MULTI BEAM JOINED ESTIMATION FOR PERSISTENT SACTTERER INTERFEROMETRY

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1. ABSTRACT

The persistent scatterer interferometry (PSI) is a powerful technique to monitor the line of sight (LOS) deformation with Millimeter accuracy in urban areas [1], [2]. Nowadays, this technique is well established for the sensors ERS and Envisat/ASAR. Nevertheless, the availability of high resolution SAR sensors enables new applications and requires new estimation principles. Application test cases for the sensor TerraSAR-X ware demonstrated already [3], [4] but the high resolution data are not really fully exploited at the moment. This paper describes a newly developed PSI estimation principle which improves the spatial resolution by the support of distributed scatterers and increases the temporal sampling by the joined estimation of different beams. The prototyped technique needs to cope with the different projections of the horizontal and vertical deformation components onto the line of sight (LOS). Basically, this allows the inversion of the beam's observation equation and finally retrieves the vertical and horizontal deformation components. This inversion requires measurements taken with different incidence angles at the same time which are not available by the given acquisition regime. This is the reason our prototype uses smoothing splines which even make possible a model free deformation estimation. The assumption is that the measured physical process can be complicated (i.e. non-linear in time) however results in a smooth deformation of the building. Practically, both smoothness and goodness of fit are finally the optimization criteria. The paper details the technical difficulties and the implemented solution. First results from a test case in our Berlin test site will be presented.

2. INTRODUCTION

Since June 2007, the sensor TerraSAR-X with its high resolution spotlight mode and 300MHz range bandwidth provides imagery which allows to resolve fine structures of buildings e.g. different floors. Remarkably, many point scatters per building are available. These long time stable scatterers i.e. persistent scatterers (PSs) enable the monitoring of structural stress of a building. However, such scatters are given by chance. In order to improve the spatial sampling of the deformation, distributed scatters can be exploited. On man made structures like roofs and building fronts, the distributed scatterers provide also a long time coherent radar return. However, their phase quality is not in the order of the PSs. This can be compensated, and especially spatial multi-looking can be avoided, by increasing the number of samples used in the estimation. Unfortunately, the temporal sampling of the monitoring is fixed by the sensor's repeat cycle of 11 days. Nevertheless, TerraSAR-X allows acquisitions with different beams i.e. a wide range of incidence angles (20-55 degree) which are temporally interlaced. On our Berlin test site, we have three stacks of TerraSAR-X data taken with different beams. We demonstrate that a joined estimation of stacks acquired with different beams improves the structural stress monitoring application. Practically, the temporal sampling rate is increased. Additionally, the overall sample number of the time series is improved by the factor of three (i.e. the number of beams). This compensates the reduced phase stability of distributed scatterers. Furthermore, the three different incidence angles allow to retrieve the horizontal and vertical deformation components by inversion of the observation geometry.

Besides of complicated spectral characteristics of the spotlight data, some technical difficulties need to be solved. Exemplarily, the interferometric pre-processing requires an inter-beam coregistration with respect to the actual local height. Also, the estimation itself needs to include an adaptive, i.e. related to height (i.e. depending on the DEM update) and incidence angle, data interpolation and extraction. This is caused by the high resolution where radargrammetry and interferometry meet [5]. Other difficulties result because the time series from each beam includes an unknown phase offset. Also, the time series of each beam needs to be interpolated for the inversion of the observation equation. And of course, phase ambiguities require a phase unwrapping in time.

The estimation principle is a joined estimation of different beams. In fact, the estimation parameters (DEM update and deformation) are retrieved from the different stacks at one and the same time. It is a complementary method to the mosaicking of different stacks [6]. Of course, this post-processing [6] is powerful as well because it can fuse ascending and descending passes. In doing so, this technique also increases the spatial density of measurements. However, the developed joined estimation better exploits the high resolution data. On the one hand, it provides for the first time a separation of horizontal and vertical motion. And on the other hand it includes the increased number of measurements directly into the parameter estimation. Another novelty is the model free estimation using smoothing splines.

11. REFERENCES

[1] A. Ferretti, C. Prati, and F. Rocca, "*Permanent Scatterers in SAR Interferometry*", IGARSS Proceeding 1999, Hamburg, Germany, pp. 1528-1530, 1999.

[2] A. Ferretti, M. Bianchi, C. Prati, and F. Rocca, "*Higher-order permanent scatterers analysis*". EURASIP J. Appl. Signal Process, 3231-3242, 2005.

[3] N. Adam, M. Eineder, N. Yague-Martinez, R. Bamler, "*High Resolution Interferometric Stacking with TerraSAR-X*", IGARSS Proceeding 2008, Boston, on CD, 2008.

[4] X. Zhu, N. Adam, and R. Bamler, "*Space-borne High Resolution SAR Tomography: Experiments in Urban Environment Using TS-X Data*", Proc. of Joint Urban 2009, Shanghai, 2009.

[5] R. Bamler, "*Interferometric Stereo Radargrammetry: Absolute Height Determination from ERS-ENVISAT Interferograms*", Proc. of IGARSS 20000; Hawaii, on CD, 2000.

[6] S. Gernhardt, N. Adam, M. Eineder, and R. Bamler "*Fusion of Persistent Sactterers from Different TerraSAR-X VHR Spotlight Data Stacks*", submitted to IGARSS 2010, Hawaii, 2010.