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Color Head-to-Head Image Registration using Correlation and Mutual Information

Duration of the thesis: 6 months

Completion: July 2013

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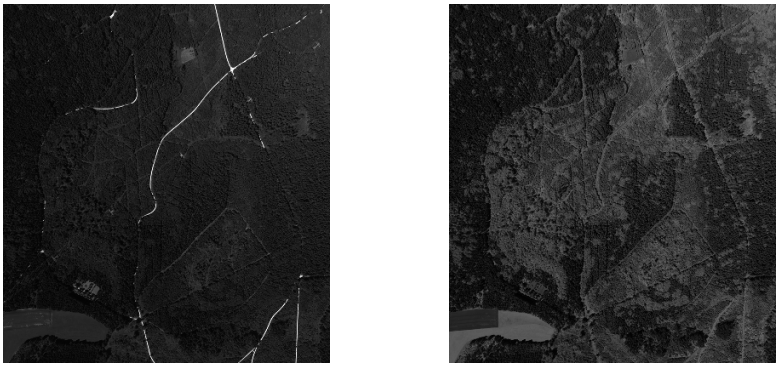
Modern large-format digital cameras include five nadir-looking camera heads. One single cone for the panchromatic high-resolution sensor and four cones for sensoring every single one of the four multispectral wave bands blue, green, red and near-to-infrared (NIR). As all of the four multispectral sensors do have an offset relating to the panchromatic sensor, a common coordinate space in which the following pansharpening process and an accurate post-processing of the aerial data acquisition can be carried out, has to be determined. This coordinate space has to be derived from a transformation process between all multispectral channels in each case. These transformation processes require a set of identical points as much as possible. In order to gain these identical points several matching approaches are introduced in the whole transformation process.



(a) (b)

Figure 1: Green Image (a) and NIR-Image (b)

A common technique is the usage of similarity measurements based on correlation. Therefore, the thesis gives a view in the fundamentals of correlation matching which takes statistical information into account. Thereby, the maximum of correlation coefficients basing on similarities in gray-value structures is searched for in image sections.

Though, this goes along with some problems relating to matching processes with the NIR-channel, as this one offers a lot of differences concerning the intensity especially in regions with much vegetation. For example, in the images above in figure 1, it seems to be clear that the green image (a) and the NIR image (b) offer totally different characteristics. This difficulty often leads to missed assignments in the registration process between both images. Therefore, the potential of an approach based on concepts derived from information theory was analyzed and compared to the correlation method in this thesis as this can make a statement in case of common information between different images. More precisely this approach is about the concept of a registration

process using mutual information between two images. Mainly, this idea was introduced in medical engineering; meanwhile it features a common technique in three dimensional dense matching processes. Hence, it was tested, if this concept has a potential in two dimensional matching processes of co-registrated images.

Essentially, this approach bases on determination of pixelwise costs between image sections of potential matching points. Therefore, similar to the correlation method, small image sections from the second image were dropped over a corresponding search section of the first image. Based on the idea of minimization of global energy of two dimensional disparities in both image sections, the potential corresponding matching point in the second image involves the point with the least sum of matching costs. This cost aggregation is determined with the help of mutual information and thereby the entropy. Both concepts are predicted on probability distributions of two variables in a random process. In this case, these are both individual and the common gray-value histograms of both image sections.

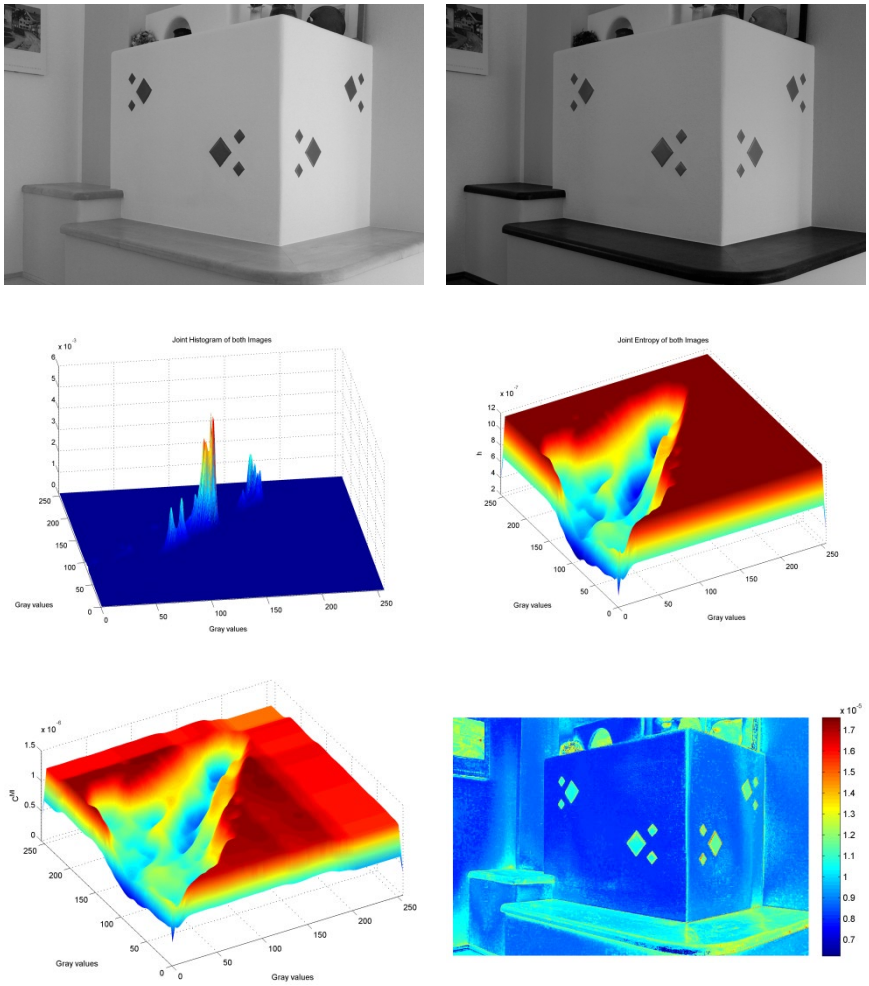


Figure 2: Joint Histogram, Joint Entropy and Matching Costs of co-registrated Images

Basically, both matching techniques do not gain subpixel accuracy. Thus it is crucial to implement interpolation methods which guarantee a sufficient, reliable result. In this case different methods basing on estimations of global respectively local extremum were tested. Eventually, both matching algorithms use a global search of minimum in case of mutual information and maximum in correlation.

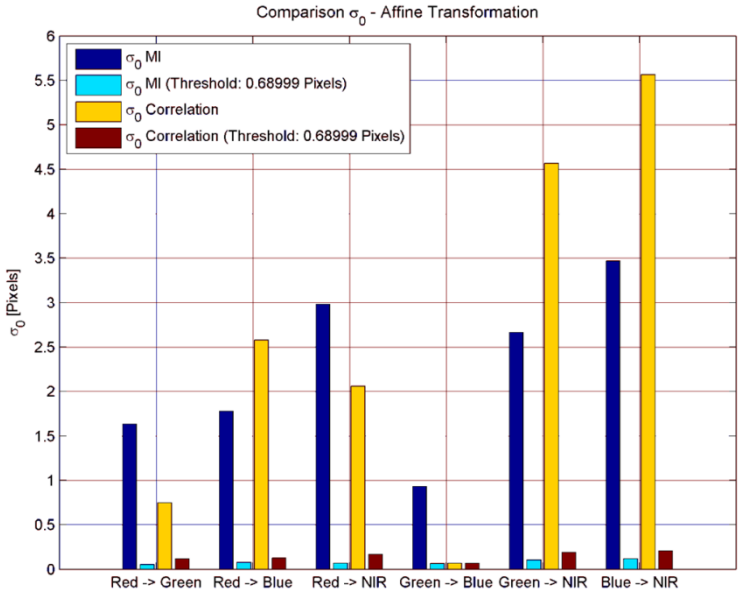


Figure 3: Accuracy Comparison of Affine Transformation

The comparison of results of both techniques was carried out in several regions which feature explicit differences in surface structures like cultivation, vegetation and soil textures. Thus, on the one hand it was analyzed in urban areas, as an example for heterogeneous surfaces. On the other hand, the algorithms were delivered in homogeneous areas like deserts and water surfaces; however, especially this case has to be regarded with suspicion. In order to show effects in the near-to-infrared channel concerning the intensities of vegetation, an aerial image of a forest area was analyzed.
Essentially, a matching algorithm based on mutual information shows a better potential then correlation. Indeed, the MI does not exhibit significantly better values in registration processes concerning the near-to-infrared channel. However, in well-structured regions the MI features improved accuracy results.
As it is noticeable in figure 4, even in forest areas, the mutual information maintains a considerable result as there are more points to eliminated by a statistical confidence region in case of correlation matching. Consequently, it is obvious that mutual information has potential in two dimensional registration processes.

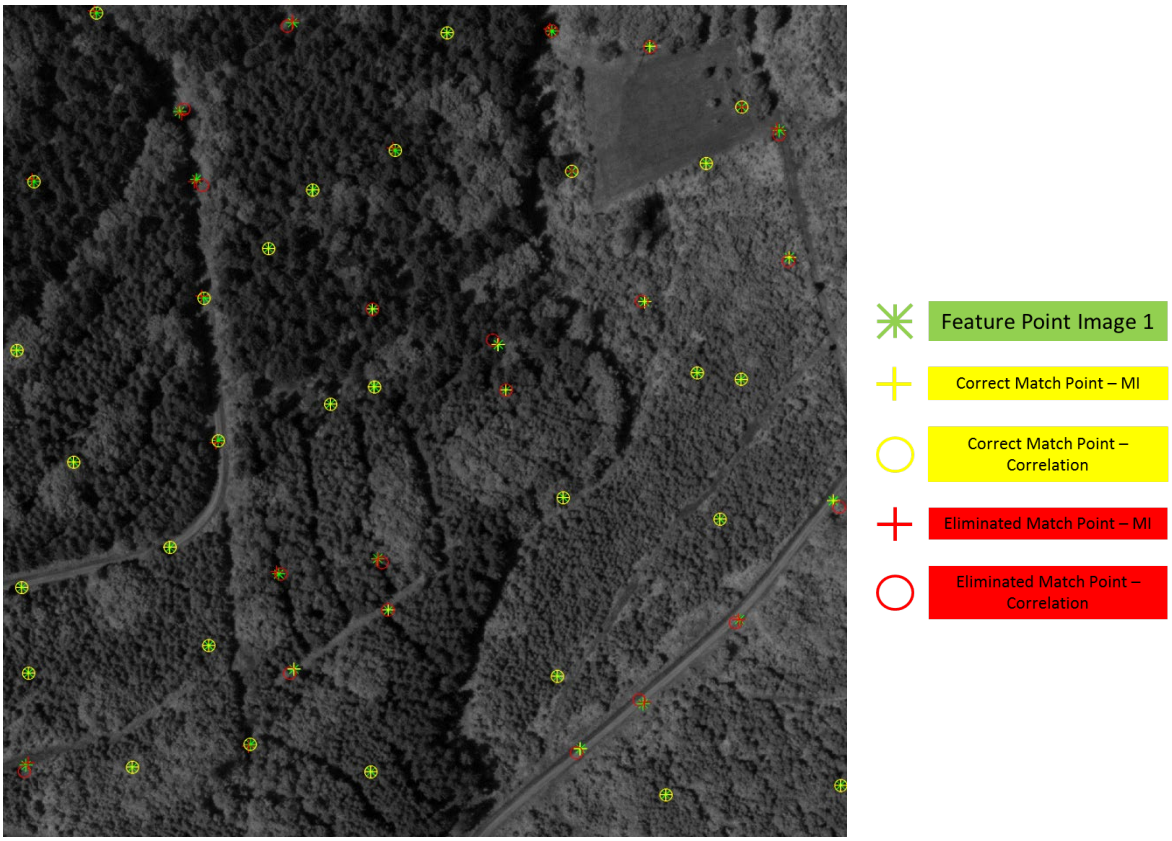


Figure 4: Matched Points in Forest Area (Green-NIR-Registration)