The Steps To Generation of the Digital True Orthophotos

Viorica DAVID, Asist. universitar, Universitatea „Politehnica" Timişoara, Romania

Abstract: *This paper presents a review of different approaches developed for the generation of true orthophotos. Orthophoto is a photographic document on which effects of terrain height and camera attitudes are removed. It constitutes hence a document on which precise measurement can be done similar to the map. With the advances in digital techniques, digital orthophotos are becoming very popular within the GIS community. However, as orthophotos do not generally take into account the surface model in the rectification, superimposition of vector data on orthos in urban or suburban areas is unsatisfactory, mainly when height differences are important. The generation of digital true orthophotos using a digital surface model is the only way to correct these effects.*

Keywords: *true orthophotos, precise measurement, digital techniques, digital surface model.*

1. Introduction

The recent advances during the past few years in digital imaging and computing technology have brought significant changes in the mapping domain. This has made the orthophotography an interesting alternative to line mapping that has evolved with the generation of digital orthophotos. Digital orthophoto production provided a larger flexibility taking mainly advantage of computing and digital image processing techniques. The major advantage of orthophotos is that they can be produced rapidly providing thus an eye pleasing and up-to-date document that portrays an impressive and huge display of geographic data. Orthophoto production nowadays is less expensive than line mapping with shorter production times due to the high degree of automation reached. Many users are utilizing these images for GIS maintenance, municipal planning, hazard mapping, disaster planning and generally for any urgent planning purposes within short time, whereas line maps would not be at hand due to longer production time. If vector information is necessary, digital orthophotos can still be used to extract this information by a simple head up digitizing, mainly if the accuracy requirements are not too high. The geometric accuracy of orthophotos depends primarily on the quality of the DTM describing the terrain surface. Therefore, a user of orthophoto data should be aware of the effects inherent to orthophotos such as misplacement of objects that are not modeled by the DTM. In fact, when the terrain surface is subject to sudden elevation changes, users may notice problems that might limit the user ability to take full advantage of the orthoimage because of discontinuities in data portrayed in some areas. The artifacts are due to buildings that might lean over other areas obscuring thus important data. Bridges also might lean or bend and appear to be displaced from their true location. To sum up, any feature that is does not lay flat on the ground might have a warped or displaced appearance. The reason is that, buildings, bridges and all man made structures cannot be correctly modeled by conventional Digital Terrain Models, as conventional ortho rectification typically uses DTM with regularly spaced points that do not account for sudden elevation changes and then do not adequately model small features. This results in displacements and occlusions that alter the perfect superimpose of vector data on the orthophoto for checking and change detection purposes. The solution is the generation of true orthophotos using digital surface models (DSM) instead of digital terrain models (DTM).

2.   Process of True Orthophoto Generation

True orthophotos are orthophotos on which all the defects are corrected included the leaning due building heights and on which every object is in its correct geometric position on the document. Several methods have developed to generate true orthophotos. All the methods are based on the same general concepts and principles that go through the following steps:

2.1. Orthogonal projection using a DSM

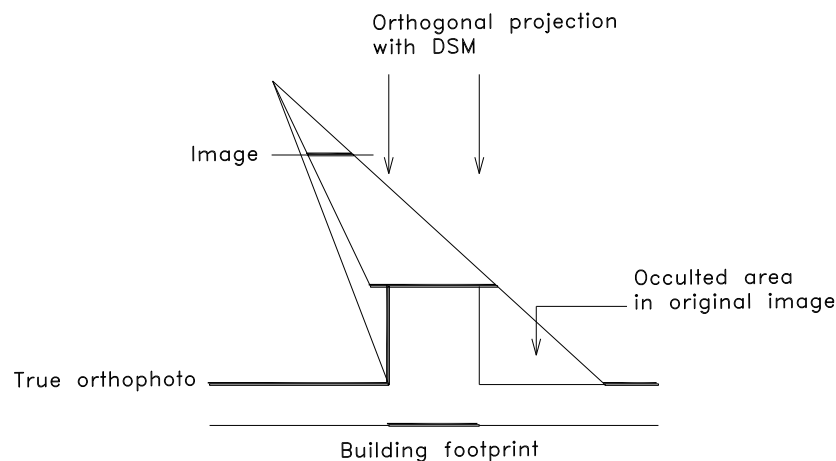Having an adequate DSM, elevated features are projected in their correct geometric positions (fig.1).

Fig. 1 True orthogonal projection using a DSM

However, even with a precise DSM, a true orthophoto is not guaranteed. In fact, if hidden zones are not detected and corrected accordingly, the gaps are simply filled with the same image leading to a doubling image. Hence, in fig.2, the radiometric value of point Q is stored twice: the value is stored in Qo first when rectifying point Q, then it is stored again in Po when rectifying point P.
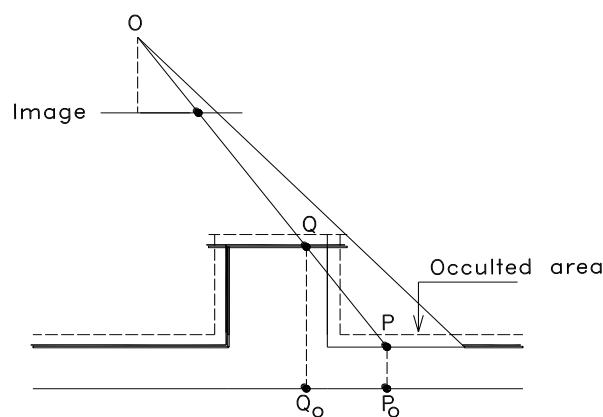

Fig. 2 Ortho rectification in case of occulted area

2.2. Detection of occulted areas

To avoid double images, occlusions have to be detected. The detection of occluded areas is based on the visibility analysis by tracing perspective rays from the top surface back to the perspective centre. In general, a widely used method for visibility analysis is the Z-Buffer algorithm (reference….). In this algorithm an image matrix, with same resolution as the image, is created an

orthophoto with a predefined background value. Each pixel is filled with the corresponding Z distance, but only in cases where the existing Z value is greater than the current value. Hence, only pixels whose rays don't intersect any other feature in their way back to the perspective centre are considered. The occulted areas are also automatically marked as part of the orthophotographic production. The most obvious defect is the double mapping in occluded areas

2.3. Merging and mosaicking of orthoimages

When producing orthophotos from individual images, these orthophotos might have gaps and missing information due to occulted areas in the images. The missing information is however available on adjacent orthophotos, it is therefore necessary to merge different orthoimages. One of the approaches generally used is the one based on the view angle rule. In this approach the grey value assigned to a given pixel on the orthoimage is the value taken from the image on which the corresponding point has the narrowest view angle.

3. Review of Methods Used To Generate True Orthophotos

True orthophotos are photographic documents on which all the defects are corrected, including the leaning due building heights; and hence every object is in its correct geometric position on the document. Several methods have developed to generate true orthophotos, some of which are reviewed hereafter.

3.1. Method based on Z-buffer

The Z-buffer algorithm is a technique based on the fact that objects in lesser depth hide those with greater depth with respect to the observer. Hence, when processing, for each pixel we compute its depth and we compare it to the depth previously computed for this location. For that location, only the pixel with the lesser depth is retained. To detect the occulted areas, this algorithm is integrated in the indirect method (top down method) of the collinearity for the rectification using a digital surface model. A digital Z-buffer matrix, with the same resolution as the original image, is created for the image and stores the minimal distance between the perspective centre and the surface for each pixel.

3.2. Method based on dense digital terrain models

This method was introduced by Ecker (1992) and further investigated by Skarlatos (1998) and uses digital terrain model with fine resolutions. The principal disadvantage of this method is the acquisition of very dense DTMs which has to be done manually as the automated methods produce bad effects.

3.3. Method based on the merging of terrain and buildings orthophotos

In this method, the digital terrain model (DTM) and the digital building model (DBM) are processed separately. Buildings are correctly rectified using the DBM, leading to a true orthophoto of building and that does not show any information regarding the surrounding terrain. On the other hand, a DTM is used with the original image, but where buildings are masked, to create a conventional orthophoto with areas corresponding to building are filled with the mask value. The merging of the two orthophotos will give the final true orthophoto (Amhar, 1998). In case building occult each other, in depth visibility analysis using digital surface model (DSM) resulting from the combination of DTM and DBM becomes necessary.

3.4. Method based on a segmented digital surface model

The method is part of automated method for the generation of true orthophotos (Boldo, 2003). It is based on enhance digital surface models acquired by correlation or LIDAR systems. The result of the segmentation is an image of identifiers or labels that associate each pixel to a region number. The detection of occulted areas is base don the tests of labels values.

3.5. Method that generates orthophotos from a sequence of oriented images

In this method all the images covering the area of interest are used in one step to generate the orthophoto. The concept governing the method is that for a point the grey value is taken on the image whose perspective centre is the closest to this point. To prevent double mapping of pixels, once a pixel is rectified it is prevented from being used again from other images. For this purpose, a flag image is created to store the pixels used and avoid their use another time.

4. Conclusion

The software developed was the Z-buffer algorithm which proved to be efficient in detecting occulted areas. In order to detect all occlusions and to fill in all the gaps it is necessary to have higher longitudinal and lateral overlaps. The cost related to the production of true orthophotos is mainly determined by the effort to produce the digital surface model and also by extension of the overlaps. Because of the higher cost induced by this, generation of true orthophotos can be limited to urban highly populated areas with man made structures presenting significant height differences.

5. Bibliography

1. *Amhar F., 1998: "The generation of true orthophoto using a 3D building model in conjunction with a conventional DTM", ISPRS, Vol. 32;*
2. *Boldo D., 2003 : "Fabrication de varies-images et correction des ombres", Bulletin d'Information de l'IGN, N°74;*
3. *Chen L., Lee L., 1993 : "Rigourous generation of digital orthophotos from SPOT images". Photogrammetric Engineering and Remote Sensing, Vol. 59, N°. 5, Mai 1993;*
4. *David V., 2007: Referat doctorat, UTCB;*
5. *Mohamed ETTARID, Ali AIT M'HAND and Redouane ALOUI, Morocco, 2005: „Digital True Orthophotos Generation", http://gsdidocs.org;*
6. *Skarlatos D., 1998: "Orthophoto production in urban areas", Photogrammetric Record, Vol. 94, N°16.*