Photogrammetry and Remote Sensing —a convergence of technologies

Prof. Dr. Armin Gruen*

Photogrammetry and Satellite Remote Sensing have originally developed along separate tracks. With the successful launch of the first dedicated earth observation satellite Landsat 1 on 23 July 1972 the technology of earth observation from space platforms received a significant boost. With its MSS sensor Landsat produced digital image data at 80m footprint. Now the stage was set for digital image processing using single images for many years to come. Contrary to that, in the 70s photogrammetry was still largely working with analogue and analytical devices, albeit with analogue film-based images, but preferably in stereo mode or even, especially in close-range applications, in multi-image modes. This situation changed dramatically when digital cameras, based on CCD sensor technology, became available at affordable prices. Parallel to that the computer technology improved its performance in terms of CPU times, storage capacity and bandwidth of data transfer continuously. So the time was ready for digital photogrammetry. Since the early 80s photogrammetry went fully digital, first a bit slow but steady in the close-range field and later, since the late 80s, also in the aerial image domain. However, until recently the processing platforms for satellite imagery, aerial and close-

range images developed independently from each other. They even differed from each other to an extent that images from one domain could not even be processed with software of the other domains.

This situation has changed. Nowadays we see the first systems which are capable of dealing with images of all domains, at least with respect to some functions.

It is rather surprising that this trend towards unified software platforms has not emerged earlier, as we can observe already for quite some time a convergence of processing methodologies. The following factors have contributed to this convergence and will continue to do so :

+ *Use of digital images.* After the introduction of digital satellite images and digital terrestrial images even the aerial image acquisition works semi- or fully digital. The different image formats or the differences in spectral channels should not pose a problem concerning the development of unified software.

+ *Sensor models.* Two major geometrical sensor models have emerged lately: The single frame model and the linear array model. Others, like panoramic or pointscan cameras are rather the exception. Both sensor models can be intergrated as plug-ins in unified application software.

+ *Multi-image acquisition and processing.* Many satellite sensors are nowadays capable of producing stereo (along-track or across-track) images or even more than two images of the same scene from different viewpoints. This opens the possibility for precise 3D georeferencing and processing. Aerial and terrestrial imagery provided for this capability already for a long time.

+ *3D processing*. The possibility of 3D processing and the steadily increasing spatial resolution of

*ETH, Inst. of Geodesy & Photogrammetry, Switzerland

Niche of the Great Buddha

Niche of the Small Buddha

Textured 3D terrain model of the area around the Great Standing Buddhas in the valley of Bamiyan, Afghanistan (total extension 49×38 sqkm). Geometry derived by automated image matching from a SPOT 5-HRG stereomodel. Texture mapped from an IKONOS pan-sharpened image mosaic. The empty Buddha niches are clearly visible in the rock face in the center of the image.

satellite imagery calls for the adoption of techniques that are already in use in photogrammetry for some time. The problems that we face with the automation of the processing chain are very similar for images from different sensor platforms.

+ *Sensor and data integration.* The use of different kind of sensor data, e.g. images and laserscan data, GPS/INS, existing map and GIS information, etc. also leads to similar technical processing requirements.

+ *Postprocessing.* After processing the image data we face problems that are also essentially independent of the type of imagery: Collecting and analys-

ing data in a Spatial Information Systems (SIS), visualization and animation of static results and processes.

With the new generation of highresolution satellite sensors (SPOT 5, ALOS PRISM, IKONOS, Quickbird, etc.) the issue of 3D modeling is gaining much more prominence. Therefore photogrammetric techniques are also becoming more important in satellite image applications. On the other hand, radiometric analyses are also attaining more attention in photogrammetry. We observe that the originally different techniques in remote sensing and photogrammetry are converging strongly

today. So it pays off to have a brief look at the photogrammetric processing methodology. In photogrammetry we distinguish the following components of the processing (modeling) chain :

1. *Design.* We have to model the sensor geometry and radiometry, the measurement network and the imaging process.
2. *Measurement.* This includes image analysis functions and the modeling of objects and complete scenes.
3. *Result modeling.* This refers to the postprocessing functions, e.g. generation of data models for SIS, visualization and animation.

In order to demonstrate what we have claimed before we show in the following the functional components of SAT-PP, a software package that is used for the **Precision Processing of Highresolution Satellite Images**. This package was derived from a similar package to be used for digital Linear Array CCD aerial images and indeed it can be used for these images as well. The software can accommodate images from IKONOS, QuickBird, ALOS PRISM, SPOT 5 HRS and sensors of similar type to be expected in the future.

The software SAT-PP includes the following modules :

- +User interface for image handling and image measurement in mono and stereo, in manual and semi-automated modes
- +Sensor model adjusted to the particular sensor geometry
- +Orientation of single stereo models and triangulation of larger units. Tie point measurement in manual, semi-automated and fully automated modes
- +Derivation of quasi-epipolar images
- +Automated generation of Digital Surface Models (DSM)
- +Generation of orthoimages
- +Mono-plotting functions
- +Extraction of objects with particular emphasis on 3D city modeling

This clearly indicates the general applicability of

a unified approach to processing methodology and to software design in satellite remote sensing and aerial photogrammetry.

As an example we show the results from the generation of a textured 3D model of the terrain of the area of the Great Standing Buddhas of Bamiyan, Afghanistan. Usually one would use aerial images for this purpose, but those were not available at these times. Therefore we used a SPOT 5-HRG stereopair in order to generate a DTM with 5m gridsize through automated image matching. The texture was derived both from panchromatic SPOT 5 images (2.5m pixels) and from pan-sharpened IKONOS images (1m pixels). The processing routines followed the photogrammetric approaches described for SAT-PP.

We are currently observing that photogrammetry and remote sensing have expanded their techniques very much in recent years—mostly towards the joint goal of precise georeferencing and 3D modeling. This has opened many new fields of applications.

The pressing need for modeling our 3D environment (3D city and terrain modeling) from aerial and highresolution satellite images will have a tremendous impact in natural hazard damage monitoring, risk analysis, car navigation, Location-based Services, virtual tourism, and in many more applications. The recent dramatic destructions of the Great Tsunami in South East Asia have made us aware again of the value of highresolution satellite imagery for fast damage assessment. This image-based recording would have been even more efficient if it had been supported by digital aerial image acquisition systems.

Already now, but even more in the near future, we are and will be overwhelmed by huge amounts of images, emerging from satellite, aerial and terrestrial platforms. A good deal of those images will have to be processed using photogrammetric techniques. This is why we see a very bright future for a joint approach to photogrammetry and remote sensing, in research, development and with respect to practical applications as well.