STUDY AND IMPROVEMENT OF IMAGE RADIOMETRY FROM ANALOGUE AIRBORNE CAMPAIGNS COMBINING LOCAL ADAPTATIVE FILTERING AND PRINCIPAL COMPONENTS ANALYSIS

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KEY WORDS: Analogue Photography, Airborne Imagery, Orthophotomosaic, Radiometry, Colorimetry, Hotspot Correction, PCA, KLT, Wallis Adaptative Filter, Moran's I, Spatial Auto-Correlation, Fourier Analysis.

1. INTRODUCTION

This work focuses on systematic radiometric inhomogeneities in airborne imagery, mostly due to hotspot and camera vignetting, which cause unaesthetic patterns on orthophotomosaic. When corrections based on physical models cannot be implemented, due to lack of additional information, Wallis filtering is used instead. Yet this correction deteriorates the contrast at the small scales. Our work consist at first on studying the impact of the filter size using Principal Component Analysis (PCA) and Fourier Analysis. A second step shows how a judicious combination of Wallis filtering and PCA could improve colour corrections resulting in a more homogeneous and readable orthophotomosaic, regardless of its considered scales.

2. METHOD

The considered data is a set of 143 orthoimages (i.e. projected in a map geometry) scanned from an analogue airborne campaign. Without further information about the weather or the Sun position, physical corrections are not relevant (Chandelier and Martinoty, 2009). In this case, a generic solution would be the use an adaptative filter, also called Wallis filter (Wallis, 1976), that locally change the mean and the standard-deviation (or in other terms, brightness and contrast) on a square sliding window. The size of the window has an influence on the image low frequencies, by removing them and, consequently, removing the contrast at smaller scales (which is an unwanted artefact) but also removing the systematic homogeneities (i.e. hotspot correction). In other words, a large window would somehow preserve the image contrast at small scales yet not remove the hotspot whereas a small window would correct the hotspot yet damage the contrast at small scales (Time Machine, 2019). This observation leads to the following question: which is the larger window size that still removes the hotspot? To answer this, a PCA has been performed over the 143 orthoimages of the campaign for different size of Wallis filter. In practice, the images have been first reduced (hotspot and vignetting are low frequency phenomenons, mostly present on small scales), given the same size (PCA need vectors of the same size as inputs) and their values extrapolated in their masked part (to avoid influence of the mask in the PCA) as shown in Figure 2. The filter size are defined as a percentage of the image size.

The spatial auto-correlation of the PCA coefficients provided by Moran's I (Moran, 1950) shows that, without filtering, the 3 first axis of the PCA have significant Moran's I (> 0.3), which means they likely carry some kind of common signal within all the images. After filtering the set of images with different window size and projecting them in the space defined by their PCA, Moran's I are computed on the images coefficients (in the PCA space). The results displayed on Figure 3 shows that the window size should not exceed 20% of the image.

Now that the largest Wallis filter is set, an issue still remain: the low frequencies removal is still too significant when displaying the resulting orthophotomosaic at small scales. This artefact come from the way the filter has been defined: for each image and for a given window size, a mean map and a standard-deviation map are computed and used to locally normalize the image before multiplying it by its new standard-deviation (e.g. 64) and its new mean (e.g. 128). A judicious approaches would consist into choosing the mean and standard-deviation maps independently from the specific patterns of the images (like forests, crops, urban area, etc.) but only related to systematic signal (typically, vignetting and hotspot). To consider only the systematic signal, a PCA is computed on local mean and standard-deviation maps and the correction (normalisation) only limited to the first PCA axis (here the 3 first ones). The desired mean and standard-deviation will be chosen as the global mean and the global standard-deviation of the image (and not 128 and 64 as before) in order to keep the appearance (and more specifically the colorimetry) of the image close the original one. Some inhomogeneities between each images are still remaining (due to exposure time, high altitude clouds, analogue film development, etc.). To reduce them, each ortho-image histogram is corrected to match the histogram of the corresponding zone in the orthophotomosaic and then iterated. Histogram matching is preferred here because of the non linear radiometric response of analogue imagery (Litvinov and Schechner, 2005). The final orthophotomosaic is corrected from the hotspot and sees its low frequencies preserved as shown in Figure 5.

3. DISCUSSIONS

Even if the current work mostly focuses on radiometric correction of orthoimages with the aim of displaying aesthetic orthophotomosaics, some further experiments are scheduled: as applying the same process directly on raw images in their initial camera geometry (interior orientation) or trying to determine the centre of the hotspot in order to estimate the position of the Sun in the sky. To sum up, this work could be considered as the first steps of future studies on the radiometry of analogue images provided by historical campaign and archived since the late nineteenth century.

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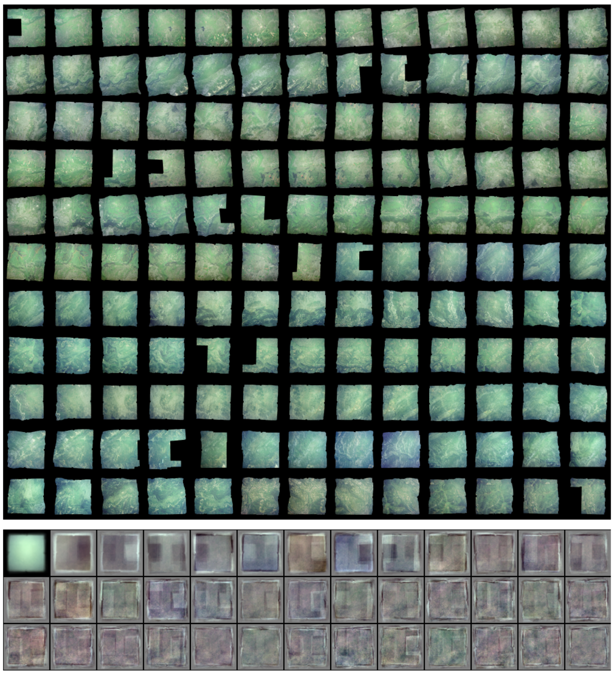

Figure 1. (up) Original ortho-images - (down) PCA first axes

Figure 2. (up) Extrapolated images - (down) PCA first axes

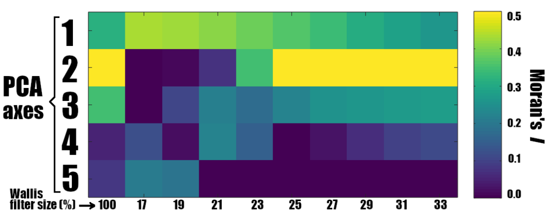

Figure 3. Spatial auto-correlation of the PCA coefficients for different sizes of Wallis filter

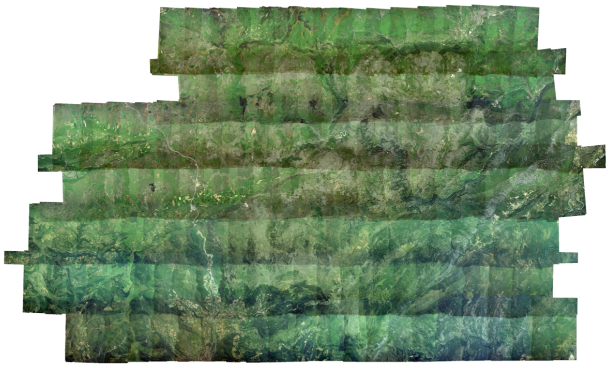

Figure 4. Orthophotomosaic without correction

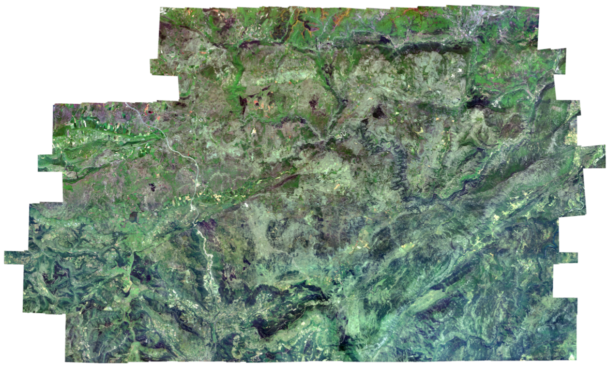

Figure 5. Orthophotomosaic after correction

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