Topographic Measurement in the Dragon-2 program

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Abstract

In the project 5297 (Topographic Measurement) the research is focused on topographic mapping and deformation measurements with SAR data from different wavelengths. SAR data is used to measure the elevation using InSAR and stereo radargrammetry. Deformations caused by slow landslides, urban subsidence, and deformation of large infrastructure elements are measured using differential InSAR and PS-InSAR. The research work was carried out over several test sites in China including glaciers, mountainous areas, and cities. During the Dragon-2 project the following topics have been investigated:

1. Topographic mapping using SAR can be done with SAR interferometry and stereo radargrammetry. In the glacier areas in western China, the high altitudes and the rugged terrain are major barriers for topographic survey and glacier research. Mt. Qilian in the Gansu province in China was chosen as one of our test areas and nearly 20 scenes of ASAR data are collected under the frame of Dragon II Programme. The results are compared with those from X band (TerraSAR-X and COSMO-SkyMed) and L-band (ALOS/PALSAR) data.

Stereo radargrammetry is an alternative in difficult terrain, mainly due to the fact that stereo radargrammetry is less sensitive to temporal decorrelation than InSAR. Using a direct approach based on RPC geocoding for SAR, DSMs can be generated from multi-image acquisitions, jointly processing data from different orbits, sensors, etc.

2. The Three Gorges Area is strongly affected by landslides. However, the Three Gorges are also a difficult area for InSAR measurements because of the dense vegetation cover, the steep mountains, and the fast local changes of water vapor content in the atmosphere. X- and C-band InSAR suffers severely from temporal and geometric decorrelation. With the L-band ALOS PALSAR data, more stable deformation measurements with D-InSAR are possible. Problematic is the lack of precise DEM data in the area. SRTM, ASTER, and local topographic maps are all quite erroneous in the area, which strongly hampers the D-InSAR and PS-InSAR measurements.

3. For urban subsidence monitoring we focus on Shanghai. Using 48 ASAR images acquired from October 2007 until February 2010, the deformation of seawalls near Shanghai has been measured. The seawall in the Nanhui district seems to suffer severely from subsidence. The obtained results near Pudong international airport show that PS-InSAR technique is proved by comparison with ground leveling measurements to be able to monitor deformation of seawalls with millimeter accuracy.

4. SAR image localization with the Rational Polynomial Coefficient (RPC) model provides a computational efficient way for geocoding SAR images. The RPC model is suitable for high-precision spaceborne SAR geocoding. The determination of the 78 unknown coefficients is the key problem. It requires the solution of an ill-posed system of linear equations. Using a hybrid solution, a fast and stable method for the determination of the unknown coefficients has been implemented and widely tested. The RPC model is also an important basis for the topographic mapping using stereo radargrammetry, because the high geocoding efficiency allows for more efficient radargrammetric methods.

To further improve the accuracy of the geocoding, the SAR data can be compared with SAR simulations with previously available DEMs. In this way, the overall accuracy can be improved, as long as the DEM is very precise in horizontal and vertical directions. The improvements can then be directly integrated into the RPC values, a technique which can be of great value for SAR satellite data vendors allowing to increase the geocoding quality of their data in a post-processing step.

地形量测研究成果

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摘要

龙项目地形测绘（项目编号：5297）研究小组近期的研究集中在利用多波段的 SAR 数据进行地形测量和地表形变量测量。高程测量主要采用了雷达干涉测量和雷达立体摄影测量方法，形变监测主要采用了 D-InSAR 和 PS-InSAR 方法。我们利用 InSAR 数据在中国多个实验区进行了冰川和高山地区地形测绘、滑坡形变监测、城市沉降以及大型建筑设施形变监测研究。项目执行期间，该主题开展的工作主要集中在以下几个方面：

1．通过雷达干涉测量和雷达立体测量技术完成对地形复杂地区的地形测绘。在中国西部冰川覆盖地区，高海拔和复杂的地形成为开展地形测量和冰川研究的主要障碍。中国西部甘肃省祁连山大雪山被选为我们的实验区，在“龙计划”二期项目中，我们搜集了该地区近二十景 ASAR 数据，并与同一区域的 X 波段 SAR 数据（COSMO-SkyMed 和 TerraSAR-X）和 L 波段 SAR 数据（ALOS PALSAR）的 InSAR 测量结果进行交叉对比分析。

雷达立体测量对时间去相关较为不敏感，因此成为代替 InSAR 技术提取地形复杂地区 DEM 的最佳选择。我们对基于物方的有理多项式系数模型（RPC）的定位方法，以及利用基于互信息量检测同名点视差的新技术分别进行了实验，得到了地形复杂地区的数字表面模型（DSM）。

2．三峡地区受滑坡影响严重，但由于该区域植被茂密山峦起伏，大气水汽含量变化剧烈，利用 InSAR 技术进行形变监测较为困难。利用 C 波段和 X 波段数据进行 InSAR 分析，时间和几何去相关非常严重，而采用 L 波段 ALOS PALSAR 数据利用雷达差分干涉测量技术则可以获得较为稳定的形变监测结果，并且通过 L 波段 SAR 数据尤其对复杂地形区域进行滑坡形变检测也是切实可行的。由于该区域的 SRTM、ASTER、地形图等 DEM 数据的误差较大，严重影响了 DInSAR 及 PS-InSAR 方法的测量精度。

3．城区形变监测主要集中在上海实验区。我们利用 48 景 2007 年 10 月至 2010 年 2 月期间获取的 ASAR 数据对上海周边海塘进行形变检测，结果显示南汇区所属海塘形变较大。通过对浦东国际机场的形变监测结果利用地面水准测量数据进行验证，表明 PS-InSAR 技术在海塘形变监测中可以达到毫米级精度。

4．通过有理多项式系数（RPC）模型进行 SAR 影像地理编码，计算效率较高。研究证明 RPC 模型对于星载 SAR 影像高精度的地理编码较为适用。78 个未知系数的确定是其中的关键问题，需要求解一个不适定的线性方程组。利用我们提出的混合解法可以快速得到稳定的无偏解，该方法的有效性通过大量实验得到了验证。RPC 模型是利用雷达立体测量技术开展地形测绘的重要基础，能够有效地提高雷达摄影测量的处理效率。

利用已有高精度 DEM 生成的 SAR 模拟影像与真实 SAR 影像匹配，能够有效地纠正地形起伏区域 SAR 影像定位误差，提高 SAR 影像地理编码的精度。该方法处理结果可以用于更新 RPC 模型参数，这对于星载 SAR 数据提供商推广其产品具有重要意义。