Atmospheric correction of very high spatial resolution images using multispectral satellite images

(PhD proposal)

Laboratory: LASTIG lab. (Univ Gustave Eiffel, IGN, ENSG), ACTE team

Localisation: LASTIG, IGN-ENSG, Saint-Mandé, France

Starting Date: September 2023

Founding: Co-founded by CNES and IGN (36 months)

Supervision: Supervisor: Bruno Vallet (IGN-LASTIG); Co-Supervisor: Manchun Lei (IGN-LASTIG), Arnaud Le Bris (IGN-LASTIG), Olivier Hagolle (CNES-CESBIO)

Keywords: Atmospheric correction, features detection, multi-sensor, radiometric normalization, surface reflectance

Context

Atmospheric correction aims to retrieve the surface reflectance (SR) at the bottom of the atmosphere (BOA) from remote sensing data by estimating atmospheric effects in order to correct them. This is a critical step in remote sensing. Most biophysical/biochemical variable inversion algorithms are based on SR. The correction of atmospheric effects is also useful for orthophotography generation (obtaining a homogeneous mosaic), change detection, and land cover mapping.

Multispectral satellites like Sentinel-2 are able to provide medium spatial resolution (≥10m) SR images (level 2A or even L3A product) to users. However, the atmospheric correction of submetric very high spatial resolution (VHR) satellite (Pléiades Neo, Pléiades HR, CO3D, CSO,...) and aerial (UltraCam, DMC,...) images, often dedicated to photogrammetry rather than to quantitative remote sensing, remains an open issue. The main problems are that:

1. These VHR sensors do not have specific spectral channels dedicated to the estimation of atmospheric parameters;
2. Aerial images are more impacted by directional effects due to the wider field of view (FOV);
3. Aerial acquisition missions often use different acquisition parameters, which make it difficult to calibrate the sensors.

The atmospheric correction of photogrammetry images can be carried out by simplified methods such as the empirical line (EL) method from *in-situ* ground truth measurements. However, if the target area includes a large number of images, collected at different times and covering a large area, such *in-situ* measurements become difficult or even impossible.

Relative radiometric normalization (RRN) is a technique to align the radiometry of a subject image to that of a reference image. Taking a SR image as the reference, it is possible to transform the subject image close to the SR by RRN [1]. RRN methods mainly focus on the determination of the targets whose SR is considered to be almost constant over time [2]. Our question is: can we use medium resolution SR images, acquired before and after the acquisition of VHR images, to retrieve the SR of VHR images by correcting atmospheric impacts, directional impacts, and variations related to sensor calibration?

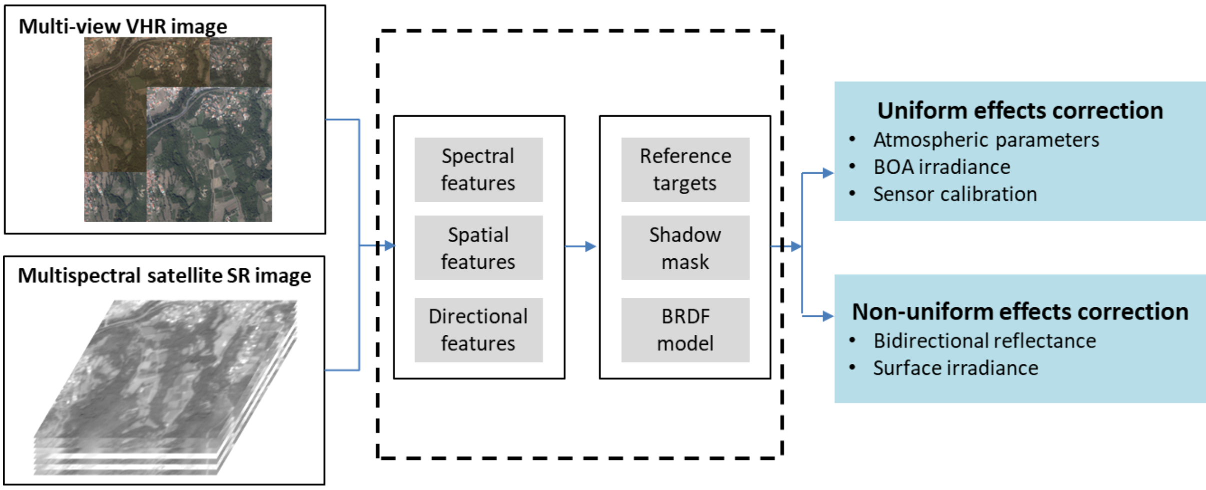

Figure 1. Illustration of the objectives.

Objectives

We consider that the three impacts mentioned above produce two types of effects in a VHR photogrammetry image: uniform effects and non-uniform effects. Uniform effects are related to atmospheric reflection, atmospheric optical thickness, total irradiance at BOA, and sensor calibration coefficients. Non-uniform effects are related to bidirectional reflectance, BOA irradiance of complex surfaces (tilted surfaces and shaded surfaces). To correct these two types of effects, we propose the following tasks:

- Task 1 will consist in defining the features and selection criteria to locate reference targets. The objective here is to study the reliability of such reference targets in relation to the impact of spatial homogeneity in the satellite image pixel and the impact of the bidirectional reflectance. This information will be provided by VHR images. The reference SR on these targets will come from L2A (time series) products from the Sentinel-2 (10m and 20m). In practice, it is difficult to find targets with perfect Lambertian property. The error budget will be studied using image simulations. We propose to update the multi-rule change detection approach [3] with these criteria to determine the reference targets. These targets will then be used to correct the uniform effects in the images using the linear relationship between the pixel value in digital count (DN) of the VHR image and the SR.

- Task 2 will study the differences in radiometric characteristics between two sensors [4]. It will be necessary to take into account the misalignment of the spectral response and the difference of bandwidth between these two types of sensor.
- Task 3 aims to the correction of directional effects. The VHR images are acquired with a high overlap rate (multi-view measurements). We aim to normalize the directional reflectance at each pixel using the available viewing directions. Homogenization techniques will be applied to remove residues. Atmospheric parameters can be adjusted for better taking into account the angles of view.
- Task 4 will consist in studying the separation of the components of sky diffuse irradiance and sun direct irradiance once the total BOA irradiance is estimated [5]. Estimating the amount of diffuse sky irradiance is indeed essential to correctly estimate the reflectance of complex scenes with both tilted and shaded surfaces.

Candidate profile

- Master 2 student in remote sensing, physics.
- A background in remote sensing, radiative transfer and radiometric correction is required, and a knowledge on change detection will be appreciated.
- Mastery of Python.
- Fluency in English.
- (Optional) Experienced with aerial/satellite sensor technology, image simulation, DART simulation.

How to apply

Before **February 28th, 2023**, please send both contacts in **a single PDF file** the following documents:

- A detailed CV
- A short letter of purpose (1 page max) stating your interest in this PhD project
- Grades and ranks over the last 3 years of study
- The contact details of 1 referent who can recommend you (name and email)

Contact

Bruno Vallet (bruno.vallet@ign.fr), Manchun Lei (manchun.lei@ign.fr), Arnaud Le Bris (arnaud.le-bris@ign.fr), Olivier Hagolle (olivier.hagolle@cnes.fr).

Références

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