3D CITY MODELLING AND VISUALIZATION OF HISTORICAL CENTERS

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ABSTRACT:

Nowadays, the synergy of photogrammetry, surveying and advanced Internet programming bring the possibility to produce 3D photorealistic models. This way of visualisation allows the user to get inside real world by means of impressive interactive virtual worlds. Furthermore, the 3D worlds created can be used by technicians and restorers in order to make studies, analyses and future predictions about specific or planned actions.
Besides, photorealistic visualization of 3D areas is applied to many areas such as architecture, archaeology, cartography, civil engineering, medicine, and last but not least, tourism. The employment of this visualization and modelling procedures, increases current market demands through Internet.
This paper is focus on the conservation and the graphic divulgation of a historic area in Paterna (Valencia, Spain). Digital photogrammetry and surveying techniques allowed us the creation of a digital terrain model used as input data for the 3D modelling of the Tower and the caves comprising the historical site (XIII century). This 3D modelling has been implemented in VRML in order to fly and walk free and interactively through the model. Furthermore, inside the model the user will find, on the one hand, some interesting photographic multimedia contents and metadata, and on the other hand, interesting viewpoints and virtual tours.

1. INTRODUCTION

Nowadays, there is an increasing demand for full three dimensional (3D) data for planning, architecture, environmental analysis, and, last but not least, tourism. A virtual historic centre should contain not only buildings and roads, but also street furniture, traffic signs, vegetation, etcetera. The more 3D features it contains, the more realistic it will be. However, management and modelling of all these kind of information is difficult and complicated. In fact, all the types of objects visible in reality should be modelled with a certain degree of genaralisation within the virtual model.

This paper shows a new software called TopVRML that is designed for creating 3D elements into virtual models, e.g. virtual 3D historical centres. TopVRML takes all the advantages of the Virtual Reality Modelling Language (VRML, 1997). Additionally, VRML is a scriptable 3D graphics language in the sense that its applications can have logic embedded with scripting or other programming languages (Huang and Claramunt, 2004).

It has been tested in a historical environment placed in the city centre of Paterna (Valencia). The site is very peculiar because surrounding the Tower there are caves and light chimneys from the XIII century.

Next sections show part of the work carried out to produce the 3D visualisation and modelling of this historical and complex area, as well as how TopVRML can be used to add realism to the virtual project. It is an interface between surveying/photogrammetry and computer modelling for creating interactive virtual photorealistic models.

2. FIELD WORK AND PHOTOGRAMMETRIC PROCESSING

Surveying and photogrammetric techniques have been used in order to fit exact size objects and images to the virtual world. Therefore, visual impression is exactly the same as if the user was in the field area. For that purpose, some transverses and radiations were carried out to collect both ground features and photogrammetric control points (Fig. 1). Furthermore, a huge digital close range photographic archive was planned and implemented.

Figure 1. Distribution of photogrammetric control points.

Besides, photogrammetric processing of the digital archive was mandatory because images were not geo-registered. Therefore, planar imagine rectification using the well-known projective transformation (Lerma, 2002), image extraction and radiometric correction were performed (Fig. 2). Last but not least, image development (using DesenRec 1.0 (Lerma and Tortosa, 2004)), colour balance and mosaics were also carried out for the right

image projections onto geometrical surfaces, e.g. the Paterna′s tower (Fig. 3).

Figure 2. Image patch after projective rectification of a planar building wall.

(a)

(b)

Figure 3. Mosaic of the Paterna′s tower: a) without colour correction; b) after colour correction.

4. BUILDING UP 3D MODELS THROUGH TOPVRML

There are in the market many high-end and middle-end software for creating 3D worlds. Most of them are used for visualising and interacting 3D city models. GIS and Computer Aided Architectural Design (CAAD) follow distinct modelling paradigms for the generation and management of virtual 3D city models (Kolbe and Plümer, 2004). However, they do not usually offer efficient management for large 3D city models, and small details are disregarded. Furthermore, they mostly make very large code files, not at all optimised.

Our software TopVRML has been developed to model and join efficiently 3D virtual objects. Additionally, the texture is mapped onto the optimised faces. The whole software is written in C++ and it makes VRML (Virtual Reality Modelling Language) code able to be used directly and interactively over the Internet or private computer networks, thanks to free VRML browsers.

Fig. 4 shows a typical error when dealing for example with vertical walls. Conventional software would produce a draped texture not at all fitting the reality, though the model is right but not optimised for Internet and interactivity purposes (Fig. 4a). However, what users are expecting are shapes and figures similar (if not identical) to the real ones (Fig. 4b).
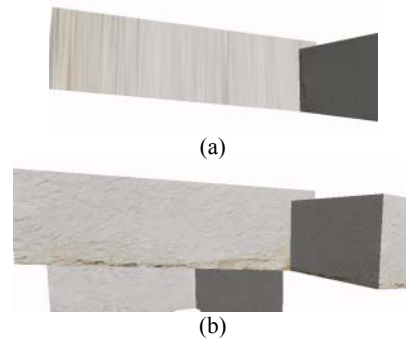

(a)

(b)

Figure 4. (a) Model generated with inappropriate software. (b) Model generated with TopVRML.

TopVRML menu has 6 items:

1. New archive
2. Prototypes
3. Object generation
4. Illumination
5. Special effects
6. Help

1. New archive:

  1.1 New work
  1.2 Observer characteristics (walking, flying or examine; space size)
  1.3 Sky and ground backgrounds
  1.4 Exit

As a way of example, it is possible to select many different backgrounds for your virtual model. Fig. 5 shows three ways of preparing sky and ground backgrounds.
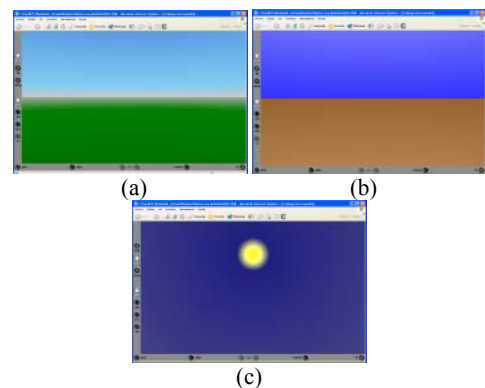

(a)   (b)

(c)

Figure 5. Different applicable background models: a) Blue sky and green ground; b) Blue sky and brown ground; c) Dark blue sky and sun.

2. Prototypes:
    2.1   Insert prototype
    2.2   Insert prototype with hyperlink
    2.3   Exit

It is possible to insert a prototype as many times the user wants, without redefining an object or set of objects. Furthermore, it is possible to link a prototype with webpages. For example, everytime the user moves close to the tower and double-clicks specific targets, additional information is displayed (Fig. 6).

Figure 6. Object with hyperlink and associated information.

3. Object generation:
    3.1   Object generation from one image
        3.1.1   Base and heights
        3.1.2   Co-ordinates
        3.1.3   Could of points (nowadays requires Matlab)
        3.1.4   Exit
    3.2   Object generation from multiple images
        3.2.1   Hexahedral (6 faces)
        3.2.2   Exit
    3.3   Geometrical shapes
        3.3.1   Cube
        3.3.2   Cylinder
        3.3.3   Cone
        3.3.4   Sphere
        3.3.5   Exit
    3.4   Exit

Figure 7 shows how easily is mapped a building when we have got the rectified facades. This is a typical boundary representation enclosing the building's volume. Besides, the procedure used to create the digital model in Fig. 8 is based upon an irregular cloud of points. The triangulation topology is determined in Matlab v.6.0. However, the texture is automatically draped to the net of triangles.

(a)

(b)   (c)   (d)

Figure 7. Building 3D generation with TopVRML software: (a) volumetric building model; (b,c,d) rectified image facades.
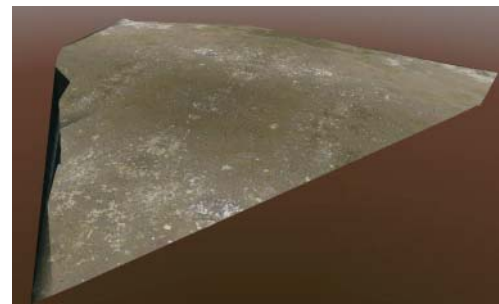

Figure 8. Digital terrain model after Delaunay triangulation and automatic textures draping.

The modelling of complicated objects is also possible mixing geometrical shapes. TopVRML offers also this possibility and it was used to model small and unconventional features as light chimneys. Table 1 summarises the different regular shapes used to build up these features. Finally, all the mixed shapes are automatically written to the same VRML archive.

Table 1. Generation and mix of geometrical shapes for building up complex objects

Name	3D shape	Mixing shapes
Cube		
Cylinder		
Cone		
Sphere		

4. Illumination:
   1.1 Directional light
   1.2 Punctual light
   1.3 Exit

Illumination menu allows the user to place both directional and punctual colour lights in the scene. Fig. 9 shows a typical example of illumination management.
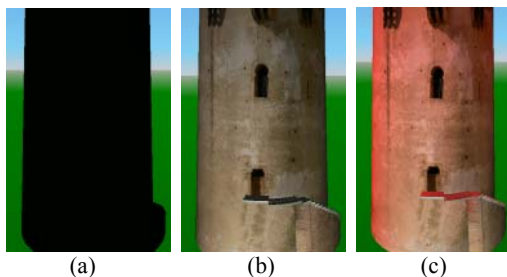

| (a) | (b) | (c) |

Figure 9. Paterna's tower differently illuminated:
a) Without light; b) Lantern light; c) Directional red light.

5. Special effect:
   5.1 Point of view (field of view, spatial positions and flight definitions)
   5.2 Sound
   5.3 Automatic object orientation (billboard)
   5.4 Exit

6. Help:
   6.1 Email:
        angarben@topo.upv.es
   6.2 Web:
        ttt.topo.upv.es/~angarben/topvrml/ayudatopvrml.htm

Besides, the 3D model can be visualise through Internet thanks to VRML browsers. Additionally, it is also possible to visualise 3D worlds over Internet in real-time making .EXE applications. Therefore, it is not necessary to install any VRML browser in your computer. For that purpose, we have also implemented a Visual Basic visualiser. One snapshot appears in Fig. 10.

Figure 10. Historical centre of Paterna (Valencia). Virtual snapshot selected from the virtual flight.

5. CONCLUSIONS

This paper has shown how it is possible to efficiently visualise and manage 3D sites by means of the new software TopVRML. It takes profit of surveying and photogrammetric campaigns, and therefore, the virtual worlds seem impressively realistic. Furthermore, interactivity within the historical centre allows the user to move freely around the model and obtain information about special features by means of hyperlinks. On the other hand, a virtual flight around the study site allows the user to discover unique Cultural Heritage through Internet. Last but not least, a visualiser has been developed to help non-specialist to navigate through the historical centre of Paterna, without any need of installing VRML browsers.

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