An Introduction to RenderMan Shaders for all you GLSLers!

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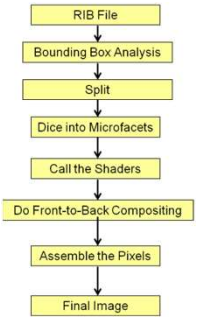

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Why Are We Even Talking About This?

1. You never know – in the future you might be in a position to use RenderMan in the making of movies, TV commercials, etc.
2. You can get RenderMan for free for non-commercial use. It is fun to experiment with.
3. You will be surprised how close what you know now matches what you need to know to run RenderMan shaders. (Congratulations!)

You can get the non-commercial version of RenderMan by starting here:

https://renderman.pixar.com/intro

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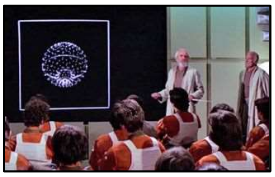
History of RenderMan, I

1977: Star Wars IV: A New Hope



1979: Ed Catmull, Alvy Ray Smith, and others leave NYIT to form the Computer Division of Lucasfilm

Image Processing

Digital Editing and Compositing

Effects

Image/Volume Rendering Hardware

1984: John Lassiter leaves Disney Animation to join Pixar

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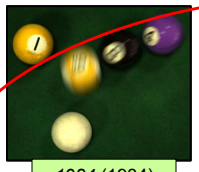
History of RenderMan, II

Image/Volume Rendering Hardware

Star Trek II (1982)
Young Sherlock Holmes (1985)

Pixar Image Computer

Rendering Software



1984 (1984)

REYES

RenderMan

Pixar Animation Studios

RIB

Shade Trees

prman

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History of RenderMan, III

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Pixar Animation Studios

1986: *Luxo Jr.*– Nominated for an Academy Award

1988: *Tin Toy* – won Academy Award for Best Animated Short

1993: RenderMan wins a Technical Academy Award

1995: *Toy Story*

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Early Uses of RenderMan in Movies

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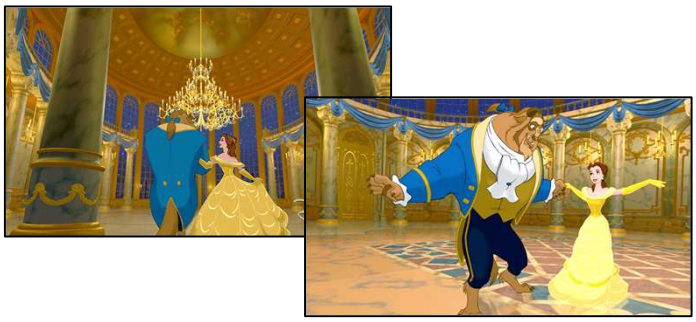

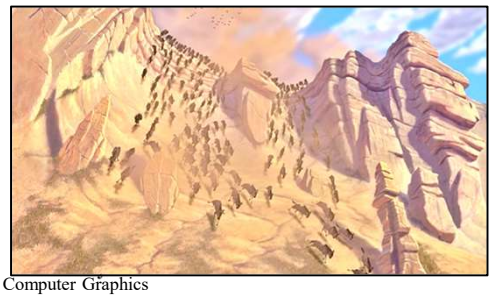

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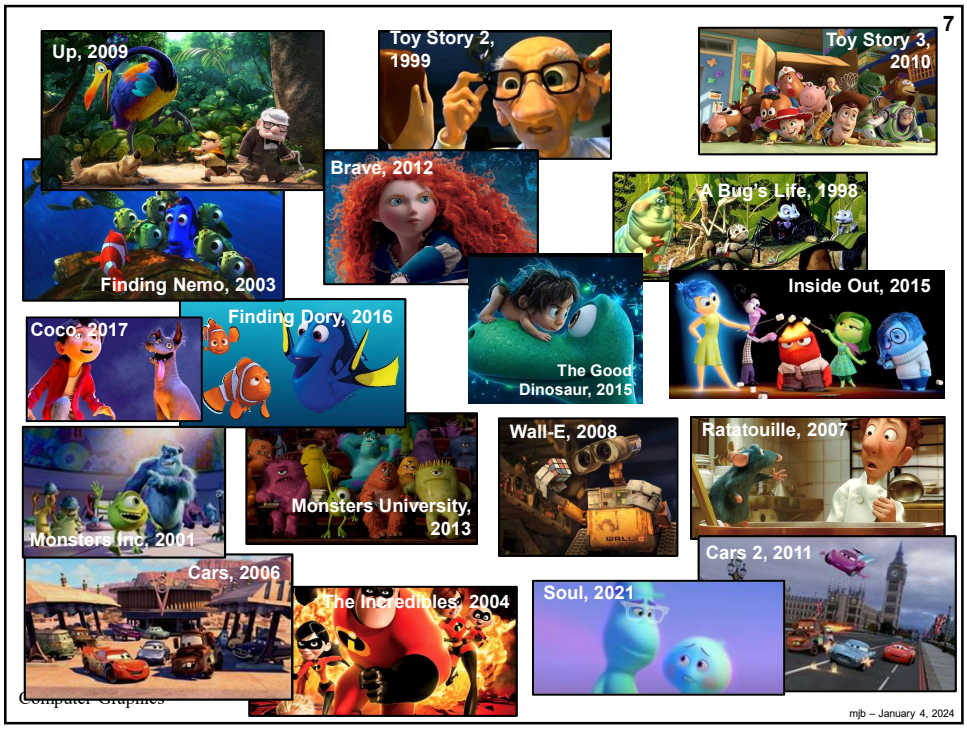
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Up, 2009
Toy Story 2, 1999
Toy Story 3, 2010
Brave, 2012
A Bug's Life, 1998
Finding Nemo, 2003
Inside Out, 2015
Coco, 2017
Finding Dory, 2016
The Good Dinosaur, 2015
Wall-E, 2008
Ratatouille, 2007
Monsters Inc, 2001
Monsters University, 2013
Cars 2, 2011
Cars, 2006
The Incredibles, 2004
Soul, 2021
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Tangled, 2010
Moana, 2016
Frozen, 2013
Frozen II, 2019
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RenderMan Software Rendering Pipeline

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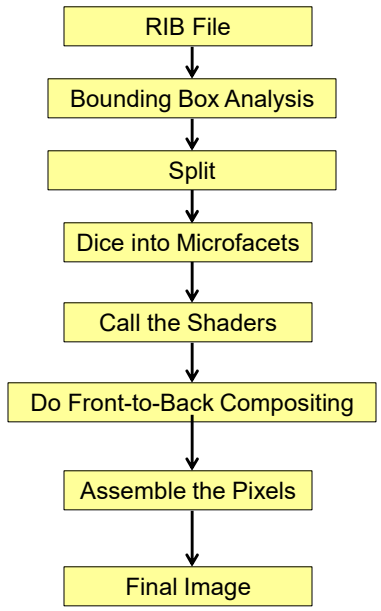

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RenderMan Composites Starting at the Eye

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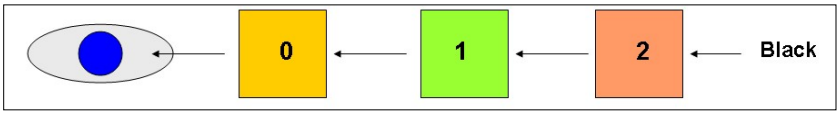
First, let's think about it back-to-front:



$$color_{12} = \alpha_2 color_2 + (1-\alpha_2) black,$$

$$color_{01} = \alpha_1 color_1 + (1-\alpha_1) color_{12},$$

$$color^* = \alpha_0 color_0 + (1-\alpha_0) color_{01}.$$

Substituting gives us the front-to-back equation:

$$color^* = \alpha_0 color_0 + (1-\alpha_0)\alpha_1 color_1 + (1-\alpha_0)(1-\alpha_1)\alpha_2 color_2 + (1-\alpha_0)(1-\alpha_1)(1-\alpha_2) black.$$

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RenderMan Renders at Higher-than-Screen-Resolution

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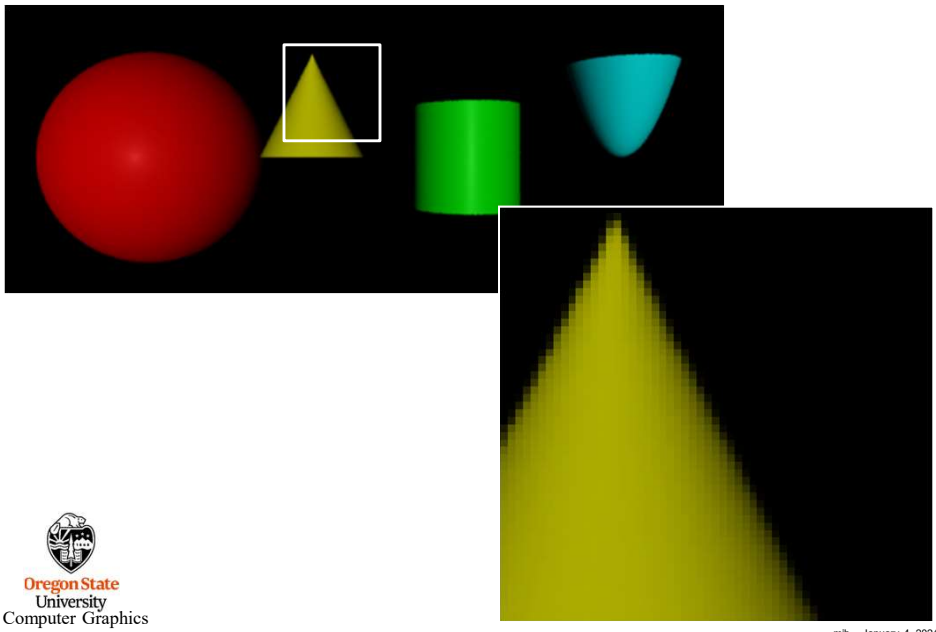

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All Six RenderMan Shader Types

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1. Displacement → ≈ GLSL Vertex Shader
2. Distortion / transformation → ≈ GLSL Vertex Shader
3. Surface → ≈ GLSL Fragment Shader
4. Lighting → ≈ GLSL Fragment Shader
5. Atmospheric / volumetric → ≈ GLSL Fragment Shader
6. Imaging → ≈ GLSL Fragment Shader

RenderMan ***Built-in Microfaceting*** ≈ Manual or GLSL Tessellation

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Fundamental Differences Between RenderMan Shaders and GLSL Shaders

Topic	RenderMan	GLSL
Goals	1. Image quality, 2. Speed	1. Speed, 2. Image quality
Shader Types	Surface, Displacement (+4 others)	Vertex, Fragment, Geometry, Tessellation, Compute
Surface Preprocessing	Microfacets	None [± Tessellation shaders]
Recompute Normals	CalculateNormal	None
Getting Rid of Pixels	Oi = 0.;	discard;
Surface/Fragment shader sets	R, G, B, αr, αg, αb	R, G, B, A [,Z]
Shader Variables	Uniform, Varying	Attribute, Uniform, Out, In
Coordinate Systems	Shader (=Model), World	Model (=OC), Eye (≈WC)
Noise	Built-in	Somewhat built-in or use a Texture
Compile Shaders	Must do yourself	Driver does it for you
Compiler messages	Cryptic	Cryptic

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RIB Commands, I

```
Display         "outputimage.tiff"  "tiff"  "rgb"
Display         “outputimage.shd”  “shadow”  “z”
Imager          “background”  “color”  [r g b]
Clipping        znear  zfar
Format          1280  1024  1.0
PixelSamples    2  2
PixelFilter     “Gaussian”  4  4
Projection      “perspective”  “fov”  60.
ScreenWindow        xleft  xright  ybottom  ytop
Translate       tx  ty  tz
Rotate          deg  rx  ry  rz
Scale           sx sy sz

WorldBegin
WorldEnd

AttributeBegin
AttributeEnd

Color           [ r g b ]
Opacity         [ r g b ]

Surface         “Plastic”  “Ka”  ka  “Kd”  kd  “Ks”  ks  “roughness”  r  “specularcolor”  [r g b]
LightSource     “ambientlight”  num  “intensity”  i  “lightcolor”  [r g b]
LightSource     “distantlight”  num  “intensity”  I  “lightcolor”  [r g b]  “from” [x y z]  “to”  [x y z]
```

Co

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RIB Commands, II


```
Polygon       "P" [x0 y0 z0  x1 y1 z1 ...]  "st"  [s0 t0  s1 t1  ...]

Points        "P" [x0 y0 z0  x1 y1 z1 ...]  "constantwidth"  w
Points        "P" [x0 y0 z0  x1 y1 z1 ...]  "width"  [w0  w1  ...]

Sphere        radius  zmin  zmax  sweepAngle
Cylinder      radius  zmin  zmax  sweepAngle
Cone          height  radius  sweepDegrees
Torus         majorRadius  minorRadius  startAngle  endAngle  sweepAngle
Hyperboloid   x0 y0 z0  x1 y1 z1  sweep_Angle
Paraboloid    zmaxRadius  zmin  zmax  sweepAngle
Disk          xHeight  radius  sweepAngle

Basis         "Bezier"  3
Curves        "cubic"  [4]  "nonperiodic"  "P"  [x0 y0 z0  x1 y1 z1  ...] "constantwidth"  [w]

TransformEnd
TransformBegin
```

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Cartesian (X) Stripes

stripes.rib

```
##RenderMan RIB
version 3.03
Declare "Prob"     "uniform float"

Display "stripes.tiff" "file" "rgb"
Format   512   512    -1
ShadingRate 1

LightSource  "ambientlight"  1  "intensity"   [0.25]
LightSource  "distantlight"    2  "intensity"  [0.75] "from"  [0  0  -10] "to"  [0  0  0]

Projection "perspective"  "fov"  [70]
WorldBegin
  Translate 0 0 8
  Surface "stripes"  "Prob" 0.8
  Color     [1  1  1]
  Opacity [1  1  1]
  Sphere 3  -3  3  360
  Translate 2.  0.  0.
WorldEnd
```

Tells RenderMan to start using a surface shader file called **stripes.slo**

Says that we want to set the **Prob** argument in that shader to **0.8**

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stripes.sl

Cartesian (X) Stripes

```
surface
stripes( float
        Prob = 0.4,  // probability of seeing orange
        Ks = 0.5,
        Kd = 0.5,
        Ka = .1,
        roughness = 0.1;
    color   specularColor = color( 1, 1, 1 )
)
{
        color stripeColor;

        float x = xcomp( P );
        //x = x + 0.30 * sin( 1. * ycomp(P) );                    // adding a wobble
        float xfrac = mod( x, 1. );

        if( xfrac < Prob )
                stripeColor = color( 1., .5, 0. );       // beaver orange?
        else
                stripeColor = Cs;

        varying vector Nf = faceforward( normalize( N ), I );
        vector V = normalize( -I );

        Oi = 1.;
        Ci = Oi * ( stripeColor * ( Ka * ambient( ) + Kd * diffuse(Nf) ) +
                                        specularColor * Ks * specular( Nf, V, roughness )  );
}
```


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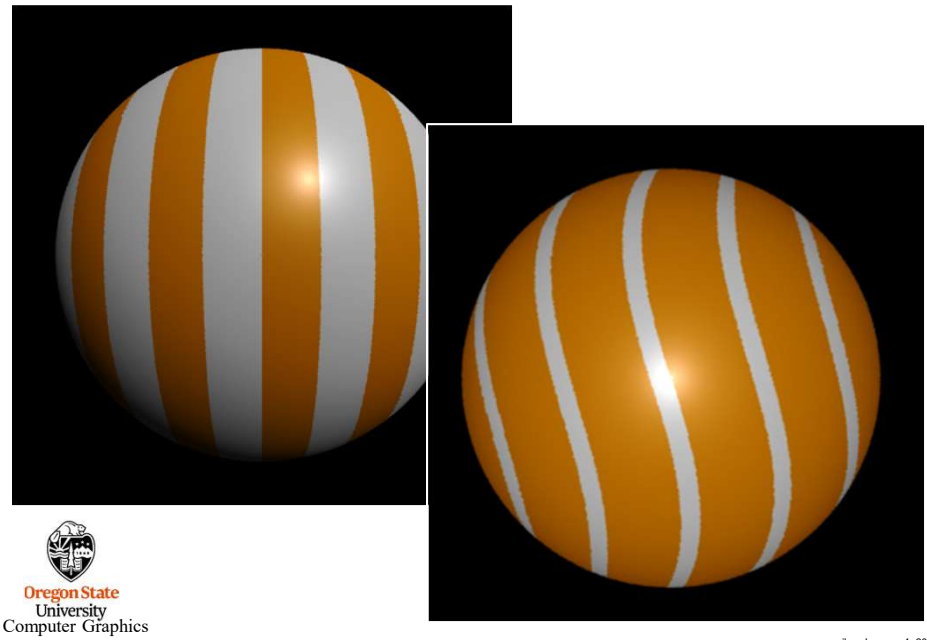
Cartesian (X) Stripes



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Rings

rings.rib

```
##RenderMan RIB
version 3.03
Declare "Prob"     "uniform float"

Display  "rings.tiff"  "file"  "rgb"
Format  500   500    -1
ShadingRate 1

LightSource  "ambientlight"  1  "intensity"   [0.25]
LightSource  "distantlight"    2  "intensity"  [0.75] "from"  [5  0  -10] "to"  [0  0  0]

Projection  "perspective"  "fov"  [70]
WorldBegin
  Translate 0 0 8
  Surface  "rings"   "Prob"  0.6
  Color     [1  1  1]
  Opacity [1  1  1]
  Sphere 3  -3  3  360
  Translate 2.  0.  0.
WorldEnd
```


Rings

rings.sl

```
surface
rings( float
            Prob = 0.4,
            Ks = 0.5,
            Kd = 0.5,
            Ka = .1,
            roughness = 0.1;
      color specularcolor = color( 1, 1, 1 )
)
{
            varying vector Nf = faceforward( normalize( N ), I );
            vector V = normalize( -I );

            float x = xcomp( P );
            float y = ycomp( P );
            float r = sqrt( x*x + y*y );
            float rfrac = mod( r, 1. );

            if( rfrac < Prob )
                        Ci = color( 1., .5, 0. );
            else
                        Ci = Cs;

            Oi = 1.;
            Ci = Oi * ( Ci * ( Ka * ambient( ) + Kd * diffuse(Nf) ) +
                        specularcolor * Ks * specular( Nf, V, roughness )  );
}
```

Rings (= Polar Stripes)

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Dots

dots.rib

```
##RenderMan RIB
version 3.03
Declare "Diam"     "uniform float"

Display "dots.tiff" "file" "rgb"
Format 512 512 -1
ShadingRate 1

LightSource  "ambientlight"  1  "intensity“  [0.25]
LightSource  "distantlight"    2  "intensity" [0.75]  "from“  [5  8  -10]  "to“  [0  0  0]

Projection  "perspective"  "fov“  [70]
WorldBegin
  Translate  0  0  6
  Surface  "dots“   "Diam“  0.10
  Color     [1 1 1]
  Opacity [1 1 1]
  TransformBegin
     Rotate 90  1. 0. 0.
     Sphere 3 -3 3 360
  TransformEnd
WorldEnd
```


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Dots

dots.sl

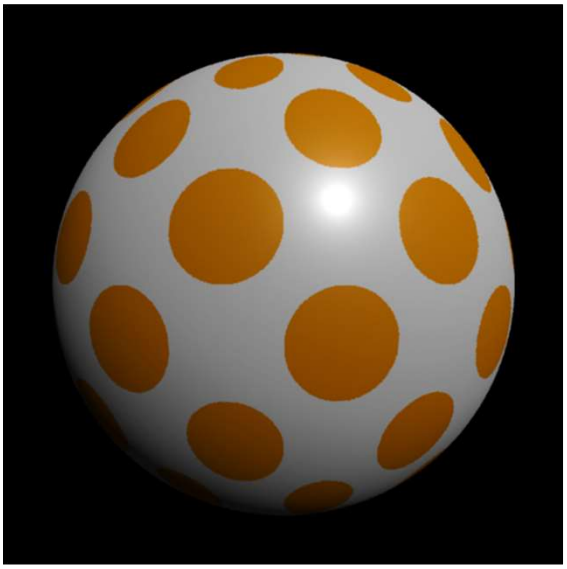

```
surface
dots( float
                Diam = 0.10,  // dot diameter
                Ks = 0.5,
                Kd = 0.5,
                Ka = .1,
                roughness = 0.1;
        color   specularColor = color( 1, 1, 1 )
)
{
                float up = 2. * u;
                float vp = v;
                float numinu = floor( up / Diam );
                float numinv = floor( vp / Diam );

                color dotColor = Cs;
                if( mod( numinu+numinv, 2 ) == 0 )
                {
                                float uc = numinu*Diam + Diam/2.;
                                float vc = numinv*Diam + Diam/2.;
                                up = up - uc;
                                vp = vp - vc;
                                point upvp =  point( up, vp, 0. );
                                point cntr   =  point( 0., 0., 0. );
                                if( distance( upvp, cntr ) < Diam/2. )
                                {
                                                dotColor = color( 1., .5, 0. );      // beaver orange?
                                }
                }

                varying vector Nf = faceforward( normalize( N ), I );
                vector V = normalize( -I );

                Oi = 1.;
                Ci = Oi * ( dotColor * ( Ka * ambient( ) + Kd * diffuse(Nf) ) +
                                                                specularColor * Ks * specular( Nf, V, roughness )  );
Co }
```


Dots



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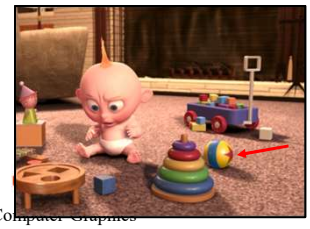
Making Good Use of a RenderMan Shader Pattern ☺



Hallmark has even made a Christmas tree ornament out if it!