A simplified method for generation of pseudo natural colours from colour infrared aerial photos

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Abstract

In spite of their high potential for automated discrimination between vegetation and human made objects, colour-infrared (CIR) aerial photos have not been in widespread use for traditional photogrammetric mapping. This is probably due to their awkward colour representation invalidating the visual analytical experience of the stereo analysts doing the actual registration of the topographical data.

In this paper, we present a method for generating pseudo natural colour (PNC) representations from CIR photos. This enables the combination of automated vegetation discrimination with traditional manual mapping methods.

The method presented is a dramatic simplification of a recently published method, going from a 7 step to a 2 step procedure. The first step is a classification of the input image into 4 domains, based on simple thresholding of a vegetation index and a saturation measure for each pixel. In the second step the blue colour component is estimated using tailored models for each domain. Green and red colour components are taken directly fron the CIR photo.

The visual impression of the results from the 2 step method is only slightly inferior to the original 7 step method. The implementation, however, is much simpler, and the logical foundation more straightforward.

KEY WORDS: Pseudo natural colour, colour infrared, aerial photos, algorithm.

1 Introduction

In attempts to automate photogrammetric mapping, it is important to distinguish between areas covered by vegetation (which are typically void of mapping objects) and areas covered by man made materials (which are typically indicative of important mapping objects: buildings, roads, etc.)

Due to the high reflectivity of chlorophyll in near-infrared wavelengths, this distinction can be based on algorithms which use information from the near-infrared spectral band (e.g. by thresholding of the normalized difference vegetation index, NDVI or other equivalent indices). This robustness, in turn, may also result in a more complete detection of the mapping objects (Knudsen and Olsen, 2003, 2002; Petzold and Walter, 1999; Walter, 2000).

Hence, colour-infrared (CIR) aerial photos, which include a red (R), a green (G), and a near-infrared (N) channel have greater potential for automated mapping than traditional (RGB) colour photos with a R, G, and blue (B) channel. CIR photos do, however, look dramatically different from RGB photos, making them hard to interpret by a human analyst trained in RGB photo interpretation. This implies that an algorithm for computing an CIR based approximation to an RGB photo is of great potential value, bridging the gap between CIR based mapping-automation and traditional mapping in the years until the newer full four-channel (NRGB) digital airborne scanners (e.g. Leberl et al., 2003; Z/I Imaging, 2003) begin to dominate the photogrammetric market.

Since the CIR images contain R and G channels, in principle all we need in order to generate an RGB image is an estimate of the B channel. To achieve this, Knudsen (2003) published this empirical expression for synthetic B channel estimation:

$$B_s = 0.70 \times G + 0.24 \times R - 0.14 \times N$$

The derivation of the expression for B_s was based on a simple linear regression and was intended as the basis for a more complete procedure for computing pseudo natural colour (PNC) approximations from CIR photos. This procedure (Knudsen, 2005) took the form of 7 steps of gradually refined approximation, which in a slightly revised version may be reiterated as:

1. get colour-infrared photo
2. compute synthetic blue channel from the empirical expression B_s
3. Generate first guess pseudo true colour image from red, green and synthetic blue channels
4. Restore achromatic (black-grey-white) areas defined using the saturation value from the iHLS system (Hanbury, 2003). These areas (typically roads) are important landmarks for the visual navigation in an image.

5. Increase intensity of vegetation covered areas defined using the infrared percentage vegetation index, $IPVI = N/(R+N)$ (Crippen, 1990)

6. Restore reddish and yellow-reddish colours using the iHLS

7. Enhance colour saturation using the iHLS

while this step-by-step method in a very direct way outlines the major differences between RGB and CIR recordings, and pinpoints the requirements for manual mapping, we shall show below that an implementation-wise much simpler way of obtaining almost identical results is possible.

2 Method

Closer inspection of the algorithm outlined above shows that most of the efforts are based on representation of three different main components of urban and suburban surfaces:

1. vegetation
2. achromatic features
3. red-tile buildings

We can outline the two first of these (and an approximation to the third) by using thresholding of IPVI and the saturation (S) component from the iHLS transformation of the CIR image:

1. if $IPVI > T_I$ and $S < T_S$ assume sparse vegetation
2. if $IPVI > T_I$ and $S > T_S$ assume dense vegetation
3. if $IPVI < T_I$ and $S < T_S$ assume achromatic features
4. if $IPVI < T_I$ and $S > T_S$ assume red-tile buildings

in this way, we have subdivided the space spanned by $(IPVI, S)$ into four domains defined by two thresholds T_I and T_S. Two of these domains represent different degrees of vegetation, one represents achromatic features, while the last represents everything else. The latter may be a quite poor approximation to the class label *red-tile buildings* assigned above. We will, however, demonstrate below that it is a quite good approximation to a group of pixels that can be treated in the same way as red tile buildings, colour-wise.

The threshold based classification outlined above results in a set of four masks; one for each class label. To reduce clutter, the masks are cleaned up using morphological filtering (cf. e.g. Haralick et al., 1987). The vegetation/achromatic classes, which are typically large-area features, are filtered by morphological opening followed by closing. The *everything else* class, which is typically more sparse, is filtered in the reverse order.

Due to the higher probability of correctly classifying dense than sparse vegetation, the reconstruction is carried out in the following order

1. sparse vegetation

2. achromatic features

3. everything else

4. dense vegetation

such that in case of ambiguities, where a pixel is assigned to more than one class (which can happen due to the morphological filtering), the pixel will eventually be reconstructed as a class with better overall skill factor than the sparse vegetation and achromatic classes.

For the RGB reconstruction of the vegetation classes, the B value is taken from the B_S model. The R and G values are taken from the CIR image, but amplified slightly to increase the contrast between a vegetation background and a *mapping object* (e.g. a building) in the foreground.

For the RGB reconstruction of the achromatic class, R, G, and B channels are assigned the value of the lightness (L) channel from the iHLS transformation. This eliminates any remaining traces of colour information in the achromatic pixels.

For the RGB reconstruction of the *everything else* class, the B value is taken from the B_S model, while the R and G values are taken from the CIR image.

3 Results and discussion

The results presented in figure 1 are based on a RGB reconstruction with $T_I = 0.5$ and $T_S = 0.1$. It is seen that the reconstruction of vegetated and achromatic areas are comparable for the old and the new algorithm. In the case of red tile roofs, the situation is a little more complex: in the case of well saturated colour areas, the old algorithm, with its colour saturation enhancement step, fares slightly better with respect to ensuring a clear delineation between building and background. In the case of low saturation, the results are more ambibguous: for the test area in the left column, the old algorithm catches more of the low saturation roofs than the new algorithm does—for the test area in the right column it is the other way round. For much practical work, the observed differences are not important.

4 Conclusion

We have presented an update and simplification of a pseudo natural colour algorithm. The old algorithm offers slihtly better results—especially in the case of low colour saturation and red tile roofs. The new algorithm offers a major implementation simplification and a more firm logical foundation.

Figure 1: Top row: original CIR photos; center row: pseudo natural colours from old algorithm lower row: pseudo natural colours from new algorithm.

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