Imagery Free from Visible Walls and Hidden Areas

True Orthoimagery of Urban Areas

Standard procedures for orthoimage generation use a Digital Elevation Model (DEM) which excludes structures such as break lines. In addition, such procedures assume complete visibility of the area in one image. Applying the standard approach over complex scenes, such as urban areas, thus results in orthoimages in which walls of buildings are visible and certain areas remain hidden. This is undesirable for many applications. The solution here, true orthoimagery, requires a detailed DEM, including break lines, and procedures for hidden-parts removal. The authors developed tools for the production of true orthoimages.

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The principle governing standard orthoimage generation is as follows: to each point in the orthoimage there corresponds one point in the original image (plane p in Figure 1). Positions b and b' correspond to the same point in the original image, but b is visible and b' is not. Positions a and a' in the orthoimage define the hidden area. The white stroke in Figure 2 marks such a hidden area caused by a building wall. Point c in Figure 1 lies on the boundary between a visible wall and the ground. In the orthoimage this wall should not be present. The black stroke in Figure 2 marks such a visible but unwanted area.

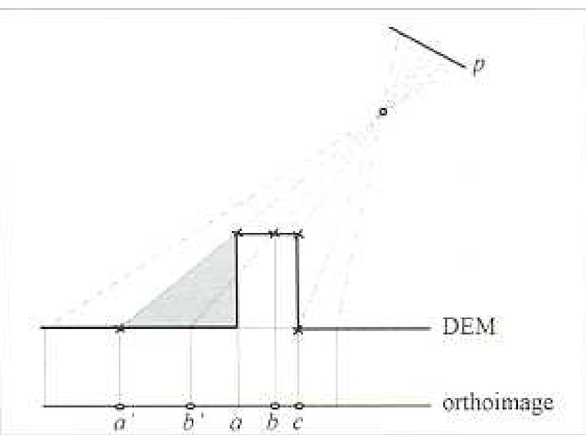

Figure 1. Basic geometry relating the original image, the DEM and the orthoimage

DEMs

Conventional DEMs represent the bare terrain, without objects such as buildings. A regular grid is used as data structure. The grid spacing is usually adapted to the standard, non-urban case. For complex scenes, the height data should obey the following requirements:

- Adaptive height density; the more complex the scene, the denser the grid should be
- Representation by vectors to avoid the inaccuracy inherent in sampling and to ease hidden-parts removal

Triangulated Irregular Networks (TINs) well fulfil both requirements. TINs describe the relief by triangles which connect irregularly distributed points with known height. Usually, constrained Delaunay triangulation is applied.

Effects of Missing Details

One common and undesired effect in the true orthoimage results from partial digitisation of a building volume. The digitisation detail will stop at a certain level, so that minor structures such as balconies with railings are not captured in the DEM. These small objects may hide areas. Similar effects, although more visually apparent, occur as the result of time discrepancy between image capture and DEM creation. Buildings may have been built or demolished during the intervening period. The level of DEM detail should be in accordance with image scale. Nevertheless, some objects, such as trees, cars, structures and substructures over the rooftops are very difficult to represent at any scale. Especially troublesome are dynamic objects, like moving cars.

Mosaic

The next step is bringing together all the images. The images should have an overlap such that each point in the orthoimage is present in at least one image. During mosaicking the following prob-

Figure 2. An original image wit

Figure 3, Perspective view of the DEM draped over with the true orthimage

lems must be solved:

- Radiometric compensation and balance is especially difficult for areas with sun shadows. In addition, such shadows move as a result of time differences between the images. When it is not possible to obtain the images in one day and within a short time span, similar illumination conditions are essential
- Inaccuracy effects caused by DEM imperfections such as terrace railings, and not-modelled objects, such as trees and containers
- Moving objects, such as cars

The present solution requires intensive expert manual labour and images with large overlap, both along and across the track.

Test

A colour true orthoimage with pixel size 10cm was produced covering a 550m. by 450m area around Diagonal Avenue in Barcelona. The camera used was a 150mm ZEISS RMK. The flight altitude was 750m, resulting in 1:5,000 images. From a set of 24 photographs, with sixty percent overlap in both directions, eighteen scenes were scanned and used to create the mosaic. From the 11,000 height points derived from the 1:5,000 topographic map, a TIN with 21,000 triangles was created. The topographic map specifications are not ideal for true orthoimage generation but part of the goal was problem determination and evaluation when using available information. The main problems, as reviewed above, require additional effort during mosaicking. Figure 3 shows a perspective view of the DEM draped with the true orthoimage.

den areas and visible walls

Future Work

Future work focuses on:

- Definition of the DEM acquisition specifications appropriate for true orthoimages. The objects, as well as the digitising method, have to be considered
- Development of semi-automatic mosaicking

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Further Reading

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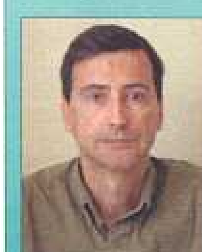

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