Edinburgh Napier University

SET09119 Physics-Based Animation

Workbook

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Part I

Getting Started

Chapter 1

Welcome

Welcome to Physics-Based Animation! This module and accompanying workbook will guide you through the process of simulating the vast mechanisms of real-word physics within software. Expect collisions, explosions, particles, and plenty of cubes and spheres rolling around everywhere.

The pre-requisite knowledge you require is:

- A Strong grasp of mathematical concepts such as trigonometry, algebra, and geometry. Linear algebra and matrix mathematics are crucial skills for this module.
- An adept or above level of skill with the C++ language.
- Knowledge of Computer Graphics technology and theory.
- Strong software debugging skills
- A willingness to spend time solving the problems presented in this workbook. Some of the exercises are challenging and require effort. There is no avoiding this. However, solving these problems will significantly aid your understanding.

1.1 Workbook Style

The workbook is task and lesson based, requiring you to solve problems to complete the code provided as a starting point for the lesson. This code will either be in the main application source file (`main.cpp`) for the lesson, or in one or more shader files (typically found in the `resources/shaders` folder). The sections you have to complete are highlighted in stars:

```
\\ *********************************
\\ You have to complete this problem
\\ *********************************
```

The problems faced generally build on previous lessons until you become familiar with the work involved.

1.2 Physics Framework

In this module we will be working with a graphics framework that has been developed specifically for the work we will be undertaking in computer graphics. The framework itself is fairly lightweight, but provides some object-oriented wrappers around standard OpenGL (which is a C API). The main job of the graphics framework is to combine a collection of libraries together to allow us to focus on computer graphics rather than writing some boiler plate code.

1.2.1 Libraries

The libraries used in the graphics framework are:

OpenGL takes care of our computer graphics rendering by enabling us to talk to our graphics card. Most of the other libraries we will use provide an interface into OpenGL. In Windows, we use the `gl/gl.h` header and the `OpenGL32.lib` library file, both of which come with the standard Windows SDK.

GLEW the GL Extension Wrangler. GLEW is a standard inclusion in modern OpenGL applications as it provides access to the modern OpenGL API. GLEW is easily downloaded, and we use the `gl/glew.h` header and the `glew32.lib` library file.

GLFW the GL FrameWork (although it is not really a framework). GLFW provides a simple mechanism to create a window that we can use to draw to, and simple methods to access keyboard and mouse input. GLFW is cross-platform, and we will be using the `GLFW/glfw3.h` header and `glfw3dll.lib` (the DLL version is a Windows only feature).

GLM the GL Mathematics library. GLM is also cross-platform and a header only library (it has a number of different headers we include for different purposes). GLM provides the mathematical types and functions required to work with OpenGL (which provides no basic mathematical types). GLM is designed to be similar in syntax to GLSL (the GL Shader Language) which we will become familiar with in the module.

FreeImage the FreeImage library allows us to load textures and attach them to OpenGL (OpenGL does not provide texture loading mechanisms). As with our other libraries, FreeImage is cross-platform. We use the `FreeImage/FreeImage.h` header and `FreeImage.lib`.

AssImp the Asset Importer library - a cross platform library that makes it easy to load in 3D model data (again OpenGL has no such mechanism). We use a number of headers in AssImp and `assimp.lib` library file.

As you can see, we work using a number of cross-platform libraries. This means that, although we will be working on Windows using Visual Studio, our code will work on any standard desktop platform (i.e. Linux and Mac OS X).

Chapter 2

Initial Setup

2.1 Getting the Code - Clone The Repository from GitHub

Everything you need to get started (including this workbook) is hosted in a git Repository. You will need to clone your own copy to work with.

```
git clone https://github.com/NapierUniversity/enu_pba.git
```

2.2 Configuring the code - CMake

Intro to CMake

The physics project makes use of the CMake build system, this allows for cross-platform compatibility, dependency acquisition and general purpose code housekeeping. If you are new to CMake, here is a simple explanation of its purpose.

CMake uses a configuration script to generate Make Files (or IDE Project files) for your project. Instead of shipping a makefile which would have to be updated, and would be specific to one platform, only the project code and a CmakeLists.txt config script is needed. The same goes for Visual studio Solution files, which are large, difficult to version, and can only be used by Visual studio.

Instead of maintaining a visual studio sln file, CMake will generate one for you. CMake does not actually *build* your code, it just *configures* your build environment for you so you can build the software.

CMake is also used to pull down the additional libraries we will need for this project. This means that you are getting a fresh and up-to date copy of all the libraries, and you will be compiling them specifically for your system. Say goodbye to linker and VCRuntime errors.

Running CMake

To keep the source directory (the directory pulled from Git) clean, we tell CMake to generate our build files in a separate directory, This is called an Out of Source Build. We can do this all from the command line easily:

```
mkdir physics_build
cd physics_build
cmake -G "Visual Studio 14 2015 Win64" ../enu_pba/
```

CMake Has a GUI interface also, this is useful if you are configuring new software and need to see and set options. This project has all the settings set to sensible defaults so you should not need to touch anything other than the configure and generate buttons. The steps are Shown in Figure 2.1.

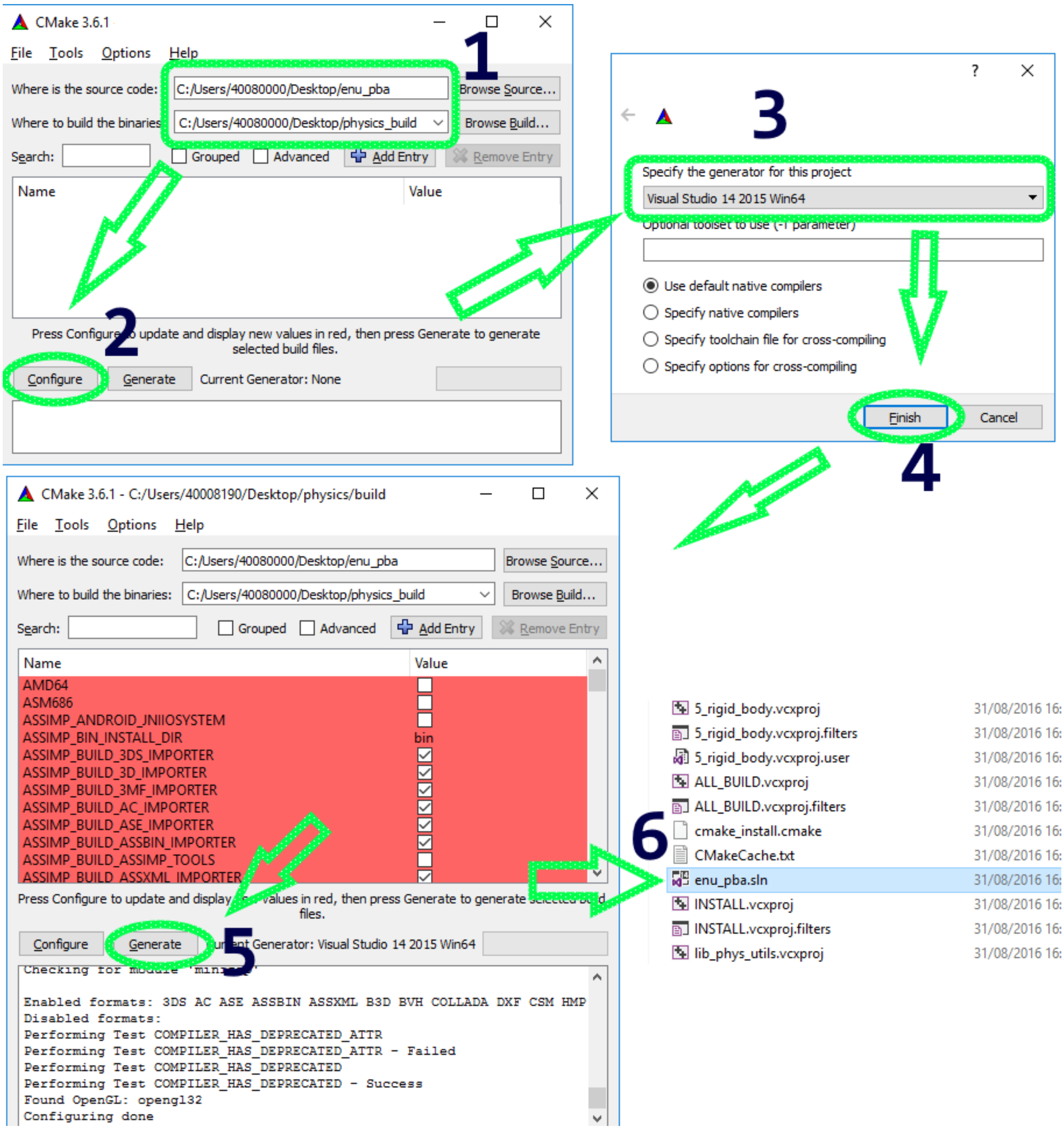

Figure 2.1: **CMake GUI Build Steps**

2.2.1 Building the code - Visual Studio

Once CMake has created the Solution file and you have opened it, you should see the following projects:

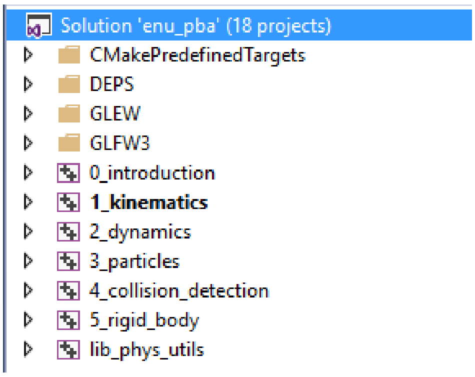

Figure 2.2: **Visual Studio projects**

The projects within the sub-folders are the libraries which we will use, so you don't need to pay attention to them. The CMakePredefinedTargets contains some CMake functions, specifically useful is the ZERO_CHECK project, this will trigger a CMake configure and rebuild without having to leave VS. This is useful if anything in the source directory has changed.

2.2.2 Running the Code

You should run this application to see the output. You will get a cyan coloured window as shown in Figure 2.3.

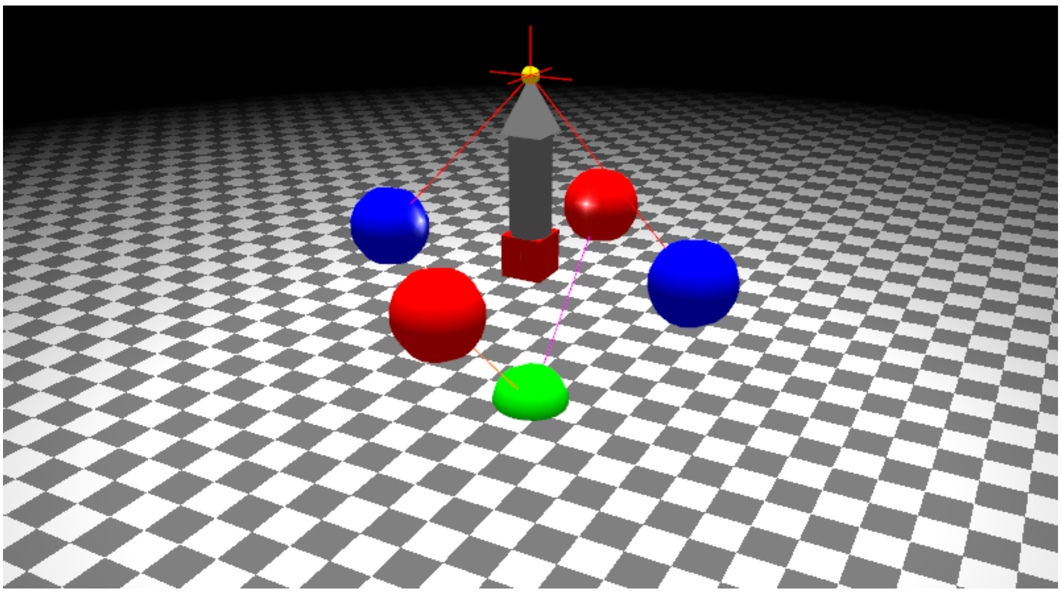

Figure 2.3: **Output from Basic Application**

Part II

Inverse Kinematics

Part III

Dynamics

Part IV

Particles

Part V

Collision Detection

Part VI

Rigid Body

Part VII

Appendix

Chapter 3

Bibliography

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Chapter 4

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