Chapter XLIV
Geometric Quality in Geographic Information IFSAR DEM Control

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INTRODUCTION

Both this, article II and another one, article I, titled "Geometric Quality In Geographic Information" published in this encyclopedia propose the theoretical aspects of the method to evaluate the geometric integrity of Digital Elevation Models obtained by different techniques and therefore, different stochastic hypotheses are considered. In the article I we considerer the classical topographic or aerial photogrammetry stereo images method (included ASTER or SPOT images) and we assume consistent stochastic hypotheses. In this Article II we consider IFSAR techniques and the stochastic

hypotheses are specific according to the particular geometry involved in this technique.

As it was established in the article I, studies performed on Digital Elevation Models (DEM), obtained by means of photogrammetry, SPOT satellite images or other methods show that the precision in the z coordinate is different from the horizontal precision. In the case of the Interferometry SAR (IFSAR), the precision in the azimuth axis may be different from the precision in the range-axis. Moreover, the error in elevation is correlated with the error in the range axis. The method employed in article I allows the evaluation of the DEM accuracy –vertical and horizontal- under

some conditions of topographic unevenness. A reference DEM is required. In recent (Zelasco et al, 2001; Zelasco, 2002a) works it has been shown, by simulation, that the vertical error estimation is good and the horizontal error estimation is reasonably good depending on the surface roughness. In this chapter we show how to employ the quality control method when a DEM is obtained by IFSAR technology taking into account the corresponding hypotheses.

Here we reformulate the Perpendicular Distance Estimation Method (PDEM) for the evaluation of IFSAR DEM accuracy. We obtain the accuracy in the azimuth-axis, range-axis and in elevation. These last two values may depend on the value of the range coordinate and the H parameter (overage antenna height). The method is viable depending on the surface feature conditions. In (Zelasco et al, 2007) the results of simulation are shown.

We develop an application to use the method with real or simulated DEM's. Finally, we propose a way to determine the evaluation of the results precision, so that, applying the method to a particular IFSAR DEM, a user knows the precision of the obtained results.

As it is see in article I, a typical way to build Digital Elevation Models (DEM) for Geographical Information Systems (GIS) is by processing aerial or satellite data. As we said the geometric quality control of the stored DEM is what we are concerned with here. « Quality » means the geometric precision measured in terms of the difference between a DEM and a reference DEM (R-DEM). Also in this case (IFSAR DEM) we assume the R-DEM is a faithful model of the actual surface. Its point density may be greater than the DEM point density.

We wish to assess the discrepancy that gives rise to the error. Normally, we need to identify without ambiguity each point M in the DEM with its homologous point P in the R-DEM.

Two reasons that can be read in the article I, make this task difficult.

To find identifiable homologous pairs of points is difficult for an operator. Automating this is a very delicate process.

We don't need to know the position of the homologous points with the proposed PDEM.

Let $e(M_k) = M_k - P_k$ where M_k, P_k are the k selected homologous pairs of points in the DEM and R-DEM respectively. Estimating $\sigma^2(e)$ (variance of the error as distance between M and P) without measuring each vector $e(M_k)$ completely, is the key advantage of the proposed PDEM. Only the projection of each $e(M_k)$ in particular directions matters. Given an M_k it becomes unnecessary to find the homologous P_k in the R-DEM. How this is done is the subject of the article I.

The goal of this PDEM is to evaluate the actual errors ('a posteriori') of a given DEM.

For the description of the PDEM see article I.

IFSAR CORRELATION PROBLEM: METHOD REFORMULATION

Now we outline the way in which the general estimator for variances in the three-dimensional case is applied to the IFSAR-derived DEM.

Figure 1 shows the geometrical problem and the correlation between the range-axis y and the z-axis. The covariance matrix is diagonal (no correlation) when a rotation around the azimuth-axis x is done. The rotation makes the z'-axis in the direction of the beam. This hypothesis is justified by the formulas presented in (Dupont, 1997; Kervyn, 2001;, Massonnet et al, 1993; Massonnet et al, 1996; Massonnet et al, 1995; Rabus et al, 2003; Touting et al, 2000) where the coordinates in the range-axis and the elevation value are function of the distance radar-target and the radar-target direction.

The x-axis (the azimuth-axis) is parallel to the antenna trajectory A_1. The y'-axis is normal to the z'-axis and belongs to the plane defined by the z'-axis and the vertical direction. With this rota-

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