ICC EUROSDR BANYOLES08 RESEARCH ACTIVITIES

R. Arbiol, L. Martinez

Institut Cartogràfic de Catalunya, Remote Sensing Area, Parc de Montjuïc s/n, 08038 Barcelona, Spain – Roman.Arbiol@icc.cat

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ABSTRACT:

This work is a review of the field experiments carried out by the Institut Cartogràfic de Catalunya (ICC) during the last years and an overview of the future work on this area.

Since 2004, ICC operates Digital Metric Camera (DMC) sensors, manufactured by Z/Imaging. These sensors are perfectly integrated in the ICC ortophoto and photogrammetric workflows. Nevertheless, there are some characteristics of the products that could be improved such us ortophoto colorimetric calibration, physical interpretation of the digital numbers (DN) provided by the camera, atmospheric correction of the imagery, etc.

From the very beginning of DMC operation, ICC has been concerned about these challenges. In order to overcome the difficulties associated to the new DMC radiometric algorithms it was decided to support the some field experiments that included the acquisition of radiometric and atmospheric ancillary data simultaneously with DMC flights.

The first field experience was performed on June, 2005 with the simultaneous acquisition of DMC and Compact Airborne Spectral Imager (CASI) images from an ICC aircraft. At the same time, ground reflectance measurements in the VISNIR spectral range were performed. Artificial radiometric targets were deployed and measured on the acquisition day in the test field.

Next experience was on July, 2008 in the frame of the EuroSDR project entitled “Radiometric Aspects of Digital Photogrammetric Images”. As in the previous experience, it included DMC and CASI airborne sensors and ground reflectance measurements. Moreover, an atmospheric LIDAR and a sun photometer were present in the test field and radiometric and resolution targets were deployed for the test.

Finally, the work makes a brief description of future field experiments with these and/or new airborne or satellite sensors. In this sense, present and future airborne sensors operated by ICC could be used to simultaneously acquire remote sensing data from ICC planes.

1. INTRODUCTION

In 2008 the European Spatial Data Research (EuroSDR) organisation started a new collaborative applied research project focused on Radiometric Performance of Digital Cameras.

The Institut Cartogràfic de Catalunya (ICC) leads this project in collaboration with other cartographic institutions, universities and research centres in Europe. In order to share experiences with different institutions working in common and well known data sets, different flight campaigns have been designed in several European areas. ICC contribution has been the Banyoles 2008 campaign. The flight campaign has been complemented with measurements of different complementary sensors obtaining atmospheric data and field radiometry.

All these images and complementary information are part of a complete dataset distributed to the institutions participating in the EuroSDR activities.

The planned contributions of ICC to these activities are:

i) Radiometric calibration of a Digital Metric Camera (DMC).

ii) Atmospheric correction of Compact Airborne Spectral Imager (CASI) and DMC imagery by using aerosol and water vapour contents, derived by an inversion method and subsequent validation with radiometric targets and in-field atmospheric measurements.

iii) Colorimetric calibration of sensor towards International Commission on Illumination (Commission Internationale de l’Eclairage, CIE) standard colour space and validation with radiometric targets.

iv) Resolution studies by means of Siemens stars and edge targets. Study of the relationship between atmosphere state and resolution and comparison with radiative transfer simulations.

This communication will start describing the two campaigns coordinated by ICC and the questions to be answered in relation to the photogrammetric cameras’ radiometry. Finally we will present some open questions to be solved and the design of a future campaign to try to answer them.

2. THE FIRST CAMPAIGN

In 2004 the ICC decided to make a commitment to a totally digital mapping workflow. Once the selection phase for a digital camera had been completed, a ZEISS/INTERGRAPH (Z/I) DMC was delivered to the ICC. This camera has a four-band multispectral frame sensor complementary to the better resolution panchromatic four frames sensor.

ICC has a long experience applying classification techniques to satellite and airborne multispectral remote sensing imagery to derive land cover maps so the first question was: Can we apply these very same techniques to get a land-use map using DMC images? If the area to be analysed were significant, the answer would be negative. Digital values for the same pixel on frames of parallel tracks could have different illumination conditions and the automatic camera aperture and time integration could be different. Even in the same track the automatic camera operation could modify the camera setting providing different digital values. Even in the same picture a similar cover in different locations could have totally different digital values due to camera vignetting effect, sun position and acquisition geometry (Figure 2.1).

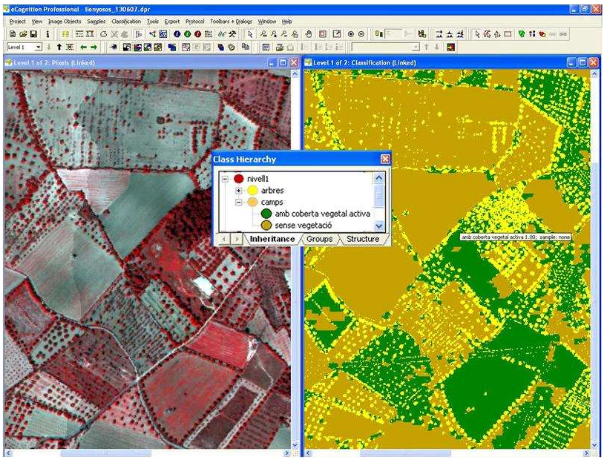


Figure 2.1. Classification of an agricultural area with DMC multispectral imagery and eCognition software

The main difficulty was the lack of a camera radiometric calibration because this is the first step in the process to get pixel reflectance. Again, this radiometric calibration would be necessary if we liked to get the most “natural” colours from the original red, green and blue original bands (Martinez et al. 2007).

With all this questions in mind a test campaign was defined. The main idea was to use the airborne hyperspectral sensor CASI flying together with a DMC camera to get simultaneous radiance values and establish gain and offset parameters for each of the camera apertures (Martinez and Arbiol 2008).

After the solution of the calibration parameters next step should be to correct the atmospheric effects on the images (Martinez et al. 2006) in order to smooth the contribution of the sun illumination and the atmosphere.

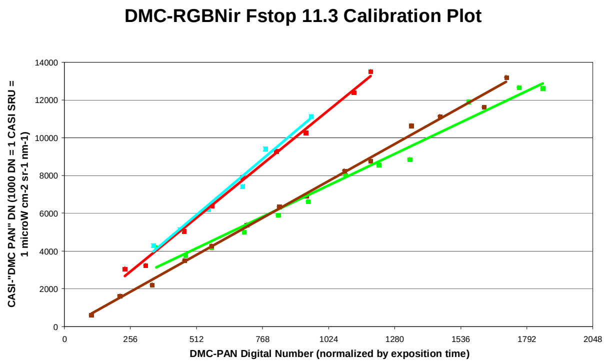
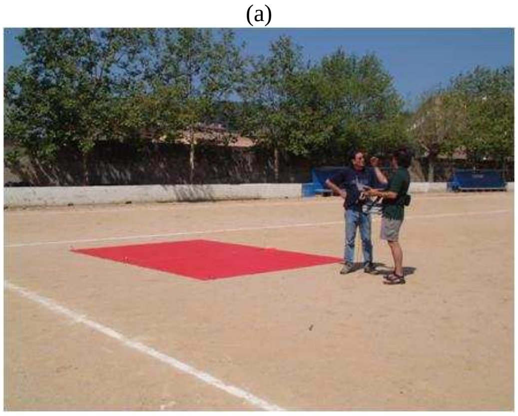


Figure 2.2. Banyoles 2005 DMC radiometric cross calibration with CASI for Fstop 11.3

The right tools to do this correction are the radiative transfer models (Vermonte et al. 1997) but some knowledge about the atmosphere moisture content and the concentration of different kinds of aerosols had to be obtained to get good results. Could we get a good estimation of those parameters from the same images? In order to answer this question some measurements with a handheld radiometer were done on the ground (Figure 2.3).

(a)



(b)

Figure 2.3. Field radiometry acquisitions during Banyoles 2005 campaign. (a) SpectralonTM reflectance reference target (b) Red canvas deployed on the test field

The campaign was carried out in Banyoles (Figure 2.4). Six tracks were flown in different directions and at different altitudes obtaining simultaneous measurements with the DMC and the CASI systems.

Figure 2.4. ICC Banyoles (Spain) ICC test field with man-made canvases deployed (June 2005).

3. BANYOLES 2008

The adjustment of the DMC radiometric calibration parameters was the main objective of the previous campaign and results obtained were indeed satisfactory enough but the secondary objective concerning the determination of atmospheric parameters to compensate that effect on DMC images was disappointing. Without real measurements the obtained values were could not be applied. Even worse, the hypothesis that the CASI could be used as a calibration system was far from reality due to a poor knowledge on the detailed response of the hyperspectral sensor. The "smile" effect and the different bandwidth depending on wavelength demonstrated to be crucial to use the CASI images (Figure 3.2 and Figure 3.3).

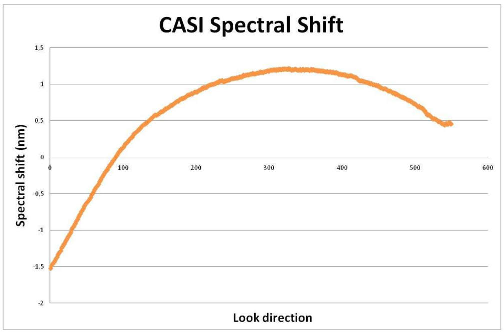


Figure 3.1. Spectral characterization of the CASI sensor. Smiling effect.

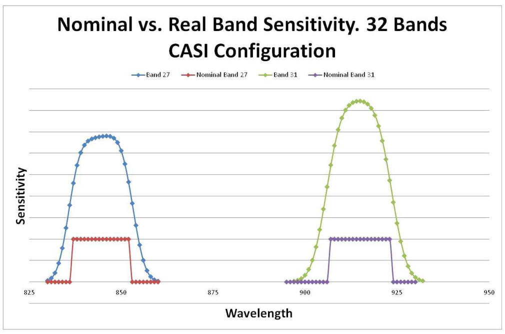


Figure 3.1. Spectral characterization of the CASI sensor. Spectral sensitivity and real bandwith

These two concerns and some doubts about the stability of the handheld radiometer measurements led to plan a new radiometric campaign with some complementary instrumentation. On-flight instruments were the same but the CASI included the ILS device to measure the incidence light at the flight altitude. On the ground, two different handheld radiometers were used concurrently and a full set of instruments to measure different atmospheric parameters (Figure 3.3): atmospheric Lidar, sun photometer, GPS station, meteorological station, etc.

(a) (b) (c)

Figure 3.3. Atmospheric measurements on the test field for Banyoles 2008 campaign. (a) UB Sunphotometer (b) UPC atmospheric Lidar (c) ICC GPS temporal reference station

A new question concerning radiometry arose after the comparison of many different flights performed with the same camera in different conditions: Is there a methodology to predict the picture quality of a photogrammetric flight if we can get some information on atmospheric conditions?

The campaign was done in Banyoles (Figure 3.4). The 12 tracks were flown in different directions and at different altitudes obtaining simultaneous measurements of the DMC and the CASI systems.

Figure 3.4. ICC Banyoles (Spain) ICC test field with man-made canvases and Siemens stars deployed (July 2008)

4. SOME PENDING QUESTIONS

After the application of the radiometric calibration to DMC images and the use of a radiative transfer model to correct the radiances using the atmospheric parameters derived from the ground instruments and the adjustment on the images we can get finally a knowledge on image pixel reflectance values. But there are a few differences left on the values obtained on different images looking at the same pixel. Directional effects appear and must be considered in order to properly characterize the land cover.

During the former 2009 Photogrammetric Week, Z/I presented (Ryan and Pagnutti 2009) a communication suggesting the possibility to calibrate DMC cameras. But some questions arise:

How stable is this calibration? Some multispectral airborne sensors need an annual calibration because some change along time on radiometric parameters is observed.

5. CONCLUSIONS

Photogrammetry and Remote Sensing started dealing with topics almost totally different but these last years we could describe a convergence process sharing objectives and looking for common methodologies.

Many questions concerning radiometry of digital aerial cameras are still open but these test campaigns can contribute to improve our knowledge on those issues in order to build some operational solution.

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