

Operational tools in forestry using remote sensing techniques.

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SECTION 1

BIOMASS

RADIOMETRIC CALIBRATION OF IMAGES FROM DIGITAL PHOTOGRAMMETRIC CAMERAS TO ESTIMATE BIOMASS

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ABSTRACT

Estimating and modelling biomass can be helpful for biomass management. It is also interesting to calculate the amount of biomass in a certain area for carbon implications, as indicated by the Kyoto protocol. In the past, remote sensing techniques have been able to estimate biomass by using reflectance in the both the red and the near infrared wavelengths (Rouse et al., 1974 (in: Jensen, 2005); Cho et al., 2007). Nowadays the sensors in the digital photogrammetric cameras gather information not only in the visible wavelengths but also in the near infrared wavelengths, which provides the possibility of using digital photogrammetric data for environmental studies. Nevertheless, there are several weaknesses in current processes that are slowing down the use of radiometric information provided by these sensors. The optimal use of the technological progress requires the calibration and validation of the photogrammetric systems (Honkavaara, 2004). In this context, calibration is the process of defining quantitatively the response of a sensor to a controlled and known input signal (Cramer, 2007).

Flight conditions (i.e. atmospheric conditions, exposure characteristics, solar elevation), and sensor characteristics, as well as post-processing effects (calibration based on radiometric corrections) have an effect on image radiometry (Markelin et al., 2008). As a result, the same object generates different digital numbers depending on its location (in the same image and in different images). Therefore, to use this information in a quantitative approach it is necessary to perform a relative and/or absolute radiometric registration. Moreover, the optimal radiometric processing procedure depends on the final application and the technique selected to extract the information: (i) classic remote sensing (using normalized data from the image) or (ii) methods using the characteristics of the anisotropic reflectance of the objects (bidirectional reflectance distribution function) (Honkavaara and Markelin, 2007). Any application related to extracting thematic information requires rigorous processing methods, which are well developed for satellite imagery and airborne sensors, but which are still in development for photogrammetric sensors. The previous issues indicate the need of developing a protocol to process the information in order to be able to use the photogrammetric data to extract thematic data by remote sensing techniques.

A comprehensive review of radiometric aspects of digital photogrammetric images and calibration experiences can be read in Honkavaara et al. (2009).

The National Plan of Aerial Orthophotography (PNOA) updates the photogrammetric information (e.g. orthophotographs) in Spain every two years, but so far none of the

data derived from the photogrammetric flights is used to extract thematic or biophysical information. Therefore it would be interesting to explore the possibility of establishing a relationship between the biomass and the radiometric information captured by the digital photogrammetric cameras, as an added value to the PNOA deliverables. The aim of this research is determining the suitability of the Ultracam Xp and Ultracam Xp for biomass estimation in grasslands.

There are two different study areas in this research. Field A is located in a grassland area in Barakaldo (Bizcaia, Spain). Field B is located in a grassland area in Cogollos (Burgos, Spain). The aerial photograph of Field A was captured by a digital photogrammetric camera Ultracam X with a Ground Sampling Distance (GSD) of 7 cm, while Field B was flown as part of the PNOA with a digital photogrammetric camera Ultracam Xp and a GSD of 25 cm. The images were calibrated to at-surface reflectance using ten portable reflectance targets with nominal reflectance values of 0%, 25%, 50%, 75% and 100%. An empirical line calibration was performed using the reflectance values for the targets and the corresponding Digital Numbers (DNs) in the images. Twenty 1 m x 1 m sample plots were placed in each study area to validate the biomass estimations obtained from the imagery (Figure 1).

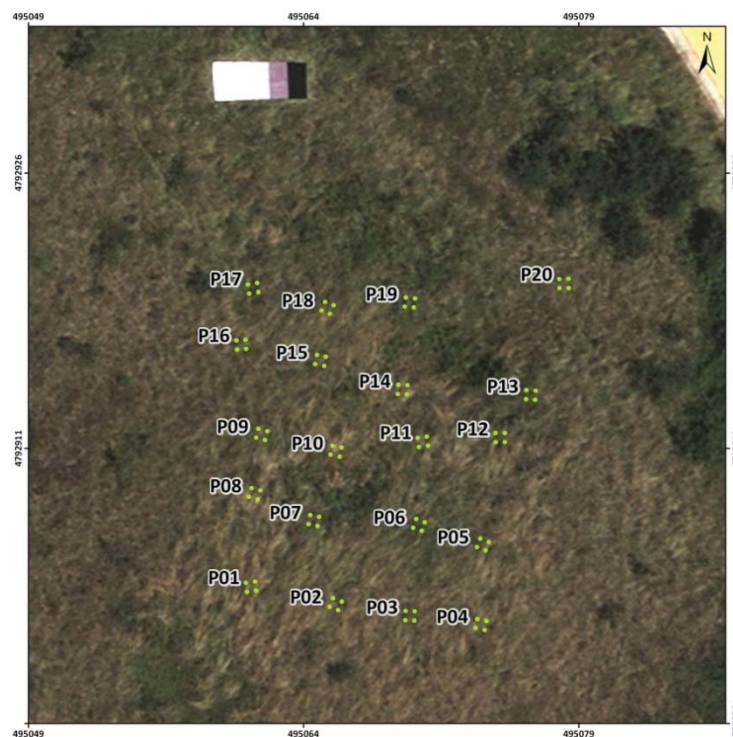


Figure 1. Location of the biomass plots (Pi), sub-plots (in green) and the reflectance targets in the data set A (Barakaldo). Coordinate reference system: ED50 UTM Zone 30.

Each 1 m x 1 m plot was located on a 2 m x 2 m homogeneous area covered by species of the *Gramineae* family. Each plot was then divided into 4 sub-plots (0.50 x 0.50 m). All of the biomass in each sub-plot was harvested and weighed in the field using a portable scale. 10% of the biomass of each NW subplot was stored and kept as a representative sample to determine the plot biomass in the laboratory. The sample was weighed in the laboratory using a precision scale before drying it in an oven. The sample was weighed again using the precision scale after the sample was dried in the oven for 24, 36, and 48

hours at 65°C, in order to obtain the dried biomass weight at 24 h, 36 h and 48 h. The dried biomass weight was used as surrogate for the aboveground dry biomass in each plot. The data analyses were conducted to study the relationships between the radiometric data gathered by the aerial camera and the biomass estimation. The data was then analyzed by study area and the results of the study areas were compared, in order to study the influence of GSD.

The results showed that it was possible to establish a relationship between the radiometric data gathered by the Ultracam and the dried biomass weight in a grassland area. The vegetation indices NDVI and Simple Ratio (SR) were the best predictors for biomass in a grassland area ($r^2=0.63$ and $r^2=0.66$, respectively, at a significance level of 5%). The quality of the calibration, as well as the GSD of the image has an impact on the estimation of the dried biomass. It has been shown that three consecutive images gathered with the same camera, during the same flight, and under very similar conditions (data set A) had significant differences in the DNs for the same targets. This means that each image would need a different equation to be radiometrically corrected. In addition, using level 2 imagery instead of level 3 imagery is recommended, so that the original DNs are kept.

Keywords: airborne sensors, near-infrared, thematic, Carbon, forestry, National Plan of Aerial Orthophotography (PNOA).

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