NUMÉRIMAGE

Canada-Quebec Agreement on the Development of RADARSAT Data

This article presents the results of a project carried out for the Canadian Space Agency's Earth Observation Application Development Program (EOADP) and the Canada-Quebec Agreement on the use of RADARSAT data. This agreement was initially signed in 1998 and renewed for three years in June 2002. It is co-managed by the Canadian Space Agency, the Ministère du Développement économique et régional, and of the Ministère des Ressources Naturelles, de la Faune et des Parcs. Subsequent issues of articles GÉOinfo will describe the projects carried out under the Canada-Quebec Agreement.

3D/3G Solutions

Remote Sensing Breaks into the Cell-phone Industry

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The growth of cities is complicating the management and planning of urban environments. Having accurate knowledge of these spaces is especially important in telecommunications, with the arrival of third-generation cellular telephony, which requires a greater number of antenna in order to constitute one of the most effective networks. What could be better for studying and modelling wave propagation, thereby optimizing antenna location, than a 3-D model of the region obtained from satellite imagery?

The 3D/3G Solution

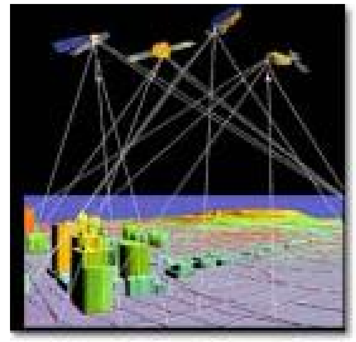
Telecommunications companies are now looking for three-dimensional digital terrain models (DTMs). The rush is due to the arrival of third-generation cellular telephony. Increasing the capacity to carry information (bandwidth) requires in-depth knowledge of the area's topography (ground DTM) as well as infrastructure location and height (ground-surface DTM).

Up to now, the main sources for DTMs have been aerial photographs and vector data from topographic maps. Unfortunately, these data are not always available or current.

VIASAT GeoTechnologies implemented the 3D/3G Solutions project to assess the stereoscopic potential of satellite images produced by different Earth observation systems in designing three-dimensional digital terrain models.

The Meaning of 3D/3G Solutions
The term derives from *three-dimensional* and *third-generation cellular telephony.*

The project assesses both stereoscopic data sensors and multisensor stereoscopy, which refers to combining two images from two different sensors. For example, this could mean combining an aerial photograph with a Landsat image or a radar image with a SPOT image. The revisit capabilities provided by using different sensors to acquire images and the potential for combining images considerably increases the capacity for producing current data.



Some Vocabulary

Photogrammetry:	The science of obtaining reliable spatial measurements from imagery.
Radiometry:	Measurement of the intensity of electromagnetic radiation, which is displayed as greyscale or on satellite imagery.
Stereoscopy:	Process that gives the appearance of relief when two images of the same object are taken from different viewpoints at the same time.
Stereoplotting:	The process of using a stereoplotter to record and convert measurements made from a stereoscopic model into a drawing or map (hardcopy or digital).
F1 mode:	Fine-beam acquisition mode (10 m of resolution) with an incidence angle of 37 to 40 degrees.
F5 mode:	Fine-beam acquisition mode (10 m of resolution) with an incidence angle of 45 to 48 degrees.
Adjacent looks:	Said of two images taken from the same direction but at different angles.
Adjacent looks:	Said of two images taken from opposite directions, one to the right of the track, one to the left.

Method

In order to achieve multisensor stereoscopy, the team heading up the project successfully integrated satellite image rectification models developed by CCRS (Canada Centre for Remote Sensing) into the Helava environment. This made it possible to model geometric distortions, the merging of images, stereoplotting, interpolation, the production of three-dimensional digital terrain models, quality control, and error correction in 3-D mode.

The stereopairs likely to yield the best results are selected according to three criteria: stereoscopic geometry, given by the image incidence angle; radiometry, given mainly by the image capture date; and the rendition of image elements. Inadequate geometry, which occurs when the incidence angle between the two images is too small, translates into inadequate hyperverticality and alters the depth perception when the object is plotted in three dimensions. Too much disparity in the radiometry of the two images in the stereopair or too much time between the capture dates will affect the three-dimensional plotting by making it difficult to identify the same feature in both images. Lastly, the ability to recognize features in the images viewed in stereo , such as the hydrographic network, road network, or buildings, will determine the DTM's scale and type.

Results

A preliminary analysis of each stereopair brought out the following:

- A radar image can only be combined with another radar image. The radiometric disparity in Landsat or SPOT optical images is too great to ensure adequate 3-D viewing. Moreover, radar images can only be used to produce ground DTMs because the spectral response of surface geometric objects, such as buildings, produce significant backscatter (corner reflection) that hinder building identification and depth perception. The same phenomenon has been observed in areas of dense vegetation. In any event, ground DTMs produced from radar images are of very good quality. Viewing stereoscopic of axial highways makes intersections readily identifiable; in certain cases, it can yield DTMs greater than 5 m in accuracy.

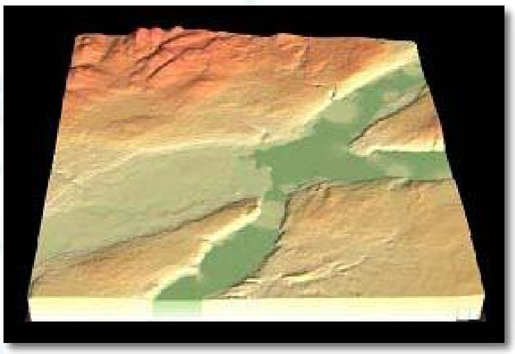
- Using Landsat images was discarded due to the periodic geometric noise probably introduced during initial processing before being purchased. This noise translates into three-dimensional ghost waves when displayed stereoscopically.

- Three-dimensional viewing is not enhanced by merging a high-resolution image with a low-resolution image.

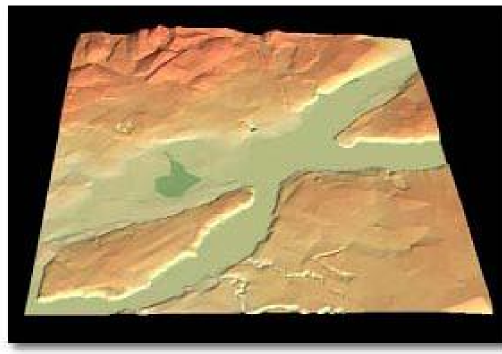
Based on initial assessment, the stereopairs that met quality criteria were processed to yield a three-dimensional digital model. Two approaches were used for each of the pairs: a semiautomatic correlation approach and a photogrammetric approach (entirely manual). Afterwards, the accuracy level of the resultant DTMs was estimated quantitatively.

A Regional Analysis

The project team had four RADARSAT images in F1 and F5 modes for the Québec study area, designated for the production of DTMs at the regional (1:100 000) and urban (1:50 000) scales. An assessment of DTM accuracy revealed a relationship between accuracy and relief. Regardless of the pair used, the error was larger with terrains with high relief than with flat terrain. Moreover, it appears that relief plays a determining role in selecting a radar pair for producing a DTM. Using an image pair with adjacent looks yields better results with high relief, whereas a combination of images with opposite viewing angles is more appropriate for flatter relief.



DTM produced from BDTA hypsometric data



Ground DTM produced from an image pair RADARSAT in F1 and F5 modes

Urban Analysis

As for downtown Montréal, which was selected as being a high-density urban area, the ground and ground-surface DTMs were produced from various combinations of optical (SPOT, aerial photos, Quickbird) and radar sensors. There is good correlation between sensor resolution and the accuracy of the stereoscopic plotting. Consequently, the higher the image's resolution, the easier it is to plot objects on the 3-D image. It also appears that a pointing on the ground is more accurate than on a high building.

Generally, high-spatial resolution optical pairs yield the most faithful ground-surface DTMs. That being said, combining images taken at different times can lead to errors in perception, since the occupancy in certain portions of the downtown area have changed, leading to building demolition or construction.

Promising Conclusions

The project led to several significant conclusions pertaining to the production of ground and ground-surface DTMs in an urban area. As a result, Helava automatic correlation of radar images and high spatial resolution optic images remains a difficult process in urban areas. Adequate correlation is built on having images with highly similar radiometry. The geometry offered by the stereopair is not always adequate or available, depending on the relief, spatial resolution, and object type. In such cases, using a pair of mixed scenes can be a very effective solution. Nevertheless, the use of scenes from different sensors increases radiometric disparity and, consequently, reduces the effectiveness of correlation, while increasing the difficulty in perceiving images in three dimensions.

Taking all this into account, it appears that using stereoscopic scenes acquired nearly simultaneously along the track of high-resolution satellites (IKONOS, QuickBird and SPOT-5) should be the preferred approach. In addition to bringing together optimal radiometry and geometry conditions as well as adequate cartographic accuracy, this acquisition method offers a satisfactory revisit frequency for producing updated DTMs in dense urban areas.

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