

## Foreword

### Mapping from High-resolution Satellite Imagery

Vincent Tao, Karsten Jacobsen, John Jensen, Gunho Sohn

There is an ever increasing use of high resolution satellite imagery. In recognition of the growing application and wide user acceptance of high resolution satellite images we are pleased to present you with this special issue on "Mapping from High Resolution Satellite Imagery," sponsored by the Softcopy Photogrammetry Committee of the ASPRS Photogrammetric Applications Division, and the International Society for Photogrammetry and Remote Sensing Commission I.

Since NASA initiated the Landsat series in 1972, a number of Earth observing satellites, such as SPOT, IRS and MOMS, have demonstrated their mapping capability with medium resolution imagery. The ground sampling distance (GSD) of those medium resolution satellite imaging sensors are on the order of 10 to 20 meters for SPOT-4, and 5 to 15 meters for MOMS-2 and IRS-1C/D. Although much enthusiastic research has been carried out, these medium resolutions have attracted little interest among users who are concerned with topographic mapping in large scale (1:10 000, 1:2500 and 1:1250). The medium resolution satellite imagery often shows deficiency in terms of the features that are required for those mapping scales. However, these satellite images primarily have been used in large area and small scale topographic mapping, land use applications, and environmental monitoring.

For a long time, high-resolution aerial photography has been the primary data source for topographic mapping. Launched in September of 1999, the IKONOS satellite opened up a new era of commercially available, high-resolution satellite imagery with the ground pixel size of 0.82-meters. Its successors, such as QuickBird-1, OrbView-3, EROS-A1, and FORMOSAT-2, are now offering a high resolution of 0.62 to 2 meters. In the near future, the number of high-resolution satellites will grow rapidly with Cartosat-2, KOMPSAT-2, EROS-B and Pleiades, which provide imagery with 0.7 to 1-meter ground resolution. A higher resolution of 0.5 meters will be available by WorldView-1, World View-2 and OrbView-5.

Aerial photos under operational conditions have a resolution of 40 lp/mm or 12 $\mu$ m pixel size. They are usually scanned with approximately 20 $\mu$ m. In relation to this, high-resolution satellite imagery with one meter ground pixel size corresponds to an aerial photo scale of 1:50 000, 0.62-meter to 1:31 000 and 0.5-meter to 1:25 000. This means high-resolution satellite images are in the scale range of traditional aerial photogrammetry and this creates competition to conventional aerial photogrammetric mapping. In some countries aerial images are classified, but this is not the case for satellite images, which can be used very openly.

High-resolution satellites are equipped with sophisticated positional systems including GPS, gyros and star sensors. Based on this, a ground positioning in the range of 10-meter standard deviation is obtainable without ground control points. The orientation information of high-resolution satellites is available as rational polynomial coefficients (RPC) and its accuracy can be improved dramatically by means of control points. Use of RPC for image exploitation and mapping has been widely adopted and has proven to be a robust and economic approach for mapping where rigorous physical sensor models may not be needed. Due to the simplicity, and generality of the RPC approach, it is likely to become a publicly accepted image sensor model exchange protocol. ASPRS has a subcommittee working on this standardization.

The number of stereo pairs being acquired by high-resolution satellites is very limited. According to DigitalGlobe, acquisition of a stereo pair takes 9 times the imaging capacity for

a single scene, but the price is only 2 to 3 times the price of a single image. So it is not an economic situation for the satellite vendors to collect stereo images without a customer order; this case may change with the higher flexibility of WorldView. An alternative solution is given with Cartosat-1, equipped with a camera viewing  $5^\circ$  ahead and a second camera viewing  $26^\circ$  back. ALOS is equipped with 3 cameras and also has 2.5-meter GSD. Recent research has shown that detailed digital elevation models (DEMs) can be generated with high-resolution satellite stereo pairs. For automatic matching in city areas, where normal angle cameras are preferred for airborne solutions, the satellite stereo pair should not have too large an angle of convergence and a base to height relation of 1:3 should not be exceeded. Multi-spectral information acquired along with the panchromatic imagery provide excellent quality for a broad range of vegetation health, environmental monitoring applications. In general, high resolution space images offer an alternative solution to traditional aerial photogrammetry and are taking a growing share of the market in photogrammetry.

Imagery being acquired by high-resolution satellite delivers very rich scene content. In the past, most feature extraction methods have been studied based on aerial photography with a higher resolution of 10 to 25 centimeters, or satellite imagery with a resolution of 5 to 10-meter GSD. Extracting natural or man-made objects from high-resolution imagery of 0.5 to 2 meters is challenging. Successful development of feature extraction technologies from high-resolution satellite imagery can greatly increase its usability in large scale mapping and remote sensing applications. In recent years, the use of high-resolution satellite imagery is increasing for civilian purposes. Due to its wider coverage and higher frequency of revisit times, emergency responses to unforeseen disasters have become more reliant on information provided by high-resolution satellite imagery. In addition, high resolution satellite images are now publicly used on a global scale for location-based internet services provided by Microsoft's Virtual Earth, Google's Google Earth, and others.

Given compatible spatial resolution to aerial photography, almost similar classes of features can be extracted from high-resolution satellite imagery. However, high-resolution satellite imagery usually provides a low signal-to-noise ratio and spatial frequency. This nature of high-resolution satellite imagery may disturb the extraction of geometric or chromatic primitives; or degrade object resolving powers, which are forced to represent absolute object scale with relatively smaller pixels. These problems may cause difficulties in applying existing feature extraction methods based on images with different resolutions. Under these circumstances, a great deal of effort is required to develop operational and automated feature extraction approaches, which are adapted to suit high-resolution satellite imagery.

Digital image processing in the last quarter of the 20th century focused primarily on per-pixel processing. We now have many classification algorithms based on object-oriented image segmentation. Continued improvement on object-oriented image segmentation will allow the image analyst to work with homogeneous patches (polygons) of biophysical information in high resolution imagery. Patches of homogeneous information are especially useful when deriving landscape ecology metrics to model landscape processes. While statistically based pattern recognition algorithms such as maximum likelihood classification will continue to be of value, they are being eclipsed by more sophisticated algorithms that make use of decision tree logic and/or expert systems which are of particular value for analyzing high spatial and spectral resolution remote sensor data. In addition, while it may be useful in many instances for the image analyst to help develop the classification rules, we will see ever greater emphasis on the use of machine learning theory and technology to allow the computer to automatically derive the production rules based on a limited amount of training data. The papers included in this special issue represent the recent research outcomes of many researchers who have been devoted to the development of mapping technologies using high-

resolution satellite imagery. The results documented here demonstrate how classical research topics, including feature extraction, data fusion, sensor modelling and land use classification, could be employed, particularly when high-resolution satellite images are used as the primary data source.

There was an overwhelming response to the call for papers of this special issue and as such, some papers were recommended for publication in future issues of PE&RS. We, the editors of this special issue, express our gratitude to the following individuals who provided reviews of the manuscripts submitted for this special issue: Luciano Alparone, Ursula Benz, Claus Brenner, Greg Biging, Thomas Blaschke, Lorenzo Bruzzone, Aurelie Bouillon, Pat Chavez, Qi Chen, Keith Clarke, Warren Cohen, Russ Congalton, Ruth Defries, Dennis Devriendt, Clive Fraser, Jay Gao, Mark Gahegan, Peng Gong, Paolo Gamba, Markus Gerke, Jose Gonssalves, Jacek Grodecki, Harry Hanley, Frank Hardisty, Kan He, Stefan Hinz, David Holland, Xiangyu Hu, Jungho Im, Ryan Jensen, Simon Kay, Siamak Khorram, Jungwon Kim, Taejung Kim, Manfred Kornus, Changno Lee, Peter Lohmann, Paul Mather, Helmut Mayer, Joseph Messina, Buddhiraju Mohan, Sunil Narumalani, Kian Pakzad, Renaud Peteri, Daniel Poli, Dale Quatrochi, Fang Qiu, Peter Reinartz, Bill Ripple, Dar Roberts, Franz Rottensteiner, Frank Scarpace, Jochen Schiewe, Uwe Sorgel, Doug Stow, Florence Tupin, Lucien Wald, Ruisheng Wang, Zhijun Wang, Uwe Weidner, Wieslaw Wolniewicz, Curtis Woodcock, Chunsun Zhang, Xiaoyang Zhan.

Guest Editor:

**Dr. Vincent Tao**

Department of Earth and Space Science and Engineering  
York University  
Toronto, Canada

Guest Co-Editors:

**Dr. Karsten Jacobsen**

Institute of Photogrammetry and GeoInformation  
University of Hannover  
Hannover, Germany

**Dr. John Jensen**

Department of Geography  
University of South Carolina  
Columbia, USA

**Dr. Gunho Sohn**

Department of Earth and Space Science and Engineering  
York University  
Toronto, Canada