CE1051A Coursework - 3D Rigid Body Dynamics

Jake Morey
BSc(Hons) Computer Games Technology,
School of Arts, Media and Computer Games
University of Abertay Dundee
100424@live.abertay.ac.uk

January 9, 2014

Contents

1 Introduction:

The purpose of this project is to create an application that involves 3D rigid body dynamics more specifically an application that simulates rigid body general motion when an impulse force is added to the object at a particular location. Before going into detail about the application this report will explain the physics behind the simulation.

2 Physics:

2.1 Rigid Body:

A rigid body can be described as a system of particles in which each particle remains the same distance from every other particle in that system. This means that the shape retains its shape and size whilst moving or that if there are any changes it is so small it is negligible or can be safely neglected. Also because the particles don't move within the system the objects distribution of mass is kept (Bourg and Bywalec, 2013; MacTaggart, 2013).

2.2 Centre Of Mass:

The centre of mass or the centre of gravity is the point in an object when cut in two will result in two objects with the same weight (Millington, 2007). Millington (2007) also describes how to calculate the centre of mass. The object must be split into particles so that the average position can be calculated.

$$G = \frac{1}{M} \sum_{n} p_i m_i \tag{2.1}$$

Where G is the position of the centre of mass, M is the mass of the entire object, p_i is the position of the particle and m_i is the mass of each particle. For certain shapes such as cuboids and spheres with uniform density the centre of mass is the centre of the shape (Millington, 2007).

$$G_x = \frac{1}{M}\int\int\int x\ dxdydz \tag{2.2}$$

$$G_y = \frac{1}{M}\int\int\int y\ dxdydz \tag{2.3}$$

$$G_z = \frac{1}{M}\int\int\int z\ dxdydz \tag{2.4}$$

$$\mathbf{G} = (G_x, G_y, G_z) \tag{2.5}$$

2.3 Inertia Tensor:

$$\begin{bmatrix} A & -H & -G \\ -H & B & -F \\ -G & -F & C \end{bmatrix}$$

$$A = \sum \rho\left(x_2^2 + x_3^2\right) \qquad B = \sum \rho\left(x_1^2 + x_3^2\right) \qquad C = \sum \rho\left(x_1^2 + x_2^2\right) \tag{2.6}$$

$$F = \sum \rho\left(x_2 x_3\right) \qquad G = \sum \rho\left(x_1 + x_3\right) \qquad H = \sum \rho\left(x_1 + x_2\right) \tag{2.7}$$

2.4 Euler Equations:

2.5 General Body of a Rigid Body:

References

Bourg, D. M. and Bywalec, B. 2013. *Physics for Game Developers: Science, Math, and Code for Realistic Effects*. O'Reilly Media, Inc. 2.1

MacTaggart, D. 2013. *Applications of Integration & Basic 3D Motion*. UAD - CE11051A. 2.1

Millington, I. 2007. *Game physics engine development*. Taylor & Francis US. 2.2, 2.2