TOPOSCOPY COMBINES PHOTOGRAMMETRIC MODELLING WITH AUTOMATIC TEXTURE MAPPING

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ABSTRACT:

Toposcopy is a close-range photogrammetric method that links a 2D map to photos taken in an horizontal or upward direction (Groneman-van der Hoeven, 2003). The method can very well be used in a built-up area like inner cities, because one only needs one photo plus a 2-dimensional map to make accurate 3D models of existing houses and other objects. Toposcopy basically combines 3D modelling and visualization which allows to map surfaces automatically when exporting the toposcopic database in the Virtual Reality Modelling Language (VRML). This language uses indices to describe both the 3D geometry and the 2D textures. In Toposcopy the values of the texture indices can automatically be determined with the build-in perspective calculation. Therefore one does not need to cut out a texture from a photo and ortho-rectify it before using it for texture mapping. Moreover, when the size of a plane is known, the number of times a pattern has to be repeated can also be calculated supposing that the pattern represents 1 square meter. Many toposcopic objects can be set-up just by tracing them in the map with a continuous line and all walls and planes in a toposcopic virtual world can be mapped with an image or repeating pattern. In the Scope program a panorama routine is included that makes it easy to link a series of photos taken from the same camera point to the map. These photos can be stitched together to a 360 degrees panorama in a program like PhotoVista (MGI software). Such a panorama can be transformed to a virtual cosmorama by mapping it on the inside of an extruded polygon. This creates a photo-realistic world, that can be augmented with 3D ground planes and objects and that can be toured in a VRML browser.

1. INTRODUCTION

In 3D CAD programs and modelling and visualisation programs like 3D Studio Max modelling and texture mapping are 2 different exercises. Measuring has to be done completely outside of these programs with some kind of land survey method or other tool.

When using the close-range photogrammetric method Toposcopy measuring, modelling and texture mapping can be combined. This paper focuses on the advantages of using the same program for these three actions.

Toposcopy links topographic or cadastral maps to photos taken in a horizontal or upward direction through a perspective calculation of 2 or 3 points that can be identified both in the photo and the map. The toposcopic method has been extensively explained in a previous paper (Groneman-van der Hoeven, 2003). In this paper we will primarily focus on new ways to create virtual worlds using single photo images, panoramas and repeating patterns. For those who are new to this method we will give a short review of the basics.

2. THE TOPOSCOPIC SYSTEM

In Toposcopy map and photos form one interactive 3D system. This is done by alternately clicking on points in the map and a photo. The map becomes 3-dimensional with the photo data and a perspective fits exactly on a photo once it is properly linked with the map.
The 3D system can be used to:

- create photo-realistic visualisations of spatial designs in the existing environment;
- make accurate 2D drawings of walls of existing houses using the toposcopic photogrammetry;
- make 3D virtual models of urban and rural areas;
- create photo-realistic virtual worlds using panoramas as a background.

Fig.1: A photo-realistic visualization of a spatial design in a photo of the existing environment.

The method is easy to carry out. A 2D map is usually available. For visualisations photos may be taken from a tripod or off-hand when in each photo there are at least 3 points that can be identified both in the photo and in the map. However, when accuracy is important, or in cases that it is difficult to orient, or in sloping areas without available elevation data we prefer to combine photography with some land survey measurements. For that we developed the toposcope with accompanying software. The toposcope is an automatic level on which an adapter with a camera are

mounted. The toposcope is used to take photos in a controlled way and to measure some 3D points in all those cases that they are not easily available otherwise. With the program Topo the toposcope can be used as a simple tachymeter. Because the level has an angiometer and can be rotated a certain number of degrees the toposcope also allows to make excellent panorama photos.

3. TOPOSCOPIC MODELLING

Toposcopy speeds-up the modelling of urban and landscape areas considerably. After linking a photo to the map you can directly acquire 3D information by clicking in one photo at the time. Therefore the method is easy to use in build-up areas like city centres.

A loose collection of 3D points will not automatically turn into a nice and recognizable 3D model. Therefore we have developed a number of specialised tools to increase the efficiency.

The program Scope works with parametric models. Most house types are distinguished by the shape of the roof and can be constructed with 5 or 6 3D points. After pressing a special house button the records spatially describing the house are set up automatically. The x/y/z coordinates are measured photogrammetrically as far as possible. However the x/y coordinates of parametric points that are invisible in the photo (usually the back of a house) are acquired by clicking in the map instead. Each time the database is exported in DXF or VRML or drawn in perspective the other 3D construction points are calculated automatically from the parameter points.

Fig.2: A 3D virtual model of a Dutch city center with a variety of house types.

You can combine different models and shapes to form a complicated building. Buildings with stacked components or round shapes are modelled by tracing the circumference in the map and extruding the shape to a height that is determined photogrammetrically. On the contrary decorative gables are traced in the photo and are extruded in a horizontal direction. Figure 2 shows several buildings with a saddle or flattened hipped roof and an decorative gable in front

4. TEXTURE MAPPING

Toposcopy has many different ways of mapping a texture or image on a plane or terrain model. Some are unique for Toposcopy, others can also be found in other visualisation and modelling methods. Now all walls, roofs and other digital models can be coloured or mapped.with a texture.

So one does not necessarily need another program to finish the 3D world. Fig.3 shows one of the helpforms that can be evoked by pressing the Shift-key.

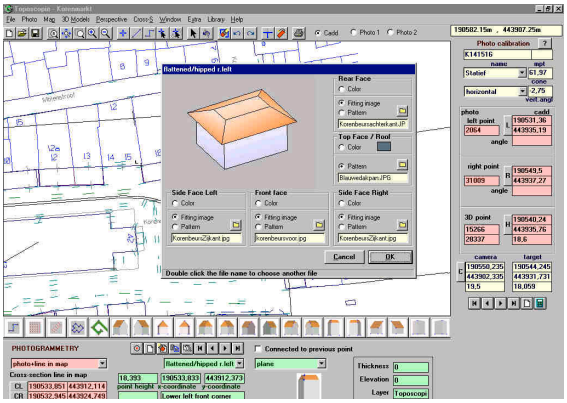

Fig.3: Form to determine the finishing of house types.

4.1 Photo images

Toposcopy basically combines 3D modelling and visualization. This has lead to a new way of fully automatic texture mapping, that can be applied when exporting the toposcopic database in the Virtual Reality Modelling Language (VRML). This language uses indices to describe both the 3D geometry and the 2D textures. In Toposcopy the values of the texture indices can automatically be determined with the build-in perspective calculation. So they are readily available. This convenient way of automatic texture mapping is the standard in Toposcopy. If one chooses to map a plane with a photo image the photo that has been used for modelling is the first choice. However when the photo is taken in an very oblique way, it is sometimes better to cut out a texture from this photo or another photo and ortho-rectify it before using it for texture mapping. In the 3D maquette of fig.2 both methods have been applied.

Aerial photos and images of maps can be mapped to ground planes or digital terrain models that may be flat or elevated.

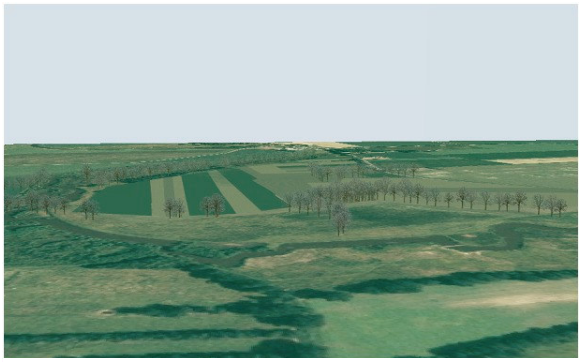

Fig.4: Aerial photo with a reconstructed landscape.

4.2 Repeating patterns

Repeating pattern are used on roofs, walls or any other digital model or plane. Because map and photos form one integrated system and all existing buildings are modelled with the toposcopic photogrammetry, the dimensions of all planes are known. That is the reason that the program can calculate how many times a pattern must be repeated to get a realistic view. The rotation of the pattern is determined by the model or the first 2 points during modelling.

4.3 Panoramas used as a background in a VR world

In the program Scope a special routine is build-in that facilitates to calibrate a series of photos taken from the same camera point. The first photo in the series is linked to the map by clicking on 2 or 3 known points in the map and the corresponding points in the photo. For all subsequent photos only the rotation angle has to be filled in. Such a series of photos can be stitched to a 360 degrees panorama in a program like PhotoVista (MGI software). For the further processing of the panorama it is important that the photos are taken is an almost perfect horizontal direction. In such a case we always use a toposcope.

Such a panorama can be build in a toposcopic virtual world. The panorama is loaded as a photo, linked to the map and also linked to an special object called cosmorama. With these data a virtual cosmorama is created during export in VRML. The viewer is at first standing in the center, where the photos have been taken. The panorama is automatically mapped on the inside of an extruded polygon, that has as many sides as there are photos taken to make the panorama. The polygon can be drawn in the map. Everything that is outside the extruded polygon can in a VR environment only be seen on the panorama. The polygon can be varied in size but the aspect ratio of the panorama image is always maintained.

The area within the polygon can be filled with ground planes and 3D objects. Because of the exact orientation of the extruded polygon the panorama forms a precise background for the 3D objects. Figure 5 shows a VR world with a changed panorama, viewed from a observation-platform modelled in VRML. When you leave the area within the polygon empty and the panorama unchanged you see the existing environment including the foreground.

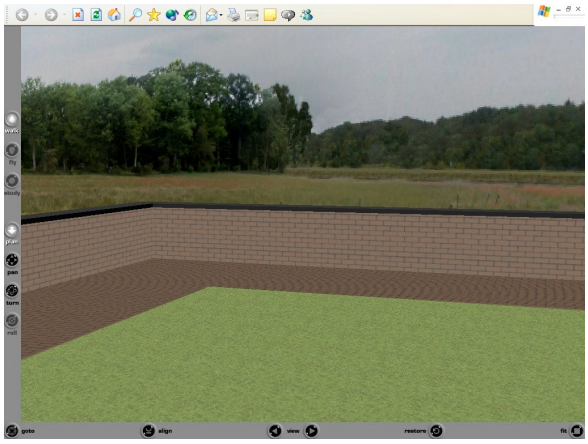

Fig.5: Enjoy in VRML a view at a changed environment!

With the navigation tools of, for example, the Cortona Client, that can be downloaded from the website of Parallel Graphics, one can move around in the virtual world.

4.4 Trees and hedges

Photo-realistic trees can be chosen from a library of trees in summer en winter shape. The textures have a alpha channel. During the export in the Virtual Reality Modelling Language they are automatically placed on transparent billboards that turn perpendicular to the direction of view. The trees can be combined with rows of woody vegetation. They are also placed on transparent vertical planes, but do not turn around in a VR world. They act as a kind of coulisses. Coulisses can also be used for other objects or figures. They can add additional depth to a virtual environment.

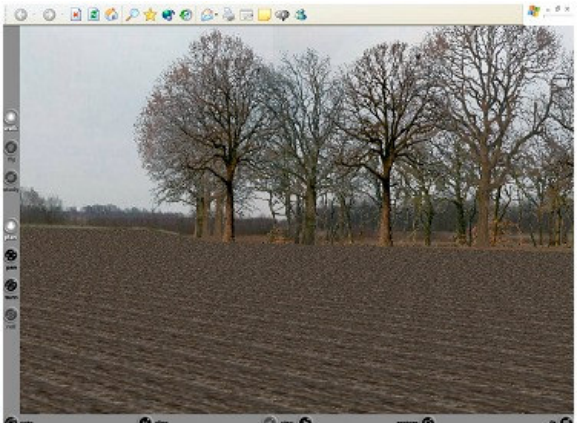

Fig.6: Trees and hedges in winter-shape placed in a Virtual World.

5. CONCLUSIONS

Toposcopy has many different ways of mapping a photo image or pattern on a surface. Because map and photos form one integrated system modelling can combined with texture mapping. When the photo that has been used for modelling is also used as a texture, the mapping can be done automatically. Photos can be linked to a map individually and when combined with others into a panorama. That is the reason why a panorama in a VRML world can be automatically mapped on an extruded polygon, that is precisely oriented in the map. In this article we give an example of a landscape panorama build in a virtual world. It is obvious that the same technique can also be applied to town squares.
For trees, rows of vegetation or other objects that are shown as coulisses in a virtual world, textures with an alpha channel are used.

References

(Groneman-van der Hoeven, 2003)*Proceedings of the ISPRS workshop Vision techniques for digital architectural and archaeological archives in Ancona, Italy,* pp 168-172.)