DSMs generation from TerraSAR-X High Resolution Spotlight imagery: evaluation of the radargrammetric approach implemented in the scientific software SISAR

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One relevant application of SAR remote sensing is the generation of Digital Surface Models (DSMs) of the Earth's surface, thanks to the SAR independence from logistic constraints on the ground, illumination and weather conditions. Starting from SAR data two different approaches can be used to generate DSMs: the well known interferometric (InSAR) and the promising radargrammetric one (StereoSAR). Interferometry uses the phase differences information between the SAR images to lead the terrain elevation; radargrammetry, on the other hand, using only the intensity information of the SAR images, requires just a couple of images to reconstruct the terrain shape, like in the classical photogrammetry. At present, it is pretty well known that the SAR interferometry may suffer for lack of coherence, especially over areas with vegetation/forest. In this sense, radargrammetry could be a possible alternative solution to avoid the classical decorrelation problem affecting the interferometric technique. The importance of the latter approach is rapidly growing just due to the new high resolution imagery (up to 1 m of GSD-Ground Sample Distance) which can be acquired by COSMO-SkyMed (Italy), TerraSAR-X (Germany) and RADARSAT-2 (Canada) sensors in SpotLight mode. The goal of this work was to evaluate the radargrammetric mapping potential of high resolution TerraSAR-X Spotlight imagery using the StereoSAR processing chain developed at the Geodesy and Geomatics Division of University of Rome “La Sapienza” during the ISPRS Project Evaluation of DEM derived from TerraSAR-X data and embedded in the scientific software SISAR (Software per Immagini Satellitari ad Alta Risoluzione). It is well known that the radargrammetric DSMs extraction procedure consists of two main steps: the stereo pair orientation and the image matching. The SISAR radargrammetric model is based on the equation of radar target acquisition and zero Doppler focalization. The radargrammetry technique performs a 3D reconstruction based on the determination of the sensor-object stereo model, in which the position of each point on the object is computed as the intersection of two radar rays coming from different positions and therefore with two different look angles. One of the crucial issue for the image orientation is the orbital estimation: SISAR model, using Lagrange polynomial to interpolate the satellite orbit, allows the possibility to orientate a SAR stereo pairs without using GCPs (Ground Control Points). As regards image matching, it is well known that different approaches have been developed within the photogrammetry and computer vision research fields. In all matching algorithms there are two fundamental aspects that must be taken into account (i) the definition of a primitive model and consequently of an identification criterion (ii) the choice of a strategy for the search of homologous points on a couple of images. Nevertheless, for SAR imagery, apart from the proper deformations already mentioned, also the typical "salt and pepper" aspect due to speckle noise has to be duly considered to carry out a successful matching. In this respect, an original matching strategy was developed at the Geodesy and Geomatics Division of University of Rome “La Sapienza”, presently subject of a pending patent. In particular, the images acquired in High Resolution SpotLight mode on the Beauport (Canada – flat forest with small build up zones), Hannover (Germany – flat urban area) and Trento (Northern Italy – valley with an urban area) areas, where accurate ground references represented by LIDAR DSMs are available, were considered in this research. In all cases, the accuracy of the generated DSMs have been evaluated using DEMANAL, a scientific software developed by Prof. Karsten Jacobsen, Leibniz University of Hannover. The overall results in terms of accuracy range between 3 meters (flat forest) and 6-7 meters (urban areas).