Noise!

Noise:

- Can be 1D, 2D, or 3D
- Is a function of input value(s)
- Ranges from -1.0 to +1.0, or from 0.0 to 1.0.
- Might look random, but really isn’t
- **Has continuity**
- Is repeatable (i.e., if you supply the same inputs, you will always get the same outputs)

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.

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

Cubic: \( C^1 \) continuity at the whole-number values
Quintic: \( C^2 \) continuity at the whole-number values

Coefficients for Cubic and Quintic Forms

<table>
<thead>
<tr>
<th>Noise values</th>
<th>Gradients</th>
<th>Curvatures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cubic</td>
<td>Quintic</td>
<td></td>
</tr>
<tr>
<td>( C_{N0} = 1 - 3t^2 + 2t^3 )</td>
<td>( C_{N0} = 1 - 10t^2 + 15t^4 - 6t^5 )</td>
<td></td>
</tr>
<tr>
<td>( C_{N1} = 3t^2 - 2t^3 = 1 - C_{N0} )</td>
<td>( C_{N1} = 10t^2 - 15t^4 + 6t^5 = 1 - C_{N0} )</td>
<td></td>
</tr>
<tr>
<td>( C_{G0} = t^2 - 2t^3 + t^4 )</td>
<td>( C_{G0} = t - 6t^3 + 8t^4 - 3t^5 )</td>
<td></td>
</tr>
<tr>
<td>( C_{G1} = -t^2 + t^3 )</td>
<td>( C_{G1} = -4t^2 + 7t^3 - 3t^4 )</td>
<td></td>
</tr>
<tr>
<td>( C_{C0} = 0 )</td>
<td>( C_{C0} = \frac{1}{2} - \frac{3}{2}t^2 + \frac{3}{2}t^3 - \frac{1}{2}t^4 )</td>
<td></td>
</tr>
<tr>
<td>( C_{C1} = 0 )</td>
<td>( C_{C1} = \frac{1}{2}t^2 - t^3 + \frac{1}{2}t^4 )</td>
<td></td>
</tr>
</tbody>
</table>
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 Erase
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".**

1 Octave

4 Octaves

Normal

Turbulent

How to Use Noise

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

Should PP be in Model or World coordinates? Why?

N = NoiseMag * noise( NoiseFreq * PP );
Displacement Shader Only

Surface and Displacement Shaders together

What’s the Difference Between These Two Images? Why?

Displacement-mapped
Bump-mapped