AUTOMATIC AND GENERIC MOSAICING OF SATELLITE IMAGES

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1. INTRODUCTION

PLEIADES High Resolution is a two-satellite constellation dedicated to Earth Observation. Satellites are planned for launch in 2011 and 2012. Key technological evolutions have been introduced in comparison with the former generation. Particularly, the resolution will be up to 70 cm (vs. 2.5 m on Spot5) in panchromatic band, and 2.8 m in multispectral bands. Another key evolution is tipping acquisition which allows the acquisition of colocalised zones.

Figure 1: A PLEIADES HR Satellite

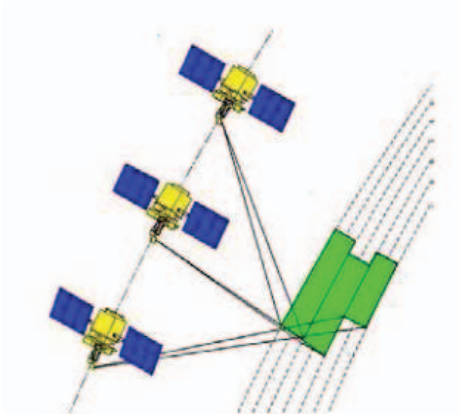
Figure 2: Illustration of tipping acquisitions

Whereas the high resolution implies a reduce swath, 20 km (12 miles) vs. 60 km (36 miles) for Spot5, the agility of the satellite ensures the coverage of such areas using consecutive acquisitions. To offer Spot5 users the same service they had, the Centre National d'Etudes Spatiales (CNES, French Space Agency) has, since 2004, decided to study [1] [2] a full automatic mosaicing process, in order to generate 60 km * 60 km images from 20 km large strips. For such a challenge, CNES has specified and developed the tool SIGMA, which is now ready to be used in PLEIADES Image Processing Unit (IPU).

This tool is able to both automatically correct the radiometry and the geometry of each image to put them in a common referential and to generate orthomosaics.

SIGMA can process a more important variety of images than PLEIADES, including satellite and airborne acquisitions, and offers a set of possibilities like automatic or external ground control points, time-based image superposition, and more. Here we present the concepts and mechanisms used in SIGMA for this processing.

Keywords: satellite images, mosaicing tool, mosaic, orthomosaic, automatic generation.

2. A FULLY AUTOMATIC MOSAICING SYSTEM

SIGMA (Automatic & Generic Integrated Mosaicing System) is based on three key concepts: refining, harmonization and seam line computation.

2.1. Refining geometric models

First, the refining task consists there of refining the geometric model of the input images captor. This task is based on automatic detection of homologous points, followed by a geometric refining by Least Mean Square (LMS) optimisation.

SIGMA can take homologous points between ground reference and images (ground control points), between images to be mosaiqued (tie points), between spectral bands of an image (registration) or between reference images in captor geometry and images. Tie points can be either used to pull the image localisation on the ground reference orthoimage or to pull the orthoimage Data Elevation Model (DEM) under the input image.
Even if the default refining is based on automatic detection of homologous points, the user can also input its own points.
A preparation phase computes all overlay zones in which the correlation phases are launched. Points are then chosen by an advanced correlator, based on pyramidal decomposition, which is highly configurable. These correlation points are filtered to establish the homologous point list.
At the end, the list containing all points is inserted in a LMS solver to obtain the new geometric model of the captors.

2.2. Generating sets of orthoimages

Next task is the generation of grids, particularly ressampling grids per image (and per subswaths if needed), but also other grids needed by the ressampling step, like provenance grids. The newest geometric model is used to compute grid nodes in a user decided step. The DEM used can be chosen by the user.

Figure 3: A set of orthoimages on Singapore

Once ressampling grids have been generated, the user generates a set of independent orthoimages. SIGMA, according to the processor configuration, massively parallelizes resampling tasks.

The result is a set of orthoimages in a common geometry.

2.3. Generating orthomosaics

Alternatively to the set of orthoimages, the user can generate a complete orthomosaic. The task allows the computation of both the radiometric harmonisation and the seam line.

Firstly, SIGMA computes a set of Look-Up Table (LUT) grids to ensure harmonisation between images, particular attention is given to harmonisation between images (global harmonisation) and harmonisation at the overlay zones (local harmonisation). Global harmonisation is needed to obtain a satisfactory global feeling whereas local harmonisation aims at helping the seam line computation.
Secondly, SIGMA computes the seam line on the overlay zones. User can order a Region Of Interest (ROI) in which the seam line must not pass. For each image couple, a dynamic programming algorithm applied on a precomputed cost map detects the less costly line [3]. The costs are optimised to avoid urban constructions and to prefer radiometric homogeneous zones.

Last, the ultimate step to generate orthomosaics is resampling, which takes into account the ressampling grids previously produced, and the LUT grids and seam line. The task can either produce an album resolution mosaic or a full resolution mosaic.

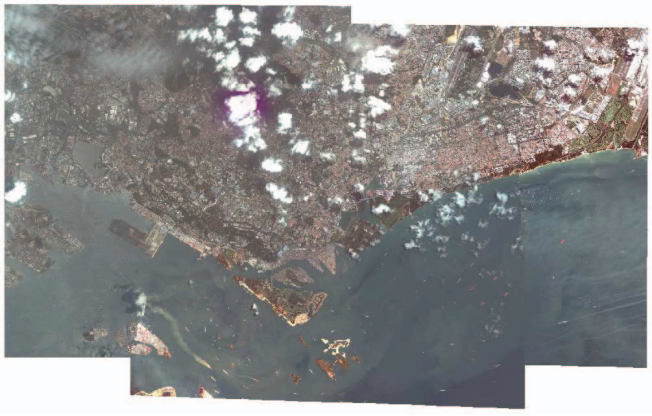

Figure 4: An orthomosaic on Singapore

3. A USER FRIENDLY TOOL

SIGMA tool is designed and developed for a nominal use in Pleiades operational Image Processing Unit. Thus it offers a fully automatic execution and time & memory consumption optimisation: all tasks are divided in unitary steps which correspond to unitary processing. Steps that can be executed at the same time are grouped into phases. The SIGMA workflow engine call tasks one by one or phase per phase, according to the number of CPU allowed by the user, up to hundreds in the operationnal IPU.

Furthermore, SIGMA is also a highly configurable user tool with its own man-machine interface, which is used by CNES image research & development. The task's order and the parameters used within each task are editable in the command file. The execution can be launched in a full execution or step by step for debugging and research.

SIGMA is designed as a multi-sensor tool: it can process an important variety of satellite and airborne images, including native geometry images and orthoimages.

4. CONCLUSION

Designed and developed for a use in PLEIADES operational Image Processing Unit, SIGMA is an automatic and generic integrated mosaicing system. It has already shown complete satisfaction. But moreover than its use in PLEIADES, SIGMA offers to the user a generic system that can process an important number of image types. CNES will continue to use this tool, operationally and for research.

5. REFERENCES

[1] F. De Lussy et al., “Pleiades-HR system products and quality, Pleiades-HR system products and geometric accuracy", ISPRS Hannover Workshop, 2005.

[2] H. Le Men and D. Boldo, "Mosaïque automatique d’orthophotographies", RFIA'2000, laboratoire MATIS, IGN-SR 990

[3] J. Chon, H. Kim “Determination of the Optimal Seam-Lines in Image Mosaicking with the Dynamic Programming (DP) on the Converted Cost Space”, ICAISC 2006