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ArcGIS™ to Unity™: a design pipeline for creation of 3D Terrain in Serious Games for Geology

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Figure 1. Screenshot from Game

Introduction

For geology students, good fieldwork skills are vital. *The Virtual Worlds Project* is a collaboration between the School of Earth and Environment, University of Leeds and Leeds College of Art to develop a blended learning game in which students practice basic field skills in a geological field mapping exercise. The game, created in Unity™ involves students exploring an open virtual landscape where they learn to collect, plot and interpret geological data on to a physical map.

The Virtual Training Environment grew from a previous web based mapping project (http://www.see.leeds.ac.uk/structure/virtualmapping/index.htm) devised by Geoffrey Lloyd (University of Leeds) in 2002 . It consists of a topographical base map to download, and a webpage of written information for the students to plot and interpret onto the map.

For this revised and updated version for 2015, the team used Unity™: Personal Edition to produce the video game element, visualised as a 3D terrain that the student would explore in First Person Perspective.   The game was compiled as both a standalone Mac and Windows version. A web-based version – using a plugin for the web-browser was also produced. This allowed the tutor and student to access the materials in the class or at home.

Unity™ itself is a 'game engine'– a suite of software tools in an integrated development environment for the creation of video games. The software is free to use and develop with, as long as it abides by non-commercial contexts. The current version is 5.0 and is available to download here –

http://unity3d.com/unity/personal-edition.

One of the key challenges during the development of this 'game environment' was the creation of the landscape from the original 2002 base map. In this paper we will walk through the design pipeline that was developed by the team, and discuss some of the issues that were discovered when translating from 2D Map to 3D environment utilising the software available within the department.

Background

Traditionally game engines like Unity have tools that lend themselves to more aesthetic needs of creating fantastical virtual landscapes as expected of the entertainment and video games industry. Low budget Terrain generation tools like Terragen, Vue, and Bryce, though creating convincing landscapes to the layperson, lack the direct control of contour construction that was required to create a geologically viable landscape.

The decision was made from the project's start that the workflow was to develop from a topographical base map to Unity's terrain tools, rather than producing the 3D Landscape first. The 2002 exercise allowed us to recycle a lot of material early on to develop the first prototype of the game. The approach also benefitted from utilising existing skills of the team – particularly ArcGIS™ suite, and their familiarity with working from maps. The approach also made sure the project was educationally sound, ensuring that the topographical base map the students would plot onto was an accurate representation of the landscape in the game, as it had driven the creation of the 3D mesh in the game engine.

The virtual landscape itself was an imagined space, based on aspects of the Moine Thrust, NW Scotland. A rationale for this was to make sure that the learning exercise could not be solved from referencing other materials online, and also not to compromise real field classes.

Making the Map

The first key step was to update the Base Map – a CorelDraw™ .eps file that was archived from the original 2002 learning resource (figure 2), and to output a Height Map that would be used by Unity to generate the terrain.
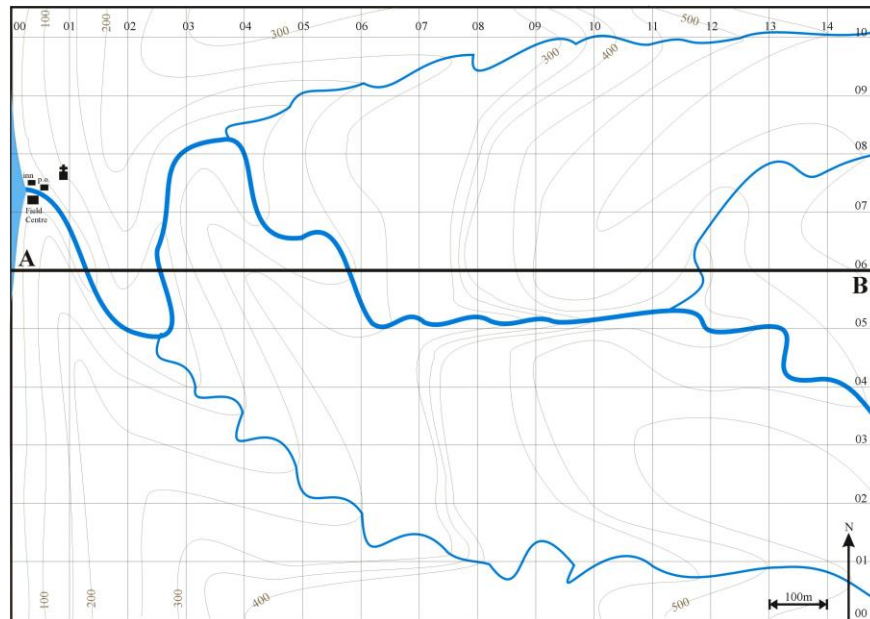
Figure 2. Original Map from 2002 exercise

The workflow began with making the material in the .eps file compatible for import into ArcGIS. One of the main issues discovered early on in the production of graphical assets for the game, was ArcGIS's limited options in image file import and output. This required the layered and vector based.eps image to be rasterized into a .bmp file that could be successfully imported into ArcGIS software. At this stage, graphical layers were removed, ie. grids and rivers, leaving only the contour lines visible in the .bmp file.

This placeholder .bmp, was initially imported into ArcMap to be georeferenced, so pixel information has a dimensional reference to a co-ordinate system. To tally up with Terrain creation tool in Unity, the bottom-left co-ordinate is 0,0; in Unity the bottom left of the 3D Terrain would have x,y,z origin point of 0,0,0 units.

Next, the ArcScan extension of ArcGIS software, provides a quick way to re-vectorize the artwork, and allows the output to be saved as line features. A preview option in the extension allows for some experimentation with values to see the best results first before applying.

As digitized contours, a field was added to the feature class to contain height information, with each contour line's height entered manually.

From this step, a map with the dimensions of 1900m by1450m and an elevation of 200m was produced and ready to move onto the next step for Unity.

Concurrently, this asset was also further adapted for the printout map for the students and for the teacher's solution.

Creating a Height Map

From the ArcGIS file – a Digital Elevation Model was produced. Contour lines were selected, using the Spatial Analyst tools to rasterize the topology. In ArcGIS – the command is - >*Spatial Analyst Tools > Interpolation > Topo to Raster·* The output is an ESRI grid, a proprietary binary format of ArcGIS.

Currently this information would not be compatible with Unity. We also discovered early in testing that the .tif file output from ArcGIS was not viable for Unity, ImageJ or Photoshop.

This led to the next step, to convert the ESRI data into ASCII text, this was achieved simply by using the conversion tools in Arc – >*Raster to ASCII·*

Opening the file in ImageJ (http://imagej.nih.gov/ij/), an open source software, the ASCII file was exported as a 16bit .tif file (figure 3)

Figure 3. Heightmap

This resulted in the classic heightmap image – where black values represented low terrain/ sea level and white represented highest elevation.

The next step is required for Unity's compatibility. The .tif image had to be converted into a RAW format for use by the Terrain tool and to change the pixel dimensions. In early prototyping of the game landscape, it was discovered the image also needed to be flipped vertically, so the 3D mesh produced from the image data was orientated as expected and not mirrored. Usually in similar 3D packages the process would create the expected displacement from the heightmap onto a mesh, but the quirk of the Terrain Tool in Unity resulted in mirroring.

For this stage – Adobe Photoshop was used to adjust, flip and re-export the file as a RAW image. – an alternative open source software would be GIMP (http://www.gimp.org/) . Another necessity was to adjust the pixel dimensions to the nearest 'power by 2' dimension, mainly to benefit the graphical computation of the Unity™ game engine.

For the needs of this project the image was resized to be 2048 by 2048 pixels, to retain the quality of the original .tif. Another requirement for the RAW format was to add a redundant extra pixel to width and height values resulting in an image of 2049 by 2049 pixels. The result was exported as a 16bit RAW file, with a PC Byte Order, which is now ready for use within Unity™.

Creating the Terrain.

The RAW file was imported into Unity directly through the Terrain tool Import Heightmap option. Firstly a flat terrain object is added to the Unity environment. Within the terrain object's inspector, an import RAW option is accessible – under the cogwheel icon. Uploading the RAW file, imports the data into Unity for the terrain mesh to be interpolated from.

The working method for this project was 1px would represent 1m^2 in the game. The Terrain for this game used the X axis as North and Z axis as East. In the terrain objects dimensions the values of the original map were inputted into the parameters – z:1900 x:1450 y: 200. Clicking apply, this step results in a generated terrain with mesh complexity (level of detail) dependant on players draw distance (figure 3), for expectations – in runtime – this would mean an object of approximately 500,000 polygons.
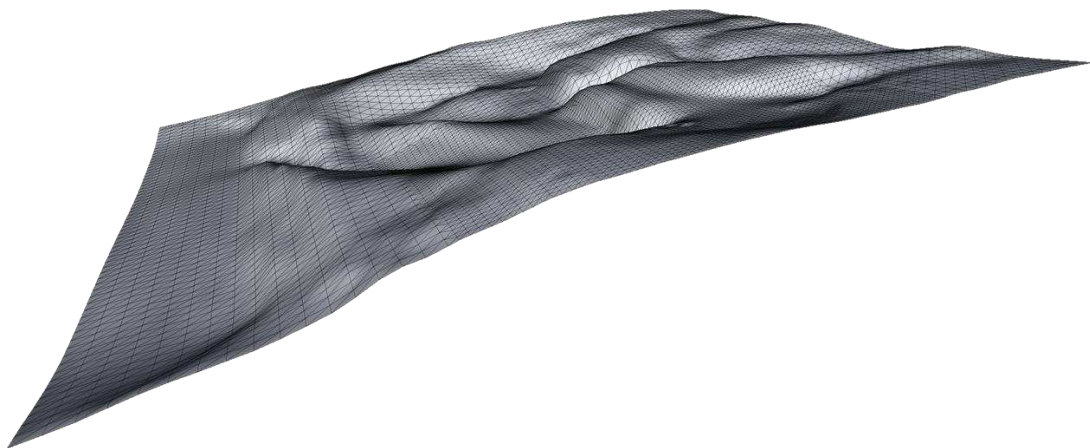

Figure 4. Terrain Mesh in Unity

In the initial prototype testing it was discovered that arbitrary values, though good on paper do not always create convincing 3D landscapes. In the original 2002 exercise

the elevation overall was 600m. Across a landscape that was roughly 2km square – the hills raised sharply and were near impossible to navigate in first person perspective. The visual impact was also unconvincing – as the environment appeared Himalayan in nature rather than the low undulation of a British rural landscape. This resulted in the map and bedding information recalculated for a 200m solution. The lesson learnt being until the map can be experienced as a 3D object – it can be hard to appreciate how the map may appear in elevation.

Next Steps

To begin populating the environment with rocks and other assets, a .tif image of the Map with completed outcrops plotted was draped over the terrain as the first layer of what is called the 'Splat Mat' in Unity terminology (figure 5). This first terrain texture was added and given the same dimensions as the map, in this case 1900px by 1450px, so it covered the mesh completely. Usually textures are small tileable images that are painted onto the terrain to give the impression of surface materials, like sand or grass.

Figure 5. Terrain Mesh with draped map

This approach was a pragmatic way of guaranteeing that placement of rock outcrops were in line with the overall paper solution. Also on this image, the finer details of rivers and streams were added, and these could be used as guides with terrain tools for carving out riverbeds. Note of caution – the additional adjustment to the terrain results in the overall poly count of the terrain object being raised, so try to avoid multiple and complex winding rivers being added to the landscape.

As the modelling of the environment progressed, the original draped image would be covered by textures representing grass and rock. Other assets like bridges, trees and wind turbines were added for both navigation and to help students determine a sense of scale.

An Orthographic top down view from Unity quickly allowed for a desktop snapshot of the games completed environment – which could used with ArcGIS as a visual reference to add features like bridges and buildings to the final map.

Conclusion

Though adequate for our project needs, a major limitation of this design pipeline is the 2D to 3D displacement method of using an image file, means complex terrain features like overhanging cliff faces or cave entrances would require other modelling techniques to implement or augment the original terrain mesh with additional 3D objects.

This design pipeline was a result of pulling together trial and error and minimal documentation of similar contexts. As the project continues to develop with future variations, this approach can be streamlined, and some steps removed completely. Developing directly within ArcGIS, or utilising other software or resources to produce heightmaps can speed up the process. With some expert programming, a custom extension for Unity could be written for direct import of an ESRI file. Anyone up for a challenge?

Further Reading

Fundamentals of Georeferencing a Raster Dataset, ArcGIS HelpGuide

http://resources.arcgis.com/en/help/main/10.1/index.html#/Fundamentals_of_georefe
rencing_a_raster_dataset/009t000000mn000000/ [accessed 31st March 2015]

Terrain Tool – Other Settings, Unity HelpGuide

http://docs.unity3d.com/Manual/terrain-OtherSettings.html

[accessed 31st March 2015]