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IMAGING SPECTROMETER DATA CORRECTION

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ABSTRACT

The paper presents part of the preprocessing steps for imaging spectrometer data, acquired in the process of laboratory tests of an imaging spectrometer model for remote sensing applications. The main relevant operations for elimination of sensor-related effects of spectrometric data, such as dark current correction, spectral and radiometric characterization, are described and highlighted. Some appropriate algorithms illustrating the proposed procedures for data correction are presented and the obtained results are shown.

1.Introduction

Imaging spectrometry measurements, as a new area in remote sensing, require new approaches for data handling, preprocessing and extraction of information from spectral images. In spectroscopy, the radiation is measured which falls onto the sensor's detector after having passed from a target source through an intervening medium on its way to the sensor. Here, the quality of measurement is the most difficult problem. The error sources are numerous and of various nature and each of them must be localized, analyzed, and characterized. The practical instruments are never ideal, therefore the optical measurements are only approximated. The preprocessing is an important part of the analysis of imaging spectrometry data and is relevant to a quantitative estimation of the data. It includes characterization and data correction procedures to eliminate the sensor effects.

2. Correction procedures for imaging spectrometer data

The correction procedures for imaging spectrometer data start up yet with the main instrument's development, with the planning and implementing of methods for laboratory characterization and envisaging methods for on-board characterization. The characterization methods are critically dependent on the instrument design and construction methods and performance requirements [1, 2, 3]. The ground-based and on-board characterization of the instrument provides coefficients for the correction algorithm. The preprocessing of imaging spectrometric data encompasses procedures, such as offset and dark current correction, spectral and radiometric correction, etc.
The greater part of an imaging spectrometer's characteristics are expected to remain constant throughout the instrument's life-time and can be characterized in laboratory condition, while others are expected to change during the operating mode and these must

be characterized on-board. The following characterization measurements are expected to be critical for data calibration:

- dark current characterization;
- spectral characterization;
- radiometric characterization

The basic preprocessing steps for characterization of an imaging spectrometer are indicated on the flow diagram shown in Figure 1. The characterization methods and relevant correction procedures are determined in detail on the basis of error analyses. The frequency of characterization processes and algorithm update will vary with error change rate.

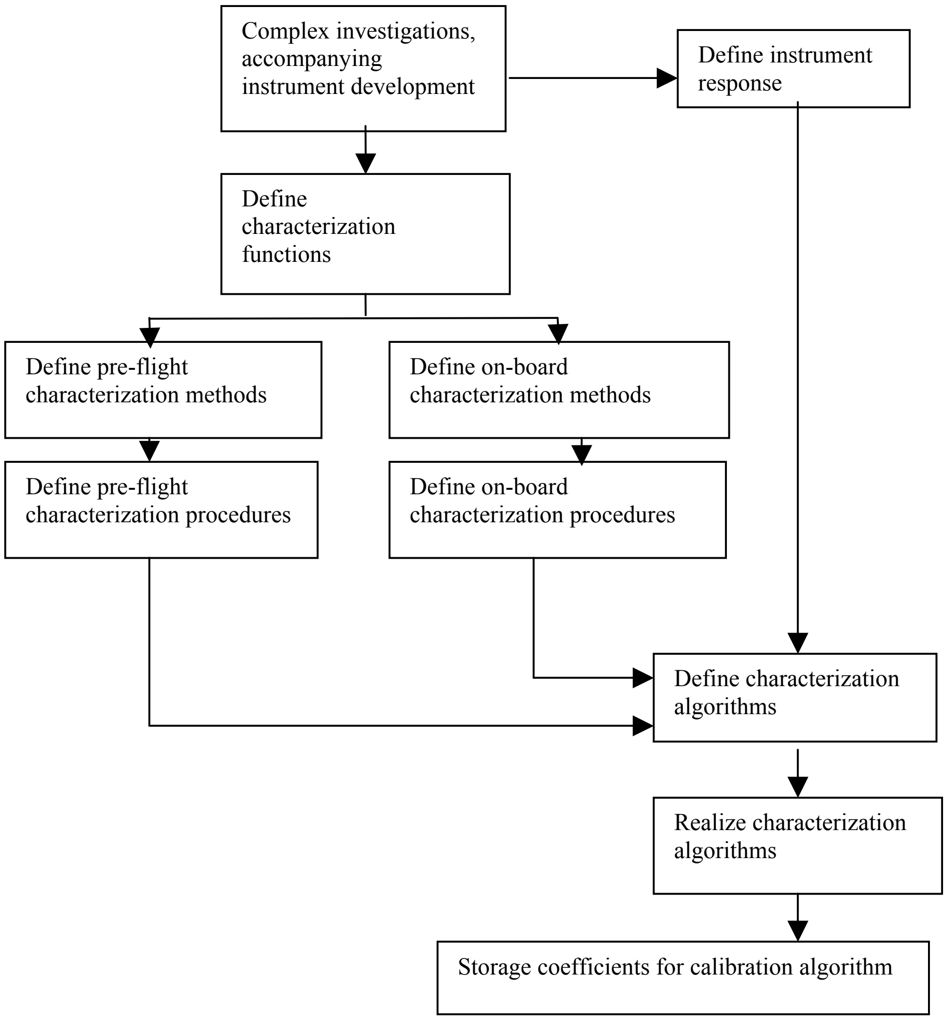


Fig. 1. Preprocessing steps for imaging spectrometer data

2.1. Dark current data correction

The measurements are made in laboratory conditions; their purpose is to determine the dark current levels variation for each pixel of the sensor array. This data obtained by laboratory means is stored as a reference for on-board obtained data. In operating mode, during nominal observation, offset correction is performed by subtracting from the signal the dark level component. Dark current correction coefficients are obtained at closed shutter. Dark current levels U^c_{ij} are given by the detector response and are stored for further processing. The processing includes calculation of the average dark current level for each pixel in the image and storage of data for implementation of the characterization algorithms. These procedures are performed for each used operating mode of the sensor. The process of dark current characterization is indicated on the flow diagram shown in Figure 2.

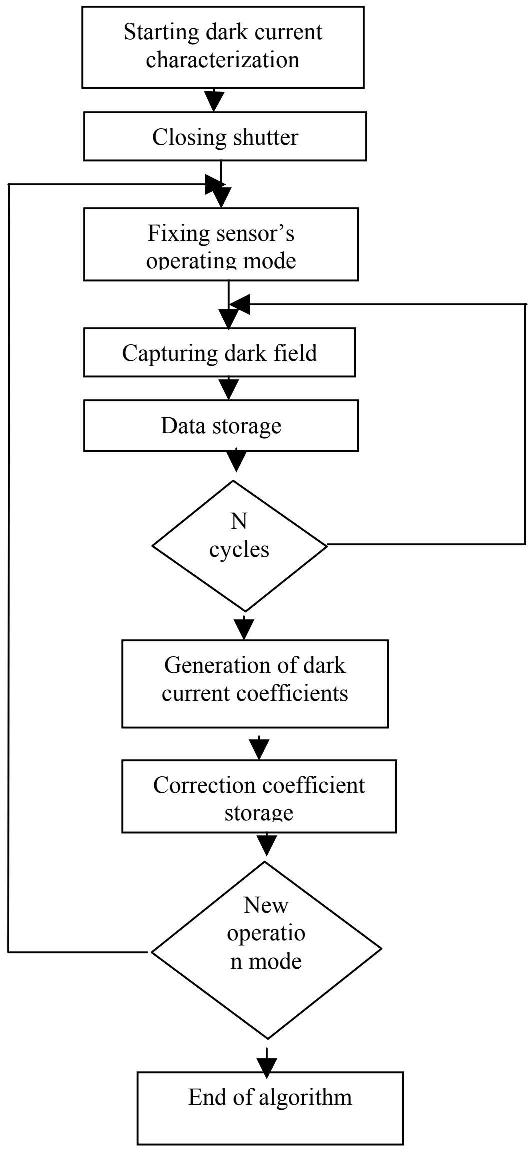
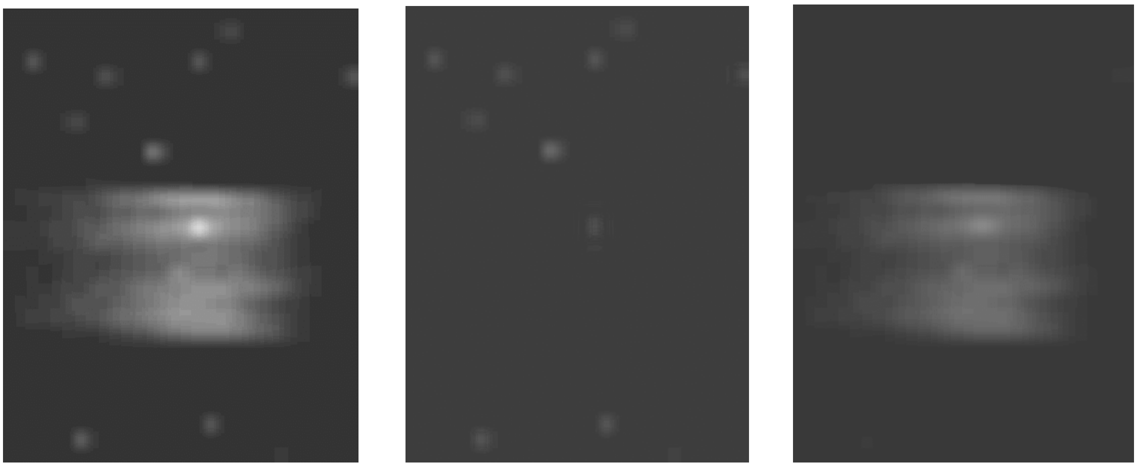


Fig. 2. Dark current data correction flow diagram



a *b* *c*

Fig. 3. Spectral test images (fragments) obtained by laboratory means; spectral band 550nm;, a – original image, b– dark current image, c – corrected image.

The process of dark current characterization - capturing images, subtracting, storage (Fig.2) - takes time and computational power, but in the corrected images, the effect of the dark current is partially eliminated and the quality is dramatically improved (Fig.3 a,b).

2.2. Spectral data correction

This data correction is used to verify spectral dispersion function of the imaging spectrometer by illuminating the entrance slit with a calibrated monochromatic source. As a reference source in laboratory condition, a monochromator with a light beam of a narrow spectral width $\Delta\lambda_{in}$ ($\Delta\lambda_{in} < \Delta\lambda_{ch}$, where $\Delta\lambda_{ch}$ is spectral channel width) is used. The output beam of the monochromator is re-imaged on a white diffuser plate. This uniform image is directed to the input optics of the instrument. In Figure 4, the spectral response function for two selected channels (center wavelength λ_{01} =500nm and λ_{02}=600nm) is shown. Assuming that the combination of a diffraction grating and an area array has a distinct geometrical alignment, the center wavelength distribution is a function of the linear position on the area array. On this assumption, effects such as the non-uniformities in the detector spacing or irregularities in the grating are neglected [4]. The grating therefore creates

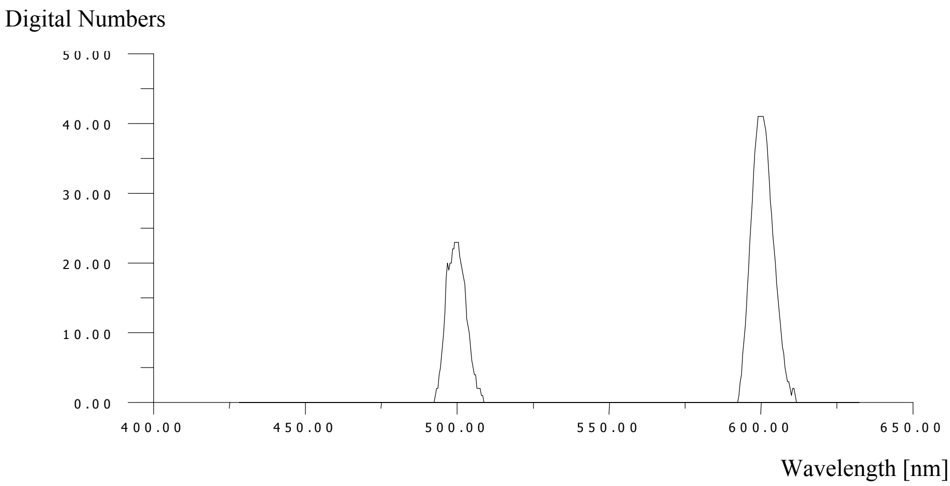


Fig.4. Spectral response functions for channel 500nm and channel 600nm.

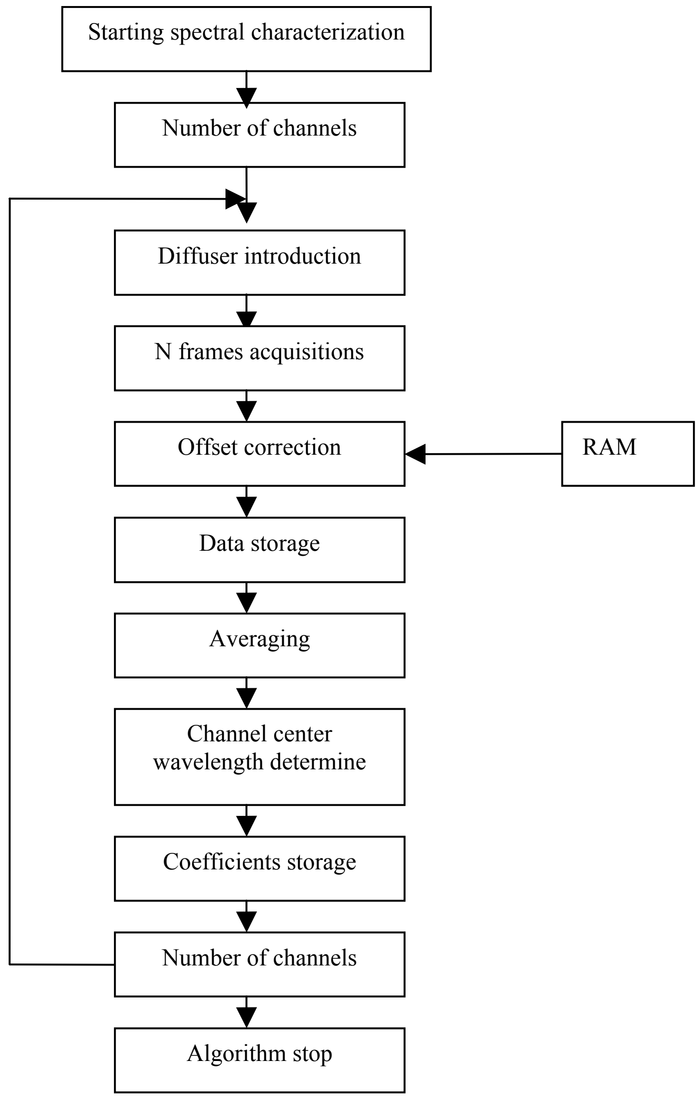


Fig. 5. Algorithm for spectral data preprocessing.

a linear dispersion on the area array and each detector element is associated with a distinct spectral channel based on the spatial extent of each element.

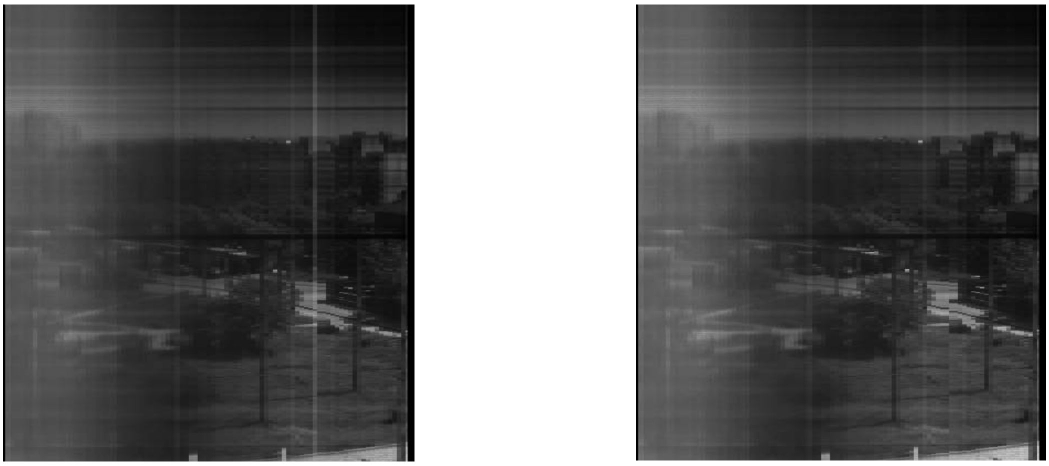
Regardless of laboratory characterization, an imaging spectrometer requires on-board procedures to check periodically the stability of this parameter. Therefore, on-board spectral characterization will be performed with laser diodes as absolute reference sources. The process of spectral characterization is shown on the flow diagram shown in Figure 5.

2.3. Radiometric data correction

Radiometric data correction includes procedures to determine the basic imaging spectrometer characteristics, such as spectral sensitivity, $S_{ij}(\lambda)=U_{ij}/L_{ij}\ (\lambda)$ (i – number of spatial pixel, j – number of spectral channel, L_{ij} – radiant power, U_{ij} –readout data), photo response non-uniformity PRNU, linearity of the response function, bad-pixel or line corrections, etc.

The most likely and important radiometric characterization procedures and the measurement procedure sequence is indicated below:

- introducing shutter;
- dark current measurement take place;
- introducing diffuser;
- photo response non uniformity coefficients determine;
- normalization coefficients calculate;
- bad-pixel or line correction
- coefficients storage.



a b

Fig. 7. Spectral image collected May 2000, in spectral band 550nm, a – original image, b – corrected image.

The imaging spectrometer data cube obtained under laboratory conditions is presented in Figure 7 as a spectral image for one spectral channel with center .wavelength λ_0 = 550nm and spectral channel width $\Delta\lambda$ = 4nm [5].

4. Conclusions

Imaging spectrometer data correction as part of data preprocessing allows for a beneficial trade-off between instrument complexity and system performance and provides for more correct interpretation of the obtained data.

4. References

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