High Resolution Satellite Imagery for Urban Mapping

Mapping Athens from Space

The use of high altitude aerial photography for mapping and updating of GIS databases in urban areas is costly and leads to serious delays. Coming high resolution satellite imagery will provide much more detail than before. The superior geometric properties of the imagery permits accurate mapping of land use patterns. The new generation of satellite images will adequately complement and partly supersede conventional mapping approaches based on photogrammetry and field survey methods.

By C. C. Kontoes, National Observatory of Athens, Institute for Ionospheric and Space Research

The potential of high spatial resolution satellite imagery for urban environmental purposes is high. The current and upcoming high resolution satellite data can complement and, in some cases, replace high altitude aerial photography for the production of land use maps at medium and larger scales (up to 1:10,000).

Airborne Versus Space

Current techniques for land use identification and mapping within urban zones are based upon the use of high altitude aerial photography (1:30,000 to 1:40,000-scale photos). Although this is an accurate technique for large scale mapping, it is not easy to apply because:

- The analyst needs to be capable of handling effectively large volumes of image files (scanned aerial photos) and large numbers of photo diapositives to cover an area equivalent to the satellite image footprint, e.g. an IRS-1C P scene, covers approximately an area of 5,300 km^2, which is equivalent to 210, 1:40,000-scale aerial photographs
- Block adjustment of large volumes of aerial photographs needs specialised facilities (Digital / Analytical / Analogue Photogrammetric stations) and highly skilled personnel
- Aerial photography acquisition requires time for organisation and often the end product delivery is guided by national security laws; bureaucratic procedures lead to delays
- The cost for ortho-photo map production is relatively high compared to the ortho-rectification of high resolution satellite imagery. Commonly, the cost for 1:40,000 aerial photography acquisition is approximately 10 Euro per km^2. In addition, block adjustment, ortho-rectification and mosaicking range in cost between 10-15 EUROS per km^2. Thus, to cover an area seen by one IRS-1C P full scene, a total budget ranging between 100-140 kEuro is required

The advantages of high resolution satellite imagery for map production are:

- Significant cost savings, as it produces large footprints, needs less control points and requires simple ortho-rectification algorithms

Sensor technology will have high potential for 1:10,000 or even larger scale mapping

- Stereo-pair capabilities, extremely long camera length and suitable base-to-height ratio values, similar to the more conventional aerial photo acquisition systems

Figure 1, Left: ortho-rectified 1:30,000 aerial photograph (1987); middle: extrac right: extract of an ortho-rectified IRS-1C P image (1997) of a 2 km^2 area locate Arrows indicate areas of small changes thro

- Various sensor alternatives will be available in the future, varying in spatial resolution and technological advancements
- Satellite image acquisition is not restricted by bureaucratic procedures and it may be realised in any time frame and frequency

Accuracy

In our tests we used IRS-1C P (5 m resolution) and KVR-1000 (2 m resolution). The test area involved the surroundings of the city of Athens in Hellas. Accuracy assessment was based on checkpoints taken from 1:5,000-scale topographic maps. The check point coordinates have were measured both on the ortho-photo map and on the ortho-rectified images from the same study area, The accuracy lies within the expected range for scale 1:10,000-mapping, when using 1:40,000-scale aerial photography, adequately ortho-rectified. The accuracy of the same points, identified in the ortho-rectified KVR-1000 and IRS-1C P scenes, lie within the expected range for 1:15,000 and 1:20,000 mapping, respectively. Future sensor technology providing stereo-pair capabilities and higher resolutions (less than 1 metre) will have high potential for 1:10,000 or even larger scale mapping.

tho-rectified KVR-1000 image (1992); ɔrth-eastern part of the city of Athens. me

Feature Identification and Interpretation

Ortho-rectified 2-metre and 5-metre imagery offers high potential for feature identification and correct interpretation compared to commonly used high altitude aerial photography. Exactly the same potential as for aerial photography is reported when the classification concerns varying housing density, industrial zones, transport facilities, green and leisure areas and sport facilities. Single features such as individual houses, buildings or narrow street segments can be identified and interpreted with relatively high certainty (up to 90 per cent) when a 2-metre resolution imagery (KVR-1000) is used. Although the same features could be identified on the 5-metre resolution imagery to a percentage attaining only up to 50 per cent, the analyst may nevertheless gain an accurate impression of land use patterns. Land use recognition, delimitation and mapping may thus be rather easily performed on a single ortho-rectified image, instead of on a series of aerial photographs, which would be otherwise required.

One metre resolution will enable identification of changes at the level of the single house

Change Detection

Change detection is the process of identifying differences in the state of an object or land use by observing it at different times (Figure 1). It may be performed within urban zones by using appropriate combinations of satellite images from different time frames, or even combinations of satellite images with historic aerial photography. The study of these data sets provides meaningful information on urban environment dynamics. Experiments with KVR-1000 imagery and older aerial photography show that their geometric accuracy enables precise geo-referencing and co-registration to proceed with change detection. Seven cases of changes in land use patterns were identified in the surroundings of Athens, between 1987 to 1997. These were mainly attributable to changes from open land green areas to residential zones and industrial activities. Images with one metre resolution or less will enable identification of changes at the level of the single house. Illegal changes may thus be identified.

Image fusion possible when co-registration is performed very accurately

Image Fusion

Image fusion enables joining of the spectral properties of the coarser resolution multi-spectral imagery with the pronounced texture information provided by the high resolution panchromatic images. The limiting factor for the current sensor technology is the large difference in pixel resolution between multi-spectral and panchromatic layers. Nevertheless, image fusion remains possible when the co-registration is performed very accurately. Coming sensors will help to overcome these difficulties because of their enhanced geometric properties and their capability to produce higher resolution multi-spectral images. Sensors like Quickbird1&2, Ikonos 1&2, and Orbview3, will offer multi-spectral products with pixel ground resolution of 4 metres.

Future

Much effort has still to be invested in the development of specialised tools, methods and models for better exploitation of the new satellite data, including:

- Tools for enhanced processing of stereo-pairs

- Better techniques for storage and retrieval of large image volumes
- Image analysis techniques which account for geometric and element structure properties on the image plane and eventually integrate human reasoning for feature recognition

Conclusions

The current and new generation of high resolution satellite imagery are appropriate for mapping land use patterns and their changes within urban areas. They are very well suited for visual interpretation of urban areas. This is because they provide almost the same level of information as aerial photographs and their inherent geometric properties permit the accurate location and delineation of features. We believe that this type of satellite imagery will become the main supporting tool for urban analysis studies in the future.

Further Reading

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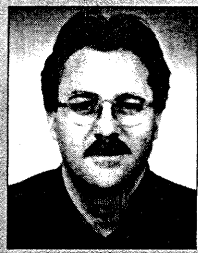
Biography of the Author


Dr Haris Kontoes

Haris Kontoes received a Phd Degree from the National Technical University of Athens in 1992. He is a researcher of the National Observatory of Athens working on the development of advanced image processing techniques for satellite image exploitation. He has served as project manager in the field of digital photogrammetry, cadastre, resource management and land use mapping by remote sensing.

National Observatory of Athens, Metaxa & Vas. Pavlou Str, Palea Penteli, PO BOX 200 48, GR 152 36, Athens, Greece, E-mail: kontoes@creator.space.noa.gr