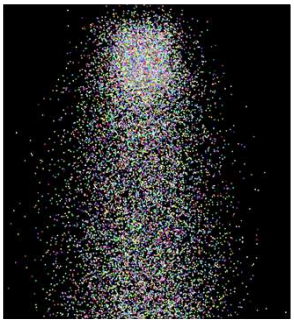
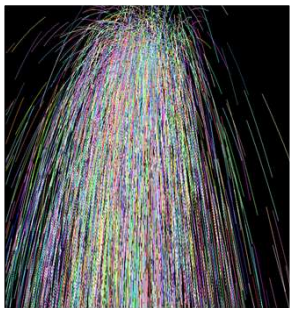
Particle Systems





Mike Bailey

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Particle Systems

- Are used to simulate the appearance of particulate, hairy, or fuzzy phenomena.
- Involve the animation of large collections of (perhaps tiny) particles which have various graphics characteristics.
- Were originally developed by Pixar's Bill Reeves for the "Genesis Sequence" in the movie *Star Trek II: The Wrath of Khan*
- Have been used to create effects of fire, smoke, rain, snow, fireworks, disintegration, dust, sand, explosions, flow, waterfalls, stars, comets, plants, hair, fuzz. Surely many more.

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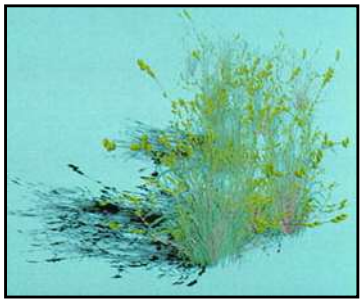
Particle Systems Examples



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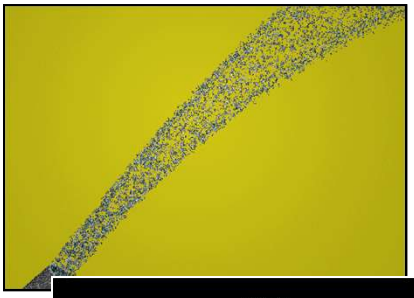
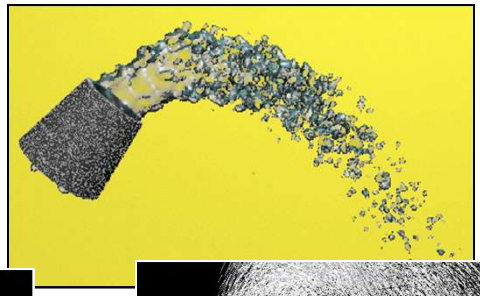
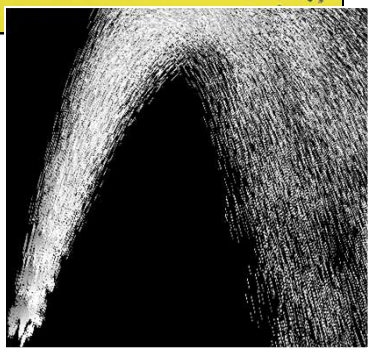
Particle Systems Examples







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Chuck Evans

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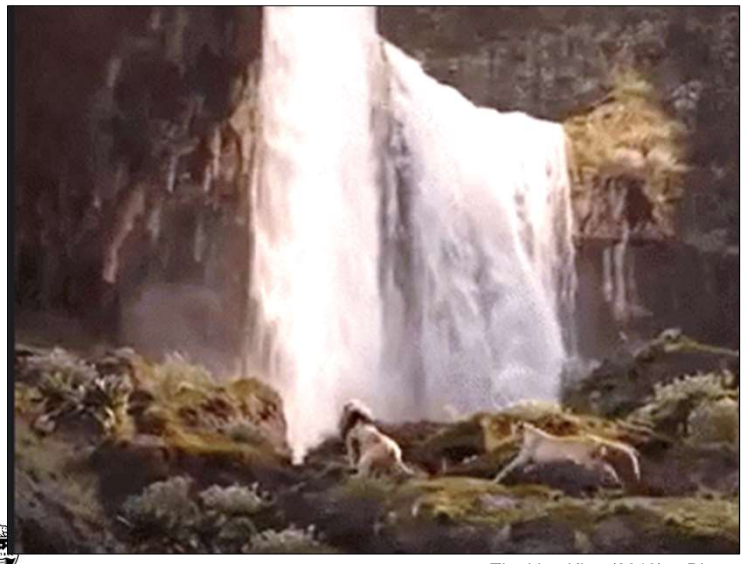
Particle Systems Examples



The Lion King (2019) -- Disney

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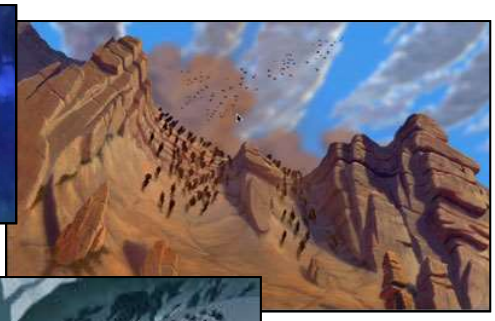
"Particles" Don't Actually Have to Be Particles

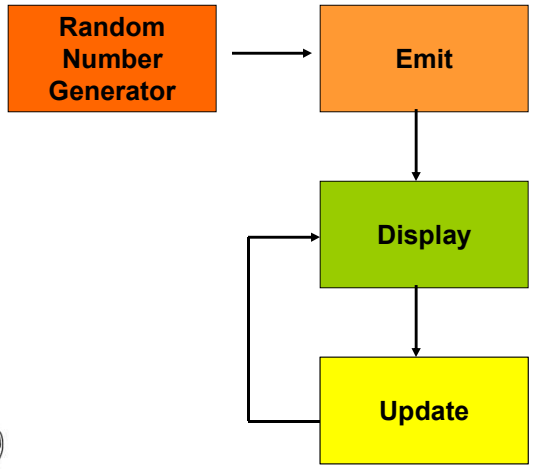


Starlings in Flight

https://www.wired.com/story/stunning-images-of-starlings-in-flight/?bxid=5bd6774e24c17c1048017a0f&cndid=39783882&esrc=AUTO_PRINT&mbid=mbid%3DCRMWIR012019%0A%0A&source=EDT_WIR_NEWSLETTER_0_ENGAGEMENT_ZZ&utm_brand=wired&utm_campaign=aud-dev&utm_content=WIR_Classics_022622&utm_mailing=WIR_Classics_022622&utm_medium=email&utm_source=nl&utm_term=WIR_Daily_TopClickers

The Process

The basic process is this:



The Emitter

The Emitter gives each particle a:

- Birth time
- Death time
- Start location
- Start velocity
- Start color
- Start size
- Start alpha (blending factor)

$$Color = (1-\alpha)Color_0 + \alpha Color_1$$

Plus, any information about how these quantities change over time

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Creating Random Values for the Emitter

```
#include <stdlib.h>


float
Ranf( float low, float high )
{
        float r = (float) rand( );              // 0 - RAND_MAX
        float t = r  /  (float) RAND_MAX;       // 0. – 1.

        return   low  +  t * ( high - low );
}


int
Ranf( int ilow, int ihigh )
{
        float low = (float) ilow;
        float high = ceil(  (float) ihigh  );

        return (int) Ranf(low,high);
}
```

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The Displayer

And the displayer draws the scene using different graphics techniques such as:

- Dots
- Small line segments
- Polygons with billboarding
- Quads with textures and billboarding
- Sprites
- Spheres, Cubes
- "Rockets"
- Lighting
- Blending
- Smearing

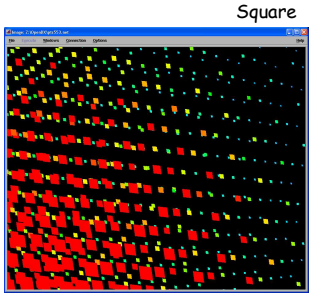
Easiest way:

```
glBegin( GL_POINTS );
        glColor3f(   r0, g0, b0 );
        glVertex3f( x0, y0, z0 );
        . . .
glEnd( );
```

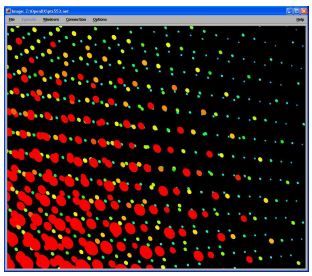
Most efficient way: Vertex Buffer Objects

OpenDX Scalar Glyphs

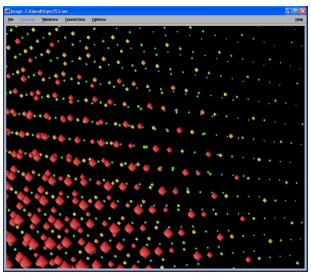
Square



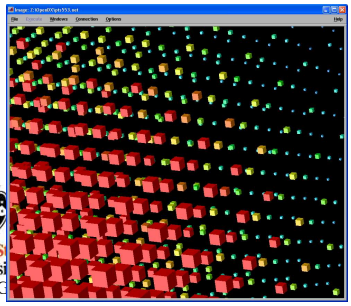
Circle



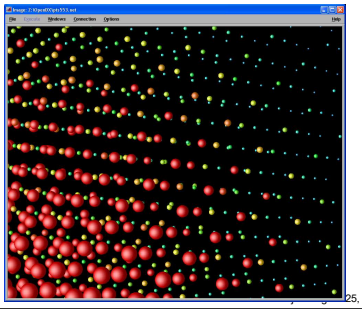
Diamond



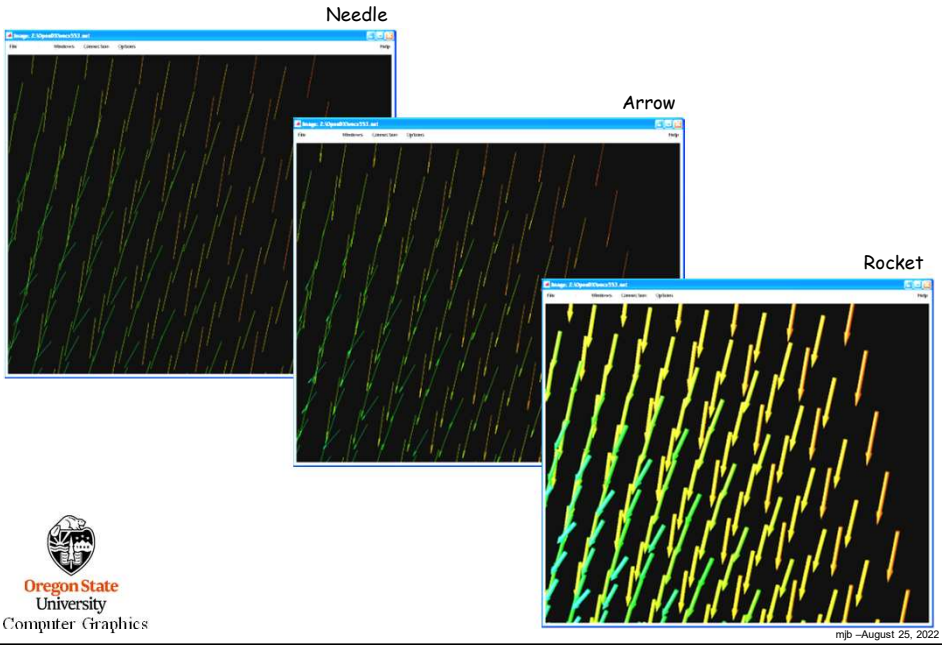
Cube



Sphere



OpenDX Vector Glyphs



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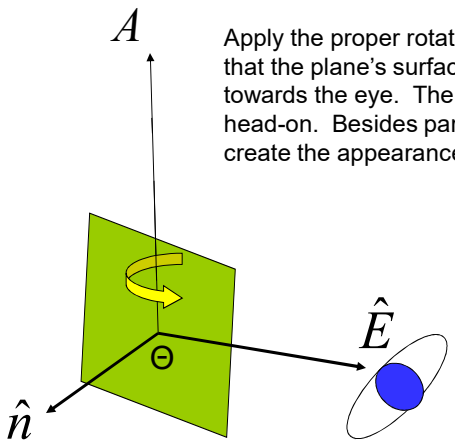
Billboarding



Apply the proper rotation about the proper axis such that the plane's surface normal is always pointed towards the eye. The eye always sees the surface head-on. Besides particle systems, this is often used to create the appearance of 3D trees from 2D tree images.

$$A = \hat{n} \times \hat{E}$$

$$\theta = \cos^{-1}\left(\hat{n} \bullet \hat{E}\right)$$

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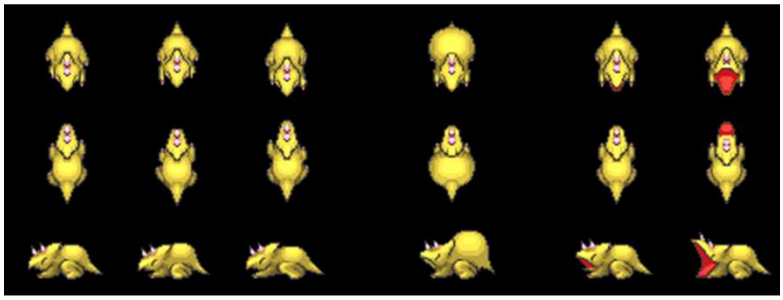
Sprites

A “sprite” is a 3D object pre-rendered to a flat 2D texture and “slipped” into a certain depth in the scene.



http://sdb.drshnaps.com

The Updater

And the simulation updates the:

- Position
- Color
- Size
- Alpha
- Interaction with other particles and other objects

Note that these can change as a function of time, position, or anything else

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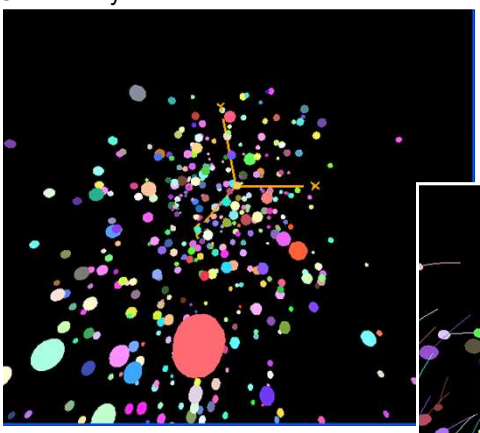
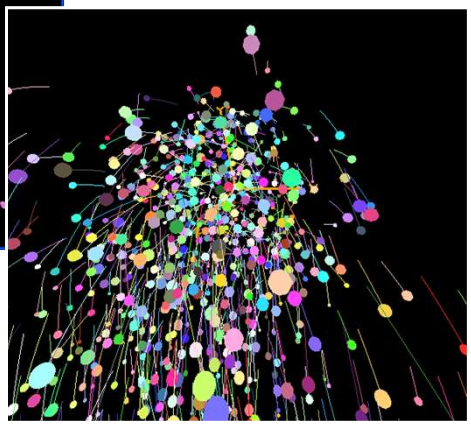
Particle Systems

Circles only



Circles with traces



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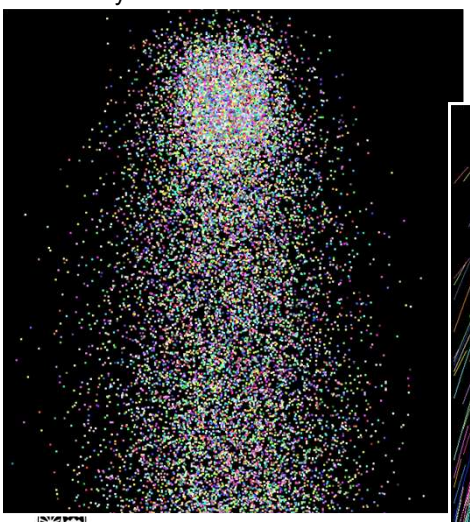
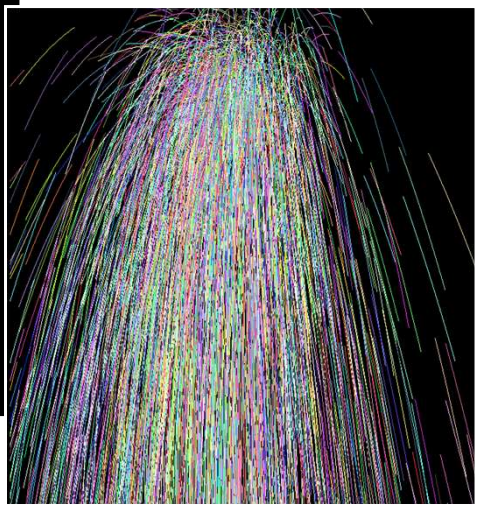
Particle Systems

Points only



Points with traces



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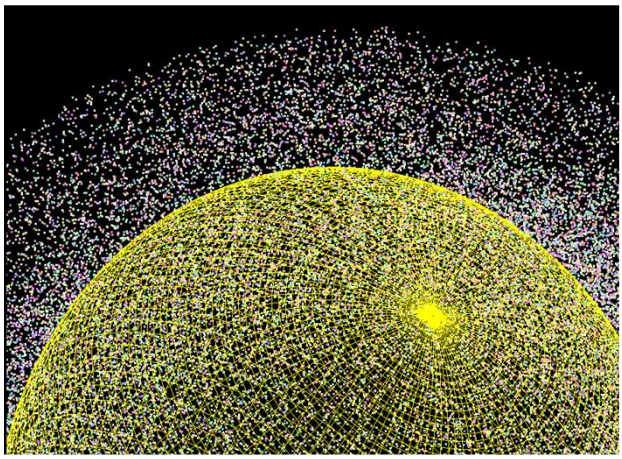
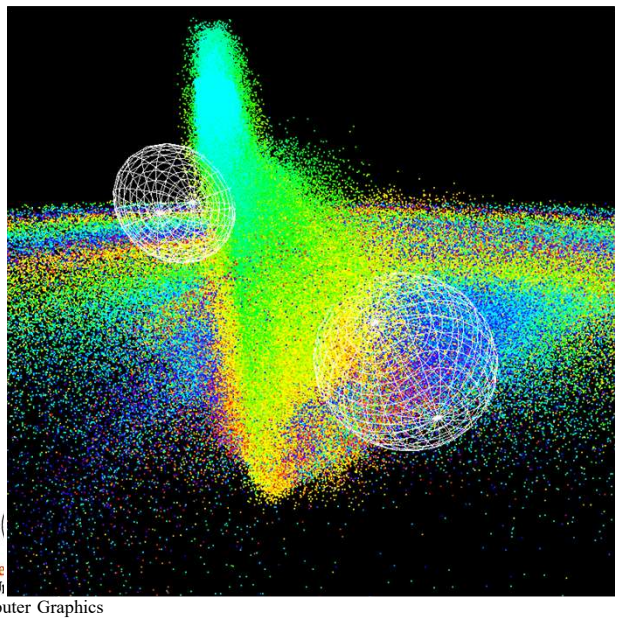
Particle Systems using OpenGL Compute Shaders



1,000,000 particles

1.3 Gparticles / sec

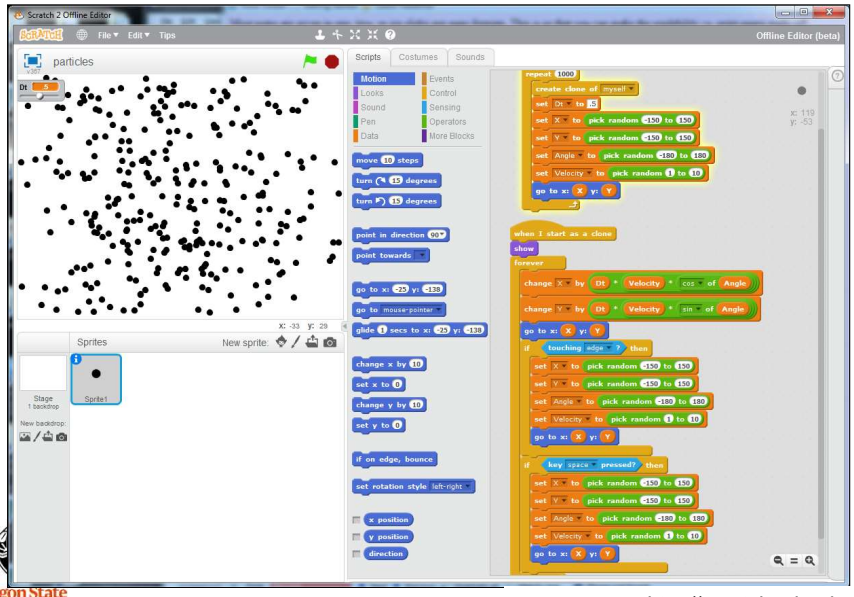
Particle Systems in the OSU Shaders Course



1,000,000 particles

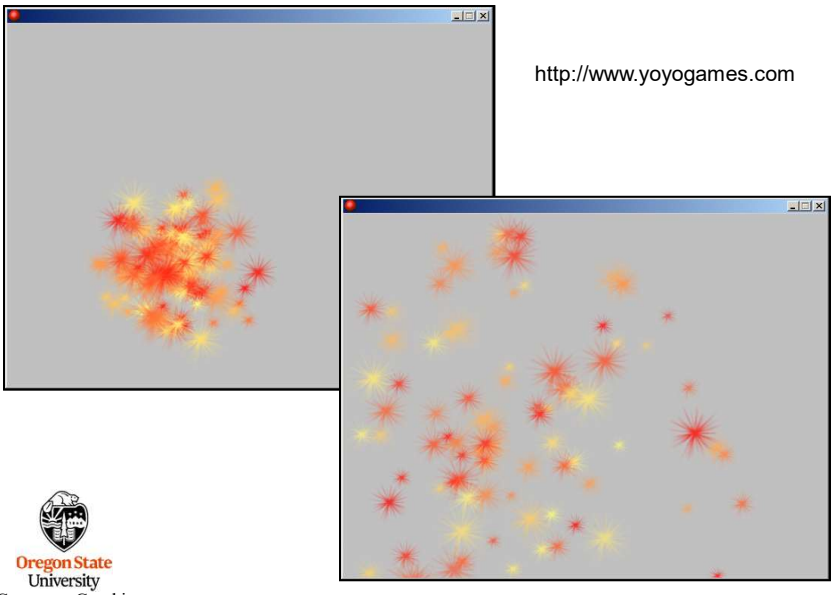
Ben Weiss

Particle Systems using Scratch



http://scratch.mit.edu

Particle Systems using Game Maker



http://www.yoyogames.com