Abstract

In this paper we describe a simple modeling technique used to create precise and complex digital terrains models using contour maps. As a case study we use the terrain of the "Monte Albán" archeological site, located in the Mexican state of Oaxaca. We employ the technique with a simple contour map to obtain a realistic tridimensional terrain model that includes the four main hills of the site.

Keywords--- 3D Modeling, GIS, Archaeological reconstruction.

1. Introduction

There are several different approaches to represent a 3D digital terrain. These depend largely on the available data and the level of detail desired. In the case of archaeological sites, their location is clearly determined by terrain features. These can clearly mark the settlement and development of the ancient cities they post-date [1].

There are a number of requirements for such a terrain model. Firstly, a terrain model should clearly show the landforms and the effects of air and water erosion over surfaces. It should also reflect a realistic representation of terrain elevation and be functional at different levels of detail. Such a model also needs to display different types of erosion (water, wind, etc.), soil composition and vegetation (amount and type). These features can be illustrated using image textures. Typically, climate and elevation are factors that determine characteristics such as the color and density of vegetation. Vegetation can be displayed as a texture or as small 3D objects on the ground. A model also needs to consider artificial elements that correspond to changes made by man, such as roads, dikes, walls, terraces and buildings in general.

Our proposal builds the terrain of an archaeological site in an easy way using a minimum of information, without need of specialized software.

The following section provides a description of existing techniques for generating digital terrains, available tools and formats commonly used to represent them.

2. Related work

In most applications, the procedure to digitally generate a terrain is based in grayscale elevation maps. In these maps lighter tones generally represent areas with increased altitude. This type of procedure is recommended for scale models including local measurements. It produces a surface where we can place different objects and apply textures to achieve realistic terrain representations.

There are more complex and detailed models that can even be georeferenced (i.e. associated with a spatial reference system) to show the location of the model on the earth’s surface at a given scale. These models are based on field measurements, remote sensing or restitution. The input formats can range from point clouds, data generated by the LiDAR sensor, contours generated by stereoscopic aerial orthophotos restitutions, until GRID format with regular elevations in space. Examples of these formats are GeoTIFF for raster images and TIN (Triangulated Irregular Network) for surface images.

2.1. Tools for terrain generation

To generate a digital terrain we can make use of different kind of applications. For example, there is 3D modeling software that includes terrain edition capabilities based in elevation maps and editing surfaces. These provide tools for lifting, leveling or plunging different parts of a surface and allow us to manually approximate the desired models. There are also specialized applications for Computer Aided Design (CAD) and Geographic Information Systems (GISs) that can generate terrain models and surfaces. To create these models we need point clouds, elevation contours or elevation grids. The input format is vector or raster; it is processed to generate a Triangulated Irregular Network (TIN), which is a triangulated surface based on vector elevation data. The latter format is very detailed but their generation and manipulation requires a great deal of processing time.

As an alternative to the TIN format, a raster GRID format can be generated at different levels of detail; this format takes a regular sampling of the elevation and generates a regular surface based on quadrants [2]. Any
of these TIN or GRID formats can be exported to formats used in modeling tools, such as X3D or Collada, to be integrated into other projects.

![Figure 1. Terrain modeling of Popocatepetl vulcano using GIS tools [3].](image)

The use of digital terrain almost always involves a great deal of processing. It does, however, allow us to generate terrains at different levels of detail according to project requirements. Models can also be shared online, as the X3D format supported in HTML5 or KML for use in Google Earth.

The videogame engine Unity [4] has a terrain editor with various possibilities of manual terrain editing, and offers the possibility to include textures in the terrains as well as trees and vegetation models. The terrains generated with this tool are realistic and designed for real-time interaction, so they are modeled with simple nets that can allow us to integrate collision detection properties. Moreover, with the Terrain Toolkit for Unity created in 2009 by Sándor Moldán we can model six different types of erosion and many possibilities of terrain smoothing and height normalization. With this toolkit we can also apply textures of the land according to their elevation. In addition, Unity can be installed in a standard mid-range personal computer.

3. Case study: terrain of the Monte Alban archaeological site

The city of Monte Alban is a legacy of the Zapotec culture which originates in the south of Mexico. In its time the city was the economic, political and religious hub of the civilization and the first urban complex of Mesoamerica. The city grew to cover an area almost as large as modern day Oaxaca city and lasted from its formation in the year 500 BC., until its decline around 850 AC. [5].

The city is surrounded by several chains of mountains which confluence at the great Valley of Oaxaca. Three hills make up the archaeological site. These are Monte Alban, El Gallo and Atzompa. Each of these has monuments at its summit and terraced fields on its flank. During the Classic Period (350-550 AC) the city reached its peak. Based on a strong control over the neighboring villages, Monte Alban extended its area of influence and established alliances with other cultures. The splendor of the city encouraged the development of science and the arts. The city had its own astronomical observatories, a writing system, a calendar, and a great variety of ceramic and stonework. The city of Monte Alban became the sacred space of the Mixtec world in the eighth century, and concluded his ascension around the year 850 when the construction of buildings came to a halt and agriculture faltered.

Our project to reconstruct the archaeological site of Monte Alban begins with the modeling of the terrain where the civilization settled. Although the first phase of the project proposes the modeling of buildings in the main square of Monte Alban, we wanted to include the mountains around these with a view to reconstructing the housing settlements that were built in the hillsides, as well as the Atzompa archaeological site.

3.1. Terrain modeling

3.1.1. Step 1 Our terrain modeling work started with the following image contour (Figure 2):

![Figure 2. Contours of the Monte Alban zone [6].](image)
The contour is initially drawn using control points (Figure 3). Next the nodes are converted to curved nodes to approach as close as possible the contour we want to capture. This procedure was performed for each of the curves in the image (Figure 4).

3.1.2. Step 2

After obtaining the contour lines in vector format, we used the Rhinoceros© 3D modeling software (although we could have used any other modeling program that generates export files in FBX format) as support to convert these contours into extruded solids. These were to serve as a reference in the Unity software in order to model the terrain manually.

Before converting the contours into solids, we placed each one in its respective height. Extrusion of the lines was carried out to obtain the hill’s solid areas (Figures 5 and 6).

3.1.3. Step 3

The extruded solids were exported in FBX format to the folder Project > Assets of a Unity© project.

We import the 3D extruded solids into a Unity project scaled to their corresponding size. Then we create a flat terrain with the necessary dimensions and proceed to modify it manually using the terrain editor of Unity, specifically the Paint height tool (Figures 7 and 8); with this tool we modified the height parameter of the flat terrain using the data obtained from original contours (in this case we started at height 225m with increasing intervals of 50 meters).

We proceeded to modify manually the flat terrain of Unity using the extruded solids as a guide: from the top view screen and with the Paint height tool activated, we choose a thick brush to elevate the terrain, changing the
height parameter when necessary, following and covering the contour, creating a level in the terrain in (approximated) reference to the solids created with Rhinoceros©. We performed this action with all other contours to obtain an approximate result of the hill (Figures 9-11).

3.1.4. Step 4 Once we have an approximation of the hills we used the Terrain toolkit of Unity to smooth the terrain between levels, simulating erosion due to weather conditions. For this project we used a small factor of erosion due to wind, water and thermal conditions, resulting in a field close to what we were looking for (the parameters used to calculate erosions were largely determined using a method of trial and error). Finally, we applied some grass textures to the terrain, and the sky created using a skybox with directional light emulating the sun.

4. Conclusions

In this paper we presented a simple technique for terrain modeling which creates a realistic model of a 3D terrain from a basic contour map using simple and accessible computational tools. As an example, we present the terrain modeling of the archaeological site of Monte Alban, located in the state of Oaxaca, Mexico. The benefits of the proposed method is that it allows the
generation of high quality terrain models using data that is easily accessible to everyone without the use of expensive specialized tools or high spec computer equipment.

![Figure 11. Approximated model of the hills.](image1)

![Figure 12. Final terrain model.](image2)

Figure 11. Approximated model of the hills.

Figure 12. Final terrain model.

Figure 13. Terrain visualization in Unity©, at execution time.

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References


