

A low-cost digital photogrammetric system linking photo and CAD data

TOPOSCOPY

Toposcopy is a new method that links a 2D map 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. After the data has been processed the map and images form an interactive 3D system. At first the system was only used to accurately visualise a 3D design in a photo of the existing environment. When Toposcopy further developed, it became possible to measure and model existing buildings and other objects at the same time, using parametric models. The results are either 3D textured or coloured 3D worlds or 2D CAD drawings of façades. Lately this new close-range photogrammetric method is successfully applied in other fields as well, like the mathematical reconstruction of the movements of a bus colliding against a road barrier from video images.

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Toposcopy is a geo-referenced visualization and close-range photogrammetric method based on the use of a low-cost digital camera and some CAD data. This article starts with a short comparison of Toposcopy and tripod-mounted laser scanning. After that the method is further explained with some examples of carried out projects.

Toposcopy versus tripod-mounted laser scanning

Toposcopy is an alternative for tripod-mounted laser scanning. In many aspects these methods are antipoles. Laser scanning measures millions of 3D points automatically and in a short time while Toposcopy measures and models a 3D object with as few points as possible by alternately clicking on points in the photo and the map. Laser scanning is particularly interesting for making a 3D model of a complex and irregular object or group of objects. On the other hand Toposcopy takes advantage of the facts that usually walls are upright and that most buildings have some symmetry. With laser scanning the processing of the data to reduce the complexity of surface meshes is difficult and time consuming, On the contrary during the export of the toposcopic database in VRML the 3D world, mostly build with parametric models, is directly fully calculated and coloured or textured automatically.

Toposcopic equipment

The means to make toposcopic visualizations and photogrammetric measurements are relatively cheap. To be independent of the availability of land survey data and to facilitate to take photos in a controlled way we assembled a new instrument, the toposcope. The base of the toposcope is an automatic level. It has a special adapter, that connects the level with a digital camera. Together with the fieldwork program Topo and a rod the toposcope can be used as a simple tachymeter. All standard landsurvey methods of determining a 3D point from angle and/or distance measurements are included in Topo. For the toposcopic method photos usually are taken in a horizontal or upward direction. When the top of a building, that has to be modelled, is not visible in the horizontal photo, then a second photo is taken in the same direction in the x/y plane, but with a positive vertical rotation angle. The accuracy of the data is sufficient for visualizations. However for accurate photogrammetric measurements we prefer to determine the camera and calibration points with a total station. This improves the photo calibration and consequently the photogrammetric measurements. In those cases the toposcope is still used to take photos in a controlled way and to do some supplementary angle measurements.

The visualisation and photogrammetry program Scope

The main program of Toposcopy is called Scope. Figure 1 shows the interface with a CAD drawing loaded. Besides the general CAD toolbar at the top of the screen, there is a bar with specialised tool buttons that automate the procedures to make ground planes, extrusions and parametric models. At the right-hand side of figure 1 is the calibration window, where the photo is being linked to the map. Most data are entered by clicking on points in the photo or the map. The calibration varies according to the available hardware and data. When the camera point is not known, it can be calculated in Scope after clicking on 3 points in the map and in the photo. In such a case the angle of the viewing cone has to be estimated. When the camera point is located with one of the standard land survey methods the viewing cone can be calculated instead. The orientation is determined with a 3D point that is known in the map and can be seen in the photo.

The photogrammetric tools

When photos and map are linked together it is very easy to measure locations and heights by alternately clicking on points in the map and a photo. The principles are simple and most routines work as well in horizontal as in upward photos:

- If the location of a point is known in the map, we can determine its height with a single click in the photo.
- If it is known that a point lies in the vertical plane running through a line known in the map, then we can determine both its location and height with a single click in the photo.
- We can also measure like that in vertical planes that are at a certain distance from the known line.
- Only when an object is not shown in the map and its height is also not known we need 2 photos to determine both its location and height.

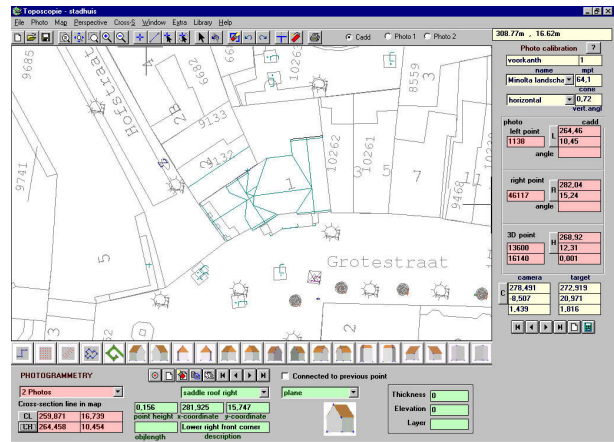


Fig.1 The program Scope with a loaded map.

2D CAD drawings of façades

Toposcopy can be used to make accurate drawings of façades. After defining the main line of a façade in the map, all windows, doors and decorations can be measured in 3D just by tracing the contours or by pointing to the diagonally opposite corners, occasionally changing the distance to the known line. This distance is positive for extruding elements and negative for sunken entrances and the like. Figure 2 shows a photo of a façade loaded in the Scope program. The traced lines are drawn on top of the photo with blue lines.

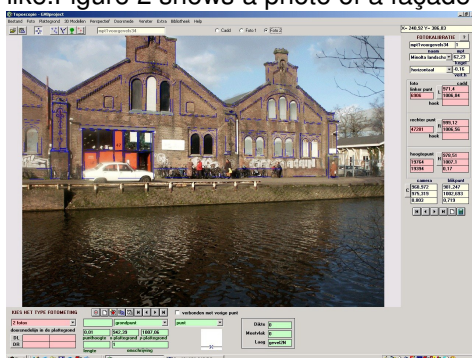


Fig.2 The program Scope with a loaded photo.

Figure 3 shows the 2D CAD drawing of the entire façade.

Toposcopy is less hindered by trees and shrubs than for example laser scanning, because this photogrammetric method is easier to combine with standard land survey techniques. When it is difficult to look through the leaves it is sometimes better to accurately measure the x/y location of the windows at the first floor with a measuring tape and to measure the height of the windows photogrammetrically where visible. After exporting the data as a 2D CAD drawing all windows usually be fully drawn with the measured data.



Fig.3 The 2D CAD drawing of the measured façade.

