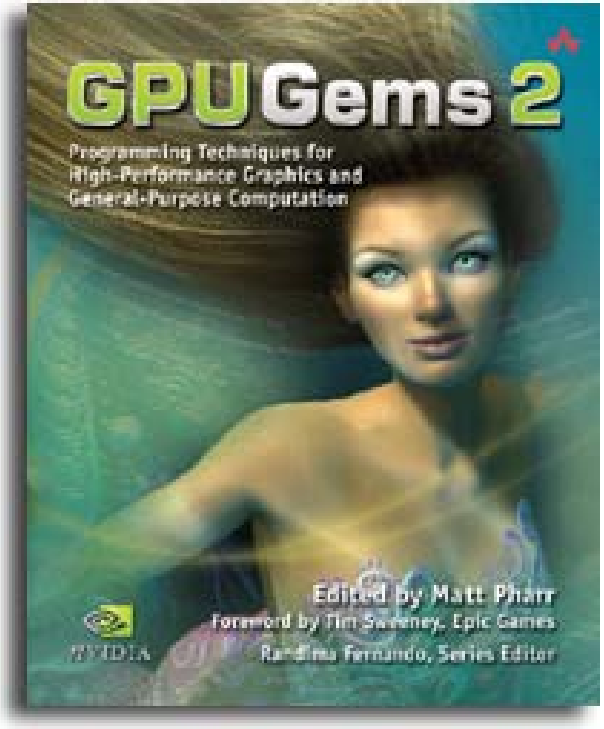
Connecting Outside of FX Composer

- User-defined annotations and semantics: "…\data\fxmapping.xml"
- Geometry Importers & C++ SDK
- More!
  - But we're out of time…
  - Details on the web site
- *Thanks!*

Sepia + Holga + lambSkin_shadow

GPU Gems 2

Programming Techniques for High-Performance Graphi
and General-Purpose Computation


GPU Gems 2
Programming Techniques for
High-Performance Graphics and
General-Purpose Computation
Edited by Matt Pharr
Foreword by Tim Sweeney, Epic Games
Randima Fernando, Series Editor
NVIDIA

- **880 full-color pages, 330 figures, hard cover**
- **$59.99**
- **Experts from universities and industry**

"The topics covered in *GPU Gems 2* are critical to the next generation of game engines."

— Gary McTaggart, Software Engineer at Valve, Creators of Half-Life and Counter-Strike

"*GPU Gems 2* isn't meant to simply adorn your bookshelf—it's required reading for anyone trying to keep pace with the rapid evolution of programmable graphics. If you're serious about graphics, this book will take you to the edge of what the GPU can do."

—Rémi Arnaud, Graphics Architect at Sony Computer Entertainment