Noise!

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Positional Noise

Idea: Pick a random number at the whole-number input values and then fit a piecewise smooth curve through those points.

The problem is that, due to the uncertainty of random numbers, you might get a good plus-or-minus distribution, or a not-so-good distribution.

Gradient Noise

Idea: Place points at the mid-line at the whole-number input values use random numbers to pick gradients (slopes) there, and then fit a piecewise smooth curve through those points with those slopes.

No matter what, you will get a good plus-or-minus distribution.

Quintic (5th order) Interpolation Creates More Continuity Than Cubic

Cubic: \( C_{00} = 1 - 3t^2 + 2t^3 \)
\( C_{01} = 3t^2 - 2t^3 + 1 - C_{00} \)
\( C_{02} = -t^2 + t^3 \)
\( C_{03} = 0 \)
\( C_{04} = 0 \)

Quintic: \( C_{00} = 1 - 10t^3 + 15t^4 - 6t^5 \)
\( C_{01} = 10t^3 - 15t^4 + 6t^5 + 1 - C_{00} \)
\( C_{02} = -t^3 + 8t^4 - 3t^5 \)
\( C_{03} = 3t^4 - 6t^5 + 1 + C_{02} \)
\( C_{04} = 0 \)
\( C_{05} = 0 \)

Coefficients for Cubic and Quintic Forms
Noise Octaves

Idea: Add multiple noise waves, each one twice the frequency and half the amplitude of the previous one.

Image Representation of 2D Noise

3D Surface Representation of 2D Noise

3D Volume Rendering of 3D Noise

3D Volume Isosurfaces of 3D Noise

Examples

Deciding when to Discard for Erosion

Color Blending for Marble

Color Blending for Clouds

Deciding when to Discard for Erosion
Turbulence

Idea: Take the absolute value of the noise about the centerline, giving the noise a “sharper” appearance and creating “creases”. Warning: this is not the same as fluid “turbulence”.

Normal

Turbulent

Turbulence Example

Normal

Turbulent

How to Use Noise

Have an equation that relates some input value (x,y,z or u,v) to output values (color, height)

Have actual input values of where we are right now

Add Noise to the actual input values to produce new “fake” input values

Use those new “fake” input values in the original equation

Idea: The graphics system will display “here”, using display parameters as if you were “over there.”

N = NoiseMag * noise( NoiseFreq * PP );

How much to amplify the noise effect

Coordinates where you are now

How much to increase the sampling rate

Should PP be in Model or World coordinates? Why?

Surface Shader Only
Displacement
Shader Only

Surface and
Displacement
Shaders
together

Displacement Only
Surface + Displacement
Surface Only
Noise
No Noise

What's the Difference Between These Two RenderMan Images? Why?

Displacement-mapped
Bump-mapped

P = P + normalize(N) \times \text{disp};
N = \text{calculateNormal}(P);

if (\text{disp} \neq 0) {
  P = P + \text{normalize}(N) \times \text{disp};
  N = \text{calculateNormal}(P);
}