TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät für Elektrotechnik und Informationstechnik • Institut für Automatisierungstechnik

Optomechatronics – Image Correction for Hyperspectral Imaging with Nanosatellites

Background

Hyperspectral imaging is currently considered as a powerful extension of multi-spectral remote sensing. Large number of contiguous spectral bands with high spectral resolution provide access to the full "spectral signatures" of each element in the observed scenes, which open up new areas of applications for data users.

To provide broader access to hyperspectral image data, a miniaturized hyperspectral imaging satellite (form factor: Cubesat 3U – Fig. 1) with LVF filter is currently being developed by Cosine Measurement Systems (The Netherlands).

Fig.1. Cubesat 3U frame example
(image: https://icubesat.files.wordpress.com/2013/01/picture-2525.jpg)

The LVF filter (Fig. 2) features narrowband spectral transmission with wavelength gradually changing in the direction of satellite motion. During recording of the images sequence, Earth image moves with respect to the filter and each element of the target scene is thereby imaged with spectral sensitivity changing from frame to frame.

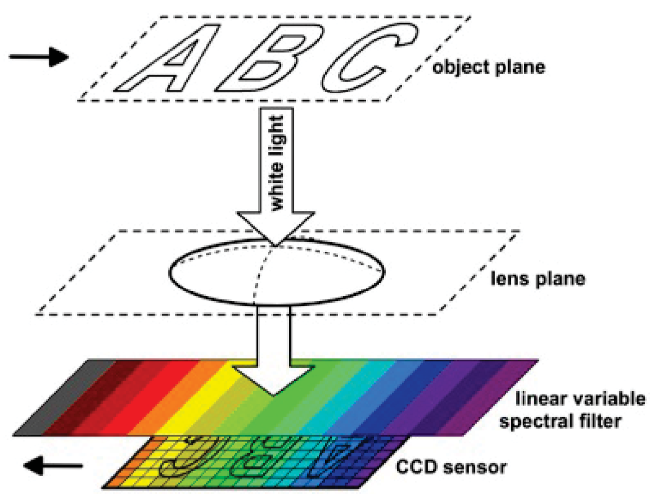

Fig.2. Principle of the hyperspectral images acquisition with LVF filter
(image: Marvin E. Klein, Bernard J. Aalderink, Roberto Padoan, Gerrit de Bruin and Ted A.G. Steemers: „Quantitative Hyperspectral Reflectance Imaging": Sensors 2008, 8(9), 5576-5618)

Hyperspectral image is then reconstructed by combining together the narrow spectral bands cut from multiple frames, what requires precise mutual registration (aligning) of the LVF-coded and geometrically distorted raw images.

Correlation – Based Registration Solution

To solve the described above registration problem, correlation image processing - based approach has been developed at the Chair of Automation Engineering (Fig. 3). The approach enables subpixel accuracy of the images alignment and is suitable for the distorted LVF – coded images.

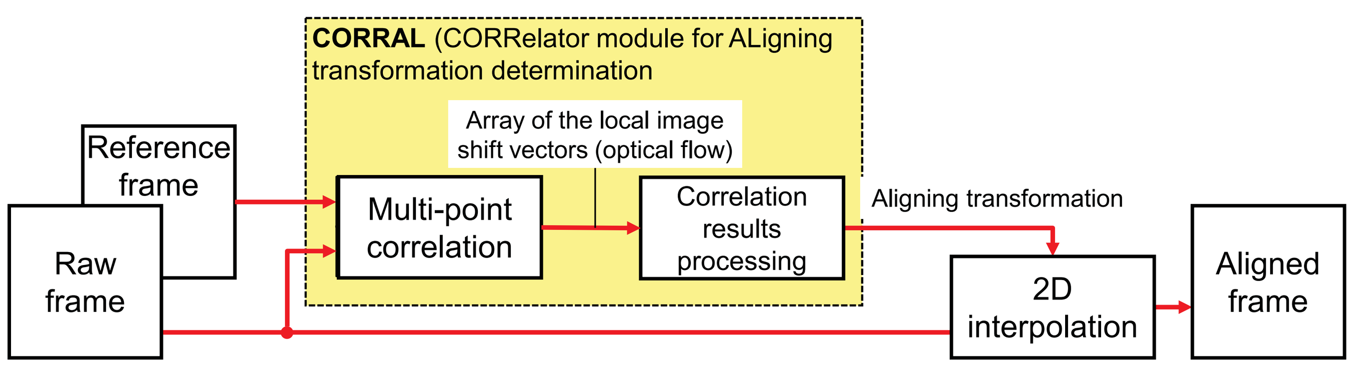

Fig.3. Correlation - based registration principle

To prove the performance of the proposed approach (to demonstrate the correlation - based co - registration of the LVF-coded images and to estimate the practically achievable registration accuracy), a simulation model of the hyperspectral imaging system is currently being developed within the frame of the ESA-funded project.

Imaging System Architecture

General architecture of the imaging system model is shown in Fig. 4. A sequence of the simulated camera images is produced by Simulated Images Generator module on the basis of the hyperspectral image data (available from the AVIRIS project (NASA / JPL)), considering the specific limitations of the planned mission (i.e., orbit model, pointing error model, camera model, optical distortions).

For the generated sequence, frame-to-frame Optical Flow (OF) fields (image motion patterns) are then determined by multi-point 2D correlation. Obtained OF fields are processed to determine frame-to-frame aligning transformations. Aligned sequence are further processed to extract the hyperspectral image information, which will be analyzed to estimate the achievable image quality.

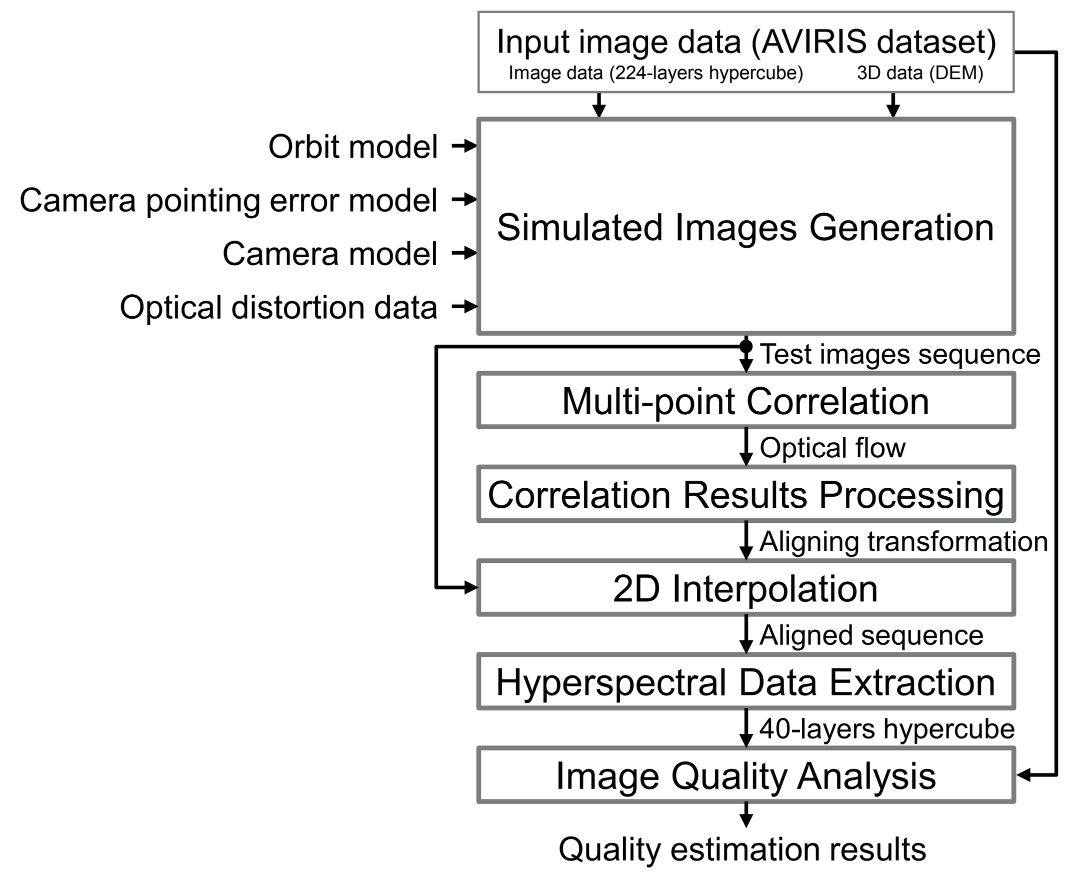

Fig.4. Imaging System Model Architecture

Images generation results

Test scene has been generated on the base of the selected AVIRIS dataset. Required size of the test scene has been obtained by mosaicking of both image and elevation files, as shown in Fig. 5. Fig. 6 shows the example of the generated LVF-coded camera image.

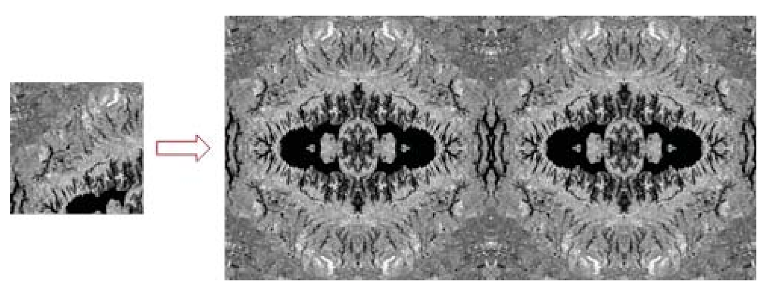

Fig.5. Image mosaicking principle (4 x 2 mosaicking example)

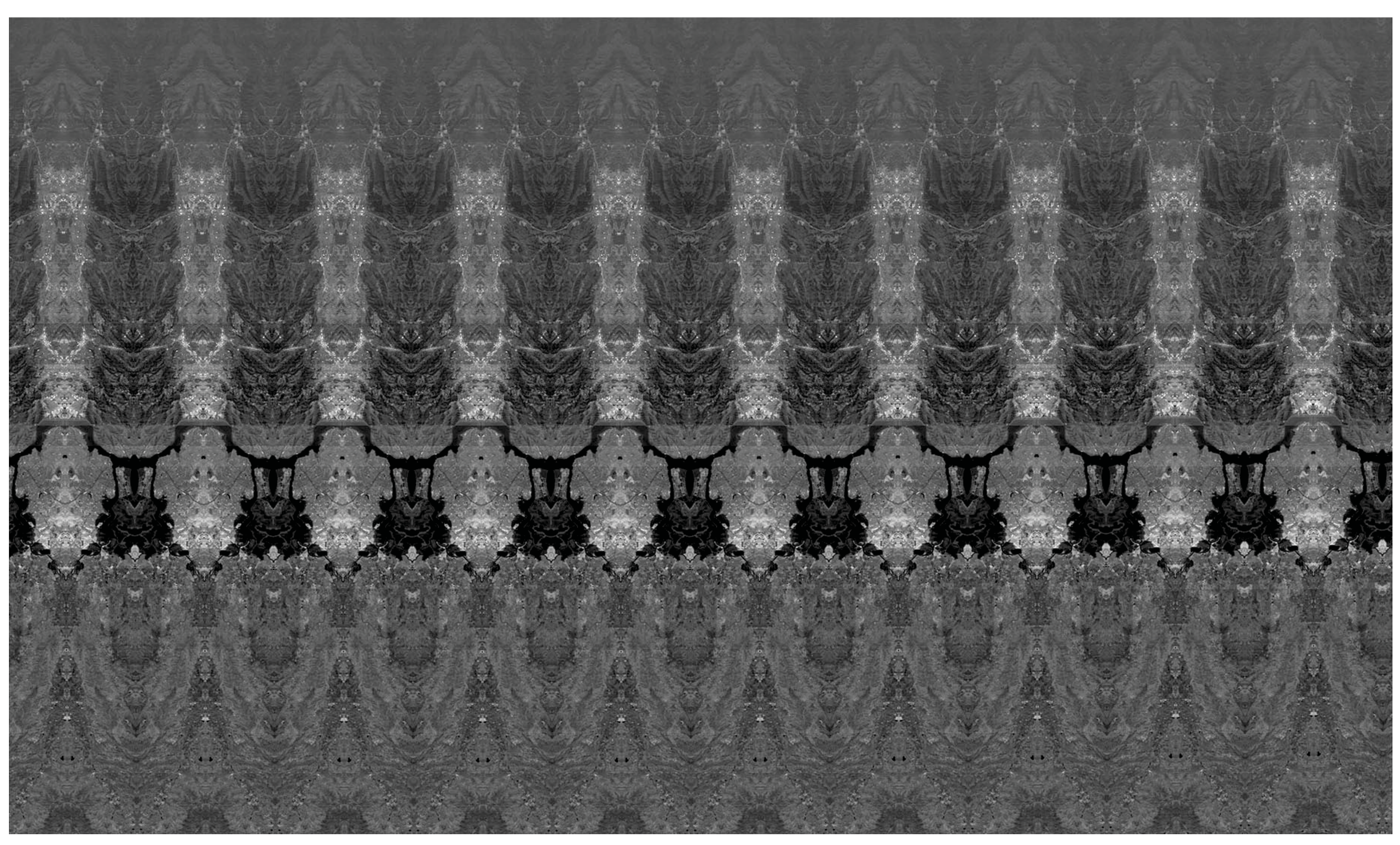

Fig.6. Simulated LVF-coded camera Image (filter wavelength changes from 400 to 1000 nm from the top to the bottom of the image)

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