Particle Systems

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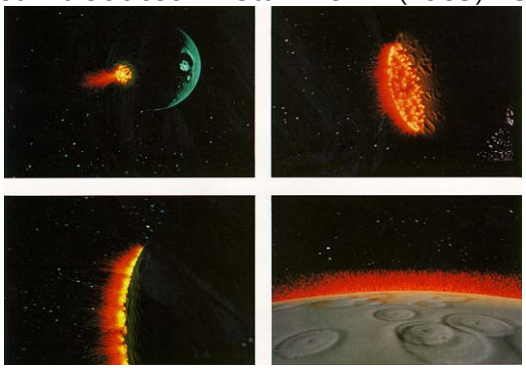
Star Trek II (1983)

- Particle Systems can be utilized to simulate a wide range of phenomena such as fire, rain, smoke, explosions, and projectiles.
- It was first introduced in Star Trek II (1983) "Genesis Effect"

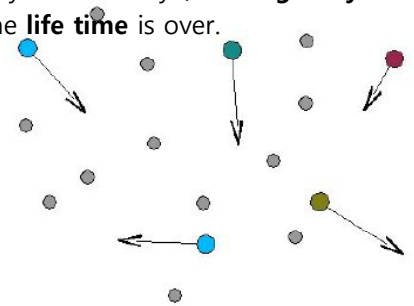


Particle Systems

- Particles (Point Sprite is removed from XNA4.0)
- Particle System Components
- Particle Systems
  - Snow/Rain
  - Explosions
  - Smoke
  - Fire

Particles

- Particle
  - A very small object that is usually modeled as a point mathematically.
  - Represented as a point with **position**, **velocity**, and **color**.
  - Each particle can be added in the particle system and moved in a physically realistic way (due to **gravity or wind**) and then died after the **life time** is over.



Particles

- Particle
  - Use a **Point Sprite** to represent a particle.
  - With point sprites (introduced in DirectX 8), graphics card only needs only one vertex for each particle.
    - Prior to point sprites, game developers had to create a rectangle (quad) and apply a texture to it for each particle.
  - Point sprites can be as small as one pixel to as large as we want
    - We can set each particle to be a different texture and/or size.
  - XNA automatically maps our texture to the vertex. It also makes sure that the texture is always facing the camera.
  - **XNA Game Studio 4.0 no longer supports point sprites http://blogs.msdn.com/b/shawnhar/archive/2010/03/22/point-sprites-in-xna-game-studio-4-0.aspx**

Particles

- Creating the ParticleVertex structure

```
public struct ParticleVertex {
    public Short2 Corner; // particle quad's corner
    public Vector3 Position;        // particle's starting position
    public Vector3 Velocity;        // particle's starting velocity
    public Color Random;// particle's color
    public float Time;      // the time at which the particle is created
    public static readonly VertexDeclaration VertexDeclaration = new
       VertexDeclaration (
         new VertexElement(0, VertexElementFormat.Short2,
                                  VertexElementUsage.Position, 0),
         new VertexElement(4, VertexElementFormat.Vector3,
                                  VertexElementUsage.Position, 1),
         new VertexElement(16, VertexElementFormat.Vector3,
                                  VertexElementUsage.Normal, 0),
    // 중간생략...)
```

Particle System

- Particle System Engine
  - Particle system class manages the multiple particles' creation, initialization, remove, update, and draw.
  - This class will be an abstract class that inherits from the DrawableGameComponent class.
  - Each individual particle system (smoke, explosion, fire, etc) will inherit from this base ParticleSystem class.

Particle System

- The particle system fields

```
// 전형적인 particle system을 일반화한 base class
pubic abstract class ParticleSystem : DrawableGameComponent {
    ParticleSettings settings = new ParticleSettings(); // particle settings
    ContentManager content;
    Effect particleEffect; // for particle animation
    EffectParameter effectViewParameter; // 중간생략 .....
    ParticleVertex[] particles;              // a particle array (circular queue)
    DynamicVertexBuffer vertexBuffer;        // for GPU
     IndexBuffer indexBuffer; // for particle quads
     int firstActiveParticle;    int firstNewParticle;
     int firstFreeParticle;      int firstRetiredParticle;
     float currentTime;
     int drawCounter;
     static Random random = new Random();
... }
```

Particle System

- Initialize the particle settings

```
// initialize particle settings on ParticleSystem
public override void Initialize()
{
    InitializeSettings(settings);
    // Allocate the particle array and fill in the corner (which never change).
    particles = new ParticleVertex[settings.MaxParticles * 4];
    for (int i = 0; i < settings.MaxParticles; i++) {
            particles[i * 4 + 0].Corner = new Short2(-1, -1);
            particles[i * 4 + 1].Corner = new Short2(1, -1);
            particles[i * 4 + 2].Corner = new Short2(1, 1);
            particles[i * 4 + 3].Corner = new Short2(-1, 1);
    }
    base.Initialize();
}
protected abstract void InitializeSettings(ParticleSettings settings);
```

Particle System

```
class FireParticleSystem : ParticleSystem  {
protected override void InitializeSettings(ParticleSettings settings) {
    settings.TextureName = "Particle₩₩fire";
    settings.MaxParticles = 2400;
    settings.Duration = TimeSpan.FromSeconds(2);
    settings.DurationRandomness = 1;
    settings.MinHorizontalVelocity = 0;   settings.MaxHorizontalVelocity = 15;
    settings.MinVerticalVelocity = -10;    settings.MaxVerticalVelocity = 10;
    settings.Gravity = new Vector3(0, 15, 0);
    settings.MinColor = new Color(255, 255, 255, 10);
    settings.MaxColor = new Color(255, 255, 255, 40);
    settings.MinStartSize = 5;
    settings.MaxStartSize = 10;
    settings.MinEndSize = 10;
    settings.MaxEndSize = 40;
    settings.BlendState = BlendState.Additive; // Use additive blending.
    }        }
```

Particle System

```
class ExplosionParticleSystem : ParticleSystem  {
protected override void InitializeSettings(ParticleSettings settings) {
    settings.TextureName = "Particle₩₩explosion";
    settings.MaxParticles = 100;
    settings.Duration = TimeSpan.FromSeconds(2);
    settings.DurationRandomness = 1;
    settings.MinHorizontalVelocity = 20;   settings.MaxHorizontalVelocity = 30;
    settings.MinVerticalVelocity = -20;    settings.MaxVerticalVelocity = 20;
    settings.EndVelocity = 0;
    settings.MinColor = Color.DarkGray;    settings.MaxColor = Color.Gray;
    settings.MinRotateSpeed = -1;    settings.MaxRotateSpeed = 1;
    settings.MinStartSize = 7;
    settings.MaxStartSize = 7;
    settings.MinEndSize = 70;
    settings.MaxEndSize = 140;
    settings.BlendState = BlendState.Additive; // Use additive blending.
    }        }
```

Particle System

```
public override void Update(GameTime gameTime)  {
    currentTime += (float)gameTime.ElapsedGameTime.TotalSeconds;
    // if active particles have reached the end of their life, move to retired section
    RetireActiveParticles();
    // if retired particles have been kept long enough, move old particle to free
    FreeRetiredParticles();
    // If we let our timer go on increasing for ever, it would eventually
    // run out of floating point precision, at which point the particles
    // would render incorrectly. An easy way to prevent this is to notice
    // that the time value doesn't matter when no particles are being drawn,
    // so we can reset it back to zero any time the active queue is empty.
    if (firstActiveParticle == firstFreeParticle)
            currentTime = 0;
    if (firstRetiredParticle == firstActiveParticle)
            drawCounter = 0;
}
```

Particle System

```
public override void Draw(GameTime gameTime)  {
    if (firstActiveParticle != firstFreeParticle)  {          // if active particle, draw
        device.BlendState = settings.BlendState;
        device.DepthStencilState = DepthStencilState.DepthRead;
// 중간 생략.. effect.SetParameters
        // Set the particle vertex and index buffer.
        device.SetVertexBuffer(vertexBuffer);
        device.Indices = indexBuffer;
        // Activate the particle effect.
        foreach (EffectPass pass in particleEffect.CurrentTechnique.Passes)  {
            pass.Apply();
            if (firstActiveParticle < firstFreeParticle)  {
                device.DrawIndexedPrimitives(PrimitiveType.TriangleList, 0,
                        firstActiveParticle * 4, (firstFreeParticle - firstActiveParticle) * 4,
                        firstActiveParticle * 6, (firstFreeParticle - firstActiveParticle) * 2);
            }
```

Particle System

```
            else    {
                device.DrawIndexedPrimitives(PrimitiveType.TriangleList, 0,
                    firstActiveParticle * 4, (settings.MaxParticles - firstActiveParticle) * 4,
                    firstActiveParticle * 6, (settings.MaxParticles - firstActiveParticle) * 2);
                if (firstFreeParticle > 0)     {
                    device.DrawIndexedPrimitives(PrimitiveType.TriangleList, 0,
                                        0, firstFreeParticle * 4, 0, firstFreeParticle * 2);
                }
            }
        }
        // Reset some of the renderstates that we changed,
        // so as not to mess up any other subsequent drawing.
        device.DepthStencilState = DepthStencilState.Default;
    }
    drawCounter++;
}
```