MULTI ASPECT VHR SAR IMAGING OF URBAN AREAS

Uwe Stilla

Photogrammetry & Remote Sensing, Technische Universitaet Muenchen
Arcisstr. 21, 80333 Muenchen, Germany

1. INTRODUCTION

Nowadays, in every country urban areas are growing and expanding. Information about urban structures and their temporal changes is very important, e.g. for monitoring health conditions of urban centers and planning purposes in different fields. Depending on the task the requirements concerning, resolution, precision, coverage, reliability, repetition, actuality, reliability, etc. are very different and are crucial for the optimal platform (e.g. airborne or spaceborne) and sensor system (e.g. optical, infrared, lidar, or radar). An increasing demand on high resolution sensors systems can be observed for analyzing urban areas and man-made objects. Due to the poor spatial resolutions of provided images in the passed decades, an Earth mapping by satellite imagery has been mainly limited to natural landscapes. Often the phenomena to be observed did not need high image resolution as they could be monitored on scales of many tens of meters. But, this is not sufficient for urban areas. Here, the main structure of the objects in the scene (buildings, streets, etc..) has dimensions that are often in the scale of tens of meters while many other items are even smaller (windows, balconies, cars and so on). Consequently, high resolution is an important requirement for an adequate, not coarse description of this kind of scene. Fortunately, in the last decades new technologies have been developed to this aim. In the field of remote sensing, an important role is played by satellite systems with high resolution sensors working in optical and radar domain. In the optical domain IKONOS and QUICKBIRD capture images with a ground sampling distance (GSD) of 1 m and better. In contrast to optical sensors Synthetic Aperture Radars (SAR) allow working day and night and in almost all weather conditions. With the development and launch of new sophisticated Synthetic Aperture Radar (SAR) systems such as Terra SAR-X, Radarsat-2 and COSMO/Skymed, urban remote sensing based on SAR data has reached a new dimension. The new systems deliver data with much higher resolution than existing SAR satellite systems. Interferometric, polarimetric and different imaging modes have paved the way to new urban remote sensing The German radar satellite TerraSAR-X was launched on 15 June 2007 and is able to operate in the "Spotlight" mode with 10 x 10 km scenes at a resolution of 1-2 meters. Independent of the TerraSAR-X mission first satellites with ultra high resolution sensors were successfully launched within the German defense program “SAR Lupe”. Modern airborne SAR systems provide spatial sampling with decimeter spacing. An example of an

SAR image taken by the MEMPHIS sensor is shown in Fig.1. For comparison an aerial image of the same area with a GSD of 10cm is shown in Fig. 2.

. Fig.1: SAR image of Munich, Test area TUM, GSD: approx. 0.2 m x 0.2 m, MEMPHIS, FGAN-FHR

Fig. 2: Aerial image of Munich, Test area TUM,, GSD: approx. 0.1 m x 0.1 m, AEROWEST/GOOGLE INC

2. MULTI ASPECT SAR IMAGES

A combination of image data acquired from different imaging modes or even from different sensors is assumed to improve the detection and identification of man-made objects in urban areas. If the extraction fails to detect an object in one SAR view, it might succeed in another view illuminated from a more favorable direction. Previous research has shown that the utilization of multi-aspect data (i.e. data of the same scene, but acquired from different directions) improves the results. This has been tested both for building recognition and reconstruction [2],[7] and for road extraction [8],[3],[4].

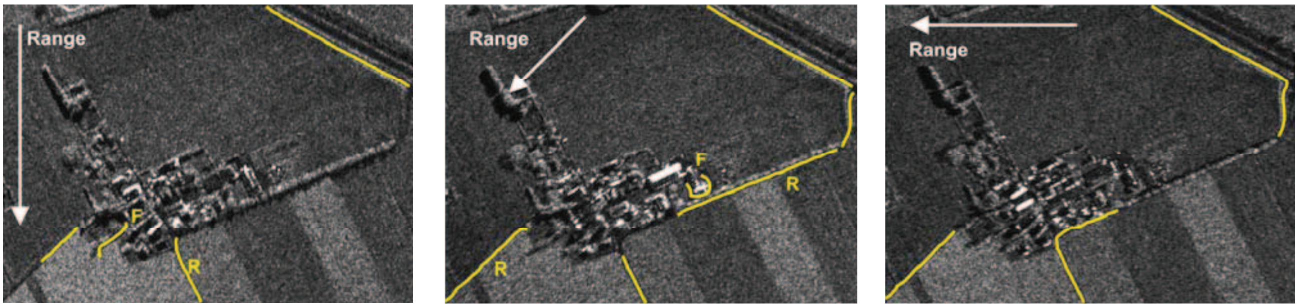

Fig. 3: Road extraxtion in differnt aspect SAR images

Multi-aspect images supply the interpreter with both complementary and redundant information. However, due to complexity of the SAR data, the information is also often contradicting. Especially in urban areas, the complexity arises through dominant scattering caused by building structures, traffic signs and metallic objects in cities. Furthermore one has to deal with the imaging characteristics of SAR, such as speckle-affected images, foreshortening, layover, and shadow [5]. For understanding these effects SAR simulations are very helpfull

[1],[4]. A correct fusion step has the ability to combine information from different sources, which in the end is more accurate and better than the information acquired from one sensor alone.

In general, better accuracy is obtained by fusing information closer to the source and working on the signal level. But in contrary to multi-spectral optical images, a fusion of multi-aspect SAR data on pixel-level hardly makes any sense. SAR data is far too complex [6]. Instead of fusing pixel-information, features (line primitives) shall be fused. Decision-level fusion means that an estimate (decision) is made based on the information from each sensor alone and these estimates are subsequently combined in a fusion process. Techniques for decision-level fusion worthy of mention are fuzzy-theory, Dempster-Shafer's method and Bayesian theory.

REFERENCES

[1] Balz T., Stilla U. (2009) Hybrid GPU based single- and double-bounce SAR simulation. *IEEE* Transactions on *Geoscience and Remote Sensing*, 47(10): 3519-3529

[2] Bolter, R., (2001). Buildings from SAR: detection and reconstruction of buildings from multiple view high resolution interferometric SAR data. PhD thesis, University of Graz, Austria.

[3] Dell'Acqua, F., Gamba, P., Lisini, G. (2003). Improvements to Urban Area Characterization Using Multitemporal and Multiangle SAR Images", IEEE Transactions on Geoscience and Remote Sensing. Vol. 4, No. 9, pp. 1996-2004

[4] Guida R, Iodice A, Riccio D, Stilla U (2008) Model-based interpretation of high resolution SAR images of buildings. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 1(2):107-119

[4] Hedman K., Stilla U., Lisini G., Gamba P. (2009) Road Network Extraction in VHR SAR images of Urban and Suburban Areas by means of Class-aided Feature-Level Fusion. *IEEE Transactions on Geoscience and Remote Sensing.* (in press)

[5] Stilla, U., Soergel, U., Thoennessen, U. (2003) Potential and limits of InSAR data for building reconstruction in built-up areas, *Journal of Photogrammetry and Remote Sensing*, 58(1–2), pp. 113–123

[6] Stilla, U., Soergel, U. (2006) Reconstruction of buildings in SAR imagery of urban areas. In: Weng, Q., Quattrochi, D.A. (eds) Urban Remote Sensing. Boca Raton, FL: Taylor & Francis, pp. 47-67

[7] Thiele, A., Cadario, E., Schulz, K., Thonnessen, U., & Soergel, U. (2007). Building Recognition From Multi-Aspect High-Resolution InSAR Data in Urban Areas, *IEEE Transactions on Geoscience and Remote Sensing*, 45, 3583-3593

[8] Tupin, F.; Houshmand, B., Datcu, M. (2002). Road detection in dense urban areas using SAR imagery and the usefulness of multiple views, IEEE Transactions on Geoscience and Remote Sensing, 40, 2405-2414