

Research into the Simulation of Shockwaves



Introduction

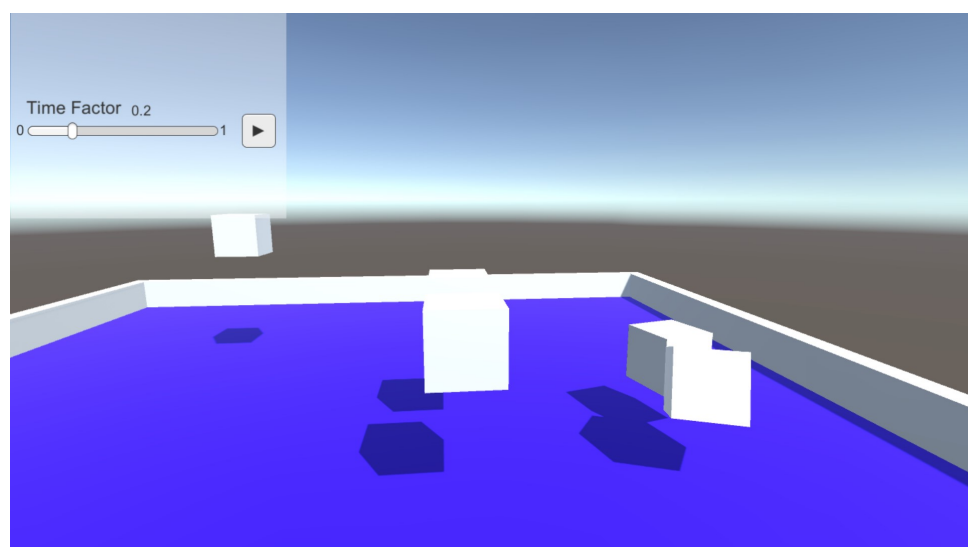
As a group, we decided to look into some of the existing technologies surrounding physics simulation. We found it interesting that explosion shockwaves are often estimated in games. We, therefore, researched into the practicality of simulating and visualising a realistic shockwave.

We began by creating our own physics engine, before moving on to extending the Unity game engine.

Our Own Physics Engine

We were successful in implementing the features below.

- Detecting intersections
- Calculated Force
- Types of Force
- Bounciness
- Basic Collisions

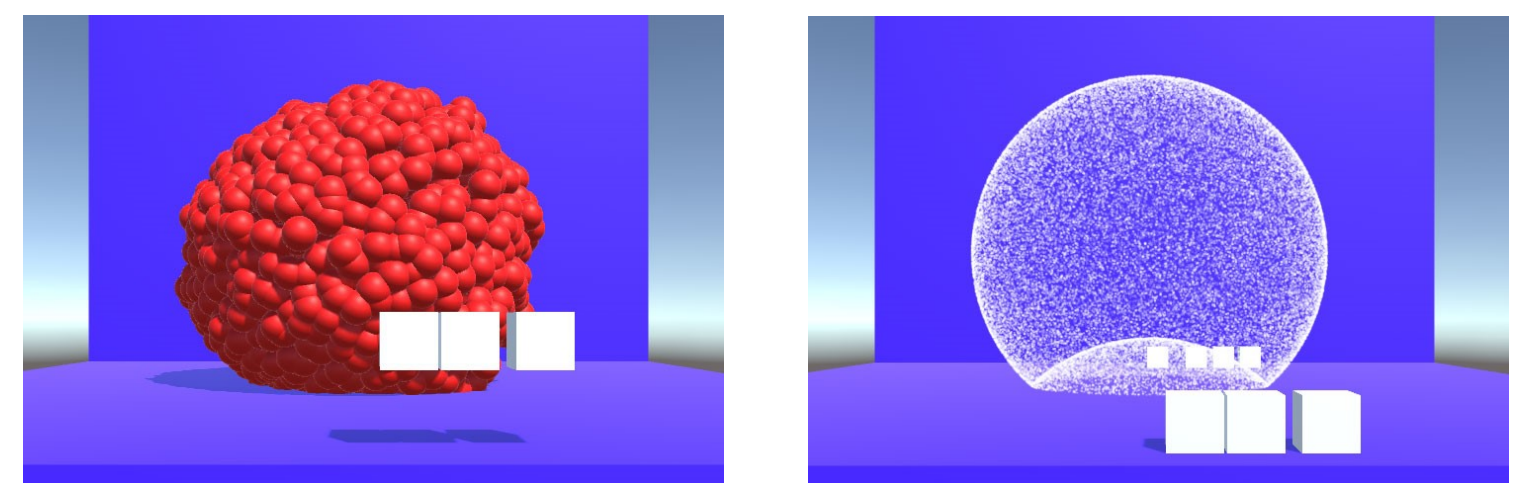


Sphere Expansion

As shockwaves are usually spherical in nature, our first idea was to use a single expanding sphere to model this. While this was successful in visualisation and collisions, it proved impossible to model reflection and diffraction, as this would have required us to change the object mesh.

Particle Systems

This was most successful solution. Particles offered us a way to simulate the wave as separate areas, allowing freedom of movement such as natural looking propagation around corners.



Physics

To make our simulation as realistic as possible, we implemented real physics equations. Below are equations for a shock wave pressure in any medium and our code equivalent.

$$\frac{p_0}{p_1} = \frac{2\gamma M^2 - \gamma - 1}{\gamma + 1}$$

$$p = \frac{F}{A}$$

```
foreach (ParticleCollisionEvent collisionEvent in collisionEvents)
{
    if (collisionEvent.velocity != Vector3.zero)
    {
        Vector3 velocity = collisionEvent.velocity;
        float radius = particleEmitter.time * startSpeed;
        float shockPressure = medium.GetShockPressure(velocity.magnitude);
        float surfaceArea = (4.0f * Mathf.PI * Mathf.Pow(radius, 2)) / NumberOfParticles;
        Vector3 force = velocity.normalized * shockPressure * surfaceArea;
        rb.AddForce(force, ForceMode.Force);
    }
}
```

Frontend

Our focus was an interior design, as we felt these scenes best visualised the properties of the shockwave.

We used assets with correct weights to further increase realism. To allow more valuable observations, we also created time and camera controls.

