An Interactive Tool for the Exploration of Contextual Architecture

Case Study: 18th Century Prior Park, Bath

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Abstract: Situated on a southern hillside overlooking the World Heritage City of Bath in Somerset is the splendid 18th century landscape garden, Prior Park. The garden, now a National Trust property, has lost many of its original features and no longer affords the visitor the rich experience it once did. This project demonstrates how digital techniques can reconstruct a complex 12-hectare landscape and simulate the visitors’ pleasure of 250 years ago.

Keywords: Historic; reconstruction; virtual reality; game; landscape.

Introduction

The use of computer models in the recreation of historic architectural buildings and landscapes is a well developed process. Three dimensional stills and flythroughs of historic buildings and landscapes are now commonplace, however the same cannot be said for real time virtual models. Although these are commonplace in the entertainment industry and in some cases this may overlap with historic recreation it is not a generally accepted practice.

This paper documents a small part of a project that brings historic recreation and virtual reality together for an exhibition that displays a fully interactive recreation of the Georgian Pleasure garden Prior Park, located in Bath, UK.

Throughout, the project has attempted to make use of readily available software and technology in an attempt to identify whether an easily accessible workflow could be used not only for this historic recreation but also for future research. This paper looks at two of these processes, development of the terrain model and of the Palladian Bridge.

The ongoing project, due to be exhibited in October at the Sorbonne, Paris, has had input from both members of The University of Bath’s Centre for Advanced Studies in Architecture (CASA) and also from the National Trust, the current owners of Prior Park Garden.

Computer modeling at the university of Bath

The Centre for Advanced Studies in Architecture at the University of Bath will as of 2009 have been developing architectural research in both historical and computer related areas for twenty years. Over this time the centre has developed several research projects that combined both of these fields.

The development of the Virtual Prior Park model has at its foundation three projects, firstly the City of Bath 3D model, created for the purpose of informing the planning process of new developments within the World Heritage City. This project has provided some of the data required for the virtual model such as the 3D model of Bath Abbey. Secondly, a project
developed at the University by Henry Chow which looked at the use of game engine technology to help inform the architectural design process (Chow, 2004). The project successfully allowed designers clients and contractors to investigate and discuss the development of the 8 East building at the University of Bath and provided the inspiration for developing the Prior park model using game engine technology.

Finally, the Prior Park recreation would not exist without the prior research carried out by Marion Harney at the University of Bath. This research project provided the historic foundation required for the model.

A brief history of prior park pleasure garden

Marion Harney reconstructed the original garden by analysing written descriptions, literary references, maps, paintings, photographs from various sources and surveys (Harney, 2005). The information collected was used in conjunction with modern surveys to reconstruct the garden. An example of one historic source is Antony Walker’s depiction of Prior Park, as seen below in Figure 1, showing the Palladian mansion overlooking pasture and woodland.

Following informal paths threading through the landscape, the original visitors experienced strategic views, moods of light and shade, planting, woodland, architectural intervention and water features. Today’s visitors on the ground - until the National Trust’s plans reach maturity - have a reduced experience, with many features lost or decayed.

Through the use of a Virtual Reality (VR) engine, however, instead of still imagery or animation, users can have a sense of involvement in the recreation of the original Prior Park. Users will gain a comprehensive three dimensional understanding of the garden and have the ability to interact with its features.

In order to fully appreciate the surroundings once enjoyed in Prior Park it is necessary to convey as much detail to the simulation user as possible, this will require the accurate simulation of high fidelity models, textures, shaders and particle effects. Realistic lighting and shadow creation as well as the ability to represent tree and plant species exactly further enhance the recreation. To recreate Prior Park, incorporating these above realistic features a game engine was utilised.

The creation of the Prior Parks model terrain and the addition of the Palladian Bridge, although only a small part of the overall model, both involve development principles much replicated throughout the virtual model. They also represent two of the most basic processes that must be carried out to create a virtual model in the CryEngine.

Terrain development

The first process to be carried out when developing a new level in the CryEngine is the creation of a basic terrain. Although not always known at this point, the levels dimensions and resolution must be decided and cannot be changed later in development. Three attempts where made to generate a terrain of suitable size for the virtual model, resulting in much wasted effort, therefore we found that prior planning of the terrain results in a much smoother workflow.

The CryEngine uses a height map based terrain generation system and can produce a functional 3D terrain with dimensions up to 8192x8192 pixels at a scale of 1 pixel per meter. We found this dimension could be increased up to 262144x262144 if lower
resolutions are used and if the engine has access to enough resources. Running the 64bit editor rather than the 32bit allows significantly larger terrains to be developed.

The Prior Park model makes use of a 4192x4192pixel terrain with a 1m resolution, shown in figure 2 (left). After testing with some larger terrains this was found to be the most suitable size for two reasons, firstly this size of terrain allowed us to use the high resolution textures we required without significant loss in performance. Secondly Prior Park occupies a small valley to the South East of the Avon Valley, shown as solid red in figure 2 (right). From this location the furthest pointy of view is the North side of the Valley, and therefore a 4192 pixel terrain was the smallest dimension that allowed this viewpoint to be included.

It is common practice for terrains to be randomly generated using the tools provided in the Sandbox Editor, these tools allow a height map to be developed by setting a number of parameters; however it is also possible to import a height map generated in other Geographic Information System (GIS) software.

To create an accurate height map of the Bath area an
Ordinance survey Digital Terrain Model (DTM) with 5m accuracy was used. The 1x1km tiles based on the OS grid were stitched together using the freeware GIS program Microdem and exported as a grayscale 4192x4192 pixel bitmap shown in figure 2.

This was then imported into the Sandbox Editor to create a basic terrain, depicted in figure 3, which due to the accuracy of the landform data appeared quite jagged, this was resolved by applying the a smoothing filter to the height map. However, a preferred solution would be to use a higher quality DTM of 1m resolution to generate the height map.

Once the 3D terrain was imported the next step in realizing the finished terrain was to begin applying textures, this was done in two stages: A macro stage in which maps where applied and micro stage where photo real textures where painted in the correct areas. The application of maps to the terrain was crucial for helping to correctly locate the position details to be added onto the landscape. This stage is usually not necessary as the accurate location of details in a common game mod is not overly crucial.

Three maps where used to construct a detailed terrain map, firstly a base map was required, once again OS survey data was used, 5x5 1:10,000 scale raster tiles where used to create a 4192x4192 texture overlay. This modern data was adequate for locating general terrain details, but more relevant texture data was needed for the areas of Prior Park and the City of Bath. For this the 1794 survey of bath, which only maps the central area of the city, and a 1780 survey of Prior Park where overlaid onto the modern OS map (figure 2 right). This was easily applied to the 3d terrain as four 1024x1024 tiles in tiff format and once applied proved to be accurate enough to place detailed brushes, roads, water feature and vegetation.

The second stage of terrain mapping took place once all the major landmarks had either been placed or marked with a holder and the maps where no longer required. To increase the detail of these textures the terrain resolution which as standard is the same as the height map, was increased in areas where detail would be needed. Terrain textures are applied by painting directly onto the terrain, which allows for very accurate and quick application.

**Detailed model development**

There is a wide variety of model and entity types available for use in the CryEngine, the most basic of which, the brush, plays the most important role in the Prior Park model. Basic brushes can be created within the Sandbox Editor in a similar fashion to many other game engines by using basic solids and Boolean operations. However this modeling technique is only suitable for creating very basic models. More complex models can be realized by employing secondary modeling programs that allow for far superior creations.

The ability to efficiently import highly detailed models into the CryEngine was a key factor for its use in creating the virtual mode. The project attempted to develop a workflow to easily reconstruct historic pieces and import them into the engine for interactive viewing.

Standing in a prominent position at the far end of the pleasure garden stands one of the park’s key landmarks, the Palladian Bridge. One of only four in existence, the bridge was constructed for Ralph Allen by Richard Jones around 1755 and is a prime example of Palladian architecture built in the local Bath stone. The bridge spans over the lower lake and is surrounded by dense foliage on one side and crosses onto open pasture.

The Palladian bridge was the first model to be fully realized for the Prior Park model. It was chosen not only due to it’s prominence in the model but also because its size and numerous details would provide a suitable test bed for many of the CryEngines more advanced modeling techniques. During its construction, several problems where encountered and many resolved; this led to the development of a consistent workflow which has been employed to realize many other models and which will be described below.

Although 3ds max is used as the exporter for the CryEngine and is capable of being used to develop
of a quarter of the main bridge, and more detailed individual models of a column and its base, two capitals, a balustrade and an arch detail.

These models were then exported via 3ds format to Autodesk 3ds Max at which point all the models’ vertices were welded. To remove any apparent faceting a smoothing modifier was applied and basic mapping co-ordinates were also added before any further modeling was undertaken. A process of copying instances of the models’ details was used to generate half-complete geometry. The instance objects are shown as blue wireframe, in Figure 6, whereas the original models are shown in red. Once imported into the game engine, these instances

the models, the preferred choice for modeling was Sketchup. Like many historic building very few architectural drawings still exist of buildings at Prior Park, therefore modeling was carried out using historic photos that were available. Sketchup allowed a very quick workflow for interpreting these photos into 3D geometry using the Photomatch tool.

After several attempts at modeling the bridge it was found that the best practice was to model as little as possible, and instead rely on the symmetry of the Georgian Architecture. Wherever possible, replication of detail was kept to a minimum and geometry was instanced later to improve performance. The final model created in Sketchup consisted (Figure 5)

Figure 4
The Palladian Bridge located at the bottom of the Prior Park landscape garden

Figure 5
Views of the Palladian bridge in Sketchup, detail models are separate to the main bridge

Figure 6
In-game view of the Palladian bridge comparing the models in Sketchup and the game engine
objects act only as reference points for locating the detail models and as such the CryEngine will not load their geometry into the memory.

The half model has a relatively high face count of 142,600 with much of this used to communicate the detail of the capitals and balusters, which play a key role in the final appearance of the virtual model. To lower this face count, Level of Detail (LOD) models were employed. These are generated from, and referenced to, the main model and contain significantly less detail. Figure 7 (right) shows the main model in red and two LOD models in yellow with face counts of 31,000 and 11,000 respectively. When viewed in the engine these are automatically switched with the main model at distance and significantly increase performance without diminished visual effect. This technique was used extensively throughout the Prior Park model and made the display of detailed architectural models possible.

Before the bridge was exported, high resolution textures were applied to the geometry as shown in figure 8 (left). We found that on first attempt using a similar technique to texturing conventional 3D models, the final textures, in game, appeared quite poor, notice the tiling in figure 8 (right). To correct this, the main geometry of the model was unwrapped to create a custom UVW map which resulted in a far superior finish but also resulted in a large time penalty. Therefore the detail models where mapped with basic UVW maps to save time. The mapping of the bridge required a total of four image maps, a diffuse map, specular map, normal map and in some cases...
parallax occlusion map to give the effect of rusticated stone masonry without an increase in model size. The textures were all generated in .dds format using the Nvidia Photoshop plugin.

The ease with which models can be imported into the CryEngine was one of the key reasons for its use in the project; this was confirmed when attempting to import the bridge model. There are two parts to the export process; firstly the textures maps are exported to the engine and converted to .mtl files. During this export the physical properties of materials can be set. Secondly the models geometry is exported. This is done, in the case of the bridge, as a single model which is made up of several nodes, all of which are linked to a dummy object for easy selection. The exporter has been successfully tested with exporting models with as many as 500,000 faces. However the total number of faces supported relies heavily upon the graphics card to render them.

Once imported the brush was copied and rotated creating the entire model. At this point one of the key benefits of employing the Engine is revealed. The CryEngine does not require levels to be compiled before use and instead relies on Screen Space Ambient Occlusion (SSAO) to fake Global illumination. Therefore all work that is done in the editor is essentially the final product. From a development point of view, we found this to be a significant benefit over other engines as materials and brushes can be setup in the same environmental conditions that will exist in the finished model.

**Conclusion**

Although the Virtual model is still in development many of the key components required for the virtual model have already been tested. By using the Cry-Engine SDK and the Sandbox Editor in conjunction with a number of easily accessible secondary design programs, a highly detailed terrain and interactive model can be generated for viewing as quickly as it may take to create an animation of the same.

The current virtual model has been exhibited to researchers and professionals working in the field of historic architecture and landscapes and has had promising feedback, especially regarding the ease...
with which viewers were able to gain a feel for the virtual environment.

Only a small part of the projects basic processes have been covered in this paper, areas such as dynamic environmental lighting, vegetation and interactive AI are still being implemented.

Reference