TRUE COLOUR VISUALIZATION OF COLOUR INFRARED AERIAL PHOTOGRAPHS

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ABSTRACT:

A practicable solution to escape the dilemma of using colour-infrared (CIR) photographs for interpretation purposes and the obligation to use true-colour (TC) photographs for the visualization is described. Colour-infrared photographs are scanned and transformed - due to the impossibility of an exact solution of this problem - to „pseudo true colour (PTC)"-images with methods of digital image processing. For each object class the transformation parameters between the colour-infrared-space (infrared-red-green) and the (pseudo) true-colour-space (red-green-blue) are computed. By means of TC and CIR-orthoimages („spectral and radiometric control points") that contain the same terrain surface and methods of least squares adjustment the reshapement components are estimated. Theoretically the determination of transformation parameters has to take all colour bands of the CIR and TC-images into consideration. This can be simplified, however, because of the high correlation of some colour bands: Practice shows that either the green channel (red colour band) resp. the blue channel (green colour band) of the CIR-input image is nearly identical with the red channel (red colour band) resp. the green channel (green colour band) of the TC-output image. So those two channels can be directly used as the respective colour channel in the (P)TC-output image and the computation of transformation parameters is reduced only to the blue channel (blue colour band) of the (P)TC-output image.

The definition of object classes represented on the aerial photographs is done in two different steps: The objects used for the estimation of transformation parameters are classified visually on the reference orthoimages by an experienced interpreter. Afterwards these areas are used as training sets for a computer assisted image classification to obtain the object class information necessary for the true colour visualization. The classification process must be repeated for all CIR-images of the project.

The investigation of quality of the PTC-images that have been computed with different methods and thus of the chosen method for the computation of PTC-images using the colour information of CIR-images is possible only up to a point. The outlined results are examined subjectively by the visual impression and quantitatively with statistical values.

KURZFASSUNG:

Eine mögliche Lösung des Dilemmas zwischen der Notwendigkeit der Verwendung von Farb-Infrarot-Bildmaterial für Interpretationsaufgaben und dem Zwang der Verwendung von Echt-Farb-Bildern für die Visualisierung wird beschrieben. Digitalisierte Farb-Infrarot-Luftbilder werden unter Zuhilfenahme von Methoden der digitalen Bildverarbeitung - aufgrund der nicht strengen Lösbarkeit dieses Problems - in „Pseudo-Echtfarb(PTC)-Bilder", umgerechnet. Die Transformationsparameter zwischen dem Farb-Infrarot-Raum (Infrarot-Rot-Grün) und dem Echtfarb-Raum (Rot-Grün-Blau) werden dabei objektklassenspezifisch berechnet. Die Bestimmung der Umbildungsparameter erfolgt mit Methoden der Ausgleichungsrechnung anhand von Echtfarb- und Farbinfrarot-Orthophotoausschnitten derselben Geländeoberfläche („spektrale und radiometrische Paßpunkte"). Theoretisch muß die Bestimmung der Transformationsparameter zwischen den beiden Farbräumen alle Spektralbänder berücksichtigen. Aufgrund der hohen Korrelation zwischen dem grünen bzw. dem blauen Farbauszug des Farb-Infrarot-Bildes und dem roten bzw. dem grünen Farbauszug des Echtfarb-Bildes - beide Farbauszüge entsprechen dem roten bzw. dem grünen Spektralbereich in der Natur - können als weitere Vereinfachung die korrespondierenden Farbauszüge direkt übernommen werden, sodaß die Umbildungsparameter nur noch für den dritten Farbauszug des Pseudo-Echtfarbbildes bestimmt werden müssen.

Die Abgrenzung der auf den Luftbildern abgebildeten Objektklassen geschieht in zwei Stufen: Die für die Berechung der Transformationselemente herangezogenen Objekte der Referenzbilder werden visuell durch einen erfahrenden Interpreten ausgewiesen. Anschließend werden diese Flächen als Trainingsgebiete für eine automatische Bildklassifikation herangezogen, um die für die Echtfarbvisualisierung notwendige Objektklassenbildung auf allen anderen Farbinfrarotbilder des gesamten Flugoperates zu erhalten.

Die Beurteilung der Qualität der unterschiedlich erzeugten „Pseudo-Echtfarb-Bilder" und somit eine Beurteilung der jeweiligen Methodik der Berechnung von Echtfarb-Bildern aus Farbinfrarotbildern ist nur bedingt möglich. Die vorliegenden Untersuchungen wurden zum einen aufgrund des persönlichen visuellen Eindrucks und zum anderen quantitativ durch die Ausweisung von statistischen Kenngrößen beurteilt.

1. INTRODUCTION

Colour Infrared (CIR) aerial photographs are widely used in many kinds of rural operations and planning. The high reflectance of vegetation in the infrared band as well as the great distinctiveness between different plants and conditions of vitality make it an indispensable means for most applications especially in those areas where interpretation is needed.

Large scale orthophotos - especially digital orthophotos - are of increasing importance as a base of maps: The fast production, the many details visible, the high grade of actuality, etc., are just some advantages over traditional maps. These benefits, combined with the nowadays available huge amount of computing power and storage capacity, will certainly show a triumphant march of the digital orthophoto in most large scale applications in the future.

The problem now arises that the non-specialist often feels confused and irritated by the false colour infrared images. People, like politicans, officials, citizens, want to see the vegetation in realistic colours rather than in bright red. One solution could be to have two photo flights (or one photo flight with two cameras aboard): One to take photographs with infrared film material in order to produce orthophotos for interpretation purposes; the other one to take photographs of the terrain on true colour based film material in order to produce orthophotos for the final visualization and presentation - a way which is normally not possible because of the high costs.

Therefore the only practical solution of this dilemma is to take photographs with that film material that has better spectral and radiometric characteristics for the interpretation of vegetation - this is the colour infrared film material - and to redisign it to a true colour photo.

2. THEORETICAL ASPECTS

The information transfer from objects to remote sensing sensor systems is done by electromagnetic radiation. Photographic systems record the object reflected sun radiation onto the emulsion of a photo. The photographically produced picture describes on the one hand the geometric characteristic of an object, on the other hand there is also a pysical description of the object in form of the colour of the object. The colour on a photo is the result of intensity and spectral compounds of the reflected sun radiation.

Using colour-infrared-film the visible and near infrared part (400nm - 900nm) of the electromagnetic spectrum is used for the information transfer. In case of a true-colour photo the emulsion of the film is sensitized only for the visible part of the spectrum (400nm - 700nm). As the spectrum of true colour photograph is a matching part of the spectrum of colour-infrared photograph it seems to be realistic to find a direct relationship between the colours of objects recorded to both of the different film types. However this is only on the first sight: By a detailled consideration of the problem a lot of colour desturbing influences - as shown below - can be found:

- *daily and seasonal change of the angle between sunposition and surface element:* due to this fact the intensity of the reflected sun radiation is reduced to $\sin\theta$ (θ: sun height) related to a vertical angle of incidence ($\theta = 90^\circ$).
- *Interaction mechanisms of sun radiation and reflected sun radiation with the atmosphere:* penetrating the atmosphere the sun radiation will be scattered, absorbed and reradiated by particels of clouds, haze, vapour, fog, smog etc. (irradiance of sunlight and skylight). Furthermore the reflected part of the sun radiation will be desturbed by similiar effects. The amount of these effects is correlated with the condition of the atmosphere. All effects concerning the interaction mechanisms of sun radiation and reflected sun radiation with the atmosphere are wavelength dependent.
- *cameraspecific distortion of radiation:* Within the objective of a photogrammetric camera the radiation decreases again: besides a position invariant reduction factor there is a component that depends on the field angle τ:

$$\Delta E_{rel.} = prop.\ \cos^{2.5}\tau \qquad (1)$$

(for modern photogrammetric cameras) and on the wavelength λ of the incoming radiation.

- *filter specific distortion of radiation:* Dependent from the type of filter used the intensity and/or the spectral structure of the incoming radiance. Colour infrared photographs usually are taken with a yellow filter to avoid the influence of skylight. So the effective electromagnetic spectrum that is recorded with colour-infrared film material lies between 500nm and 900nm.
- *film specific recording of radiation and photographic developing process:* Dependent on the intensity and the spectral structure of radiation, on the characteristic and spectral sensitivity curves of the film, and last but not least on the time during which the irradiance is incident on the emulsion surface, the three dye layers (cyan, magenta and yellow in the case of a subtractive photographic process) of the film - after the developing process - will be coloured in relation to the specific parts of the spectrum.
- *object specific reflectance of radiation:* Besides the above mentioned influences the main part of radiometric differences (colour and intensity) on the photograph is caused by the characteristic of reflectance of the specific object. The variation in reflectance is dependent on the geometry (form, structure of surface), and the chemical and physical characteristic of the objects. A complete and definite description of the reflectance characteristic of an object can be given by the reflectance function that characterizes the relation between the incoming radiation (L_e within a differential solid angle $d\Omega_e$ with the direction $\theta_e;\phi_e$) and the reflected radiation (dL_r with the direction $\theta_r;\phi_r$)

$$f(\Theta_e, \Phi_e; \Theta_r; \Phi_r) = \frac{dL_r(\Theta_e, \Phi_e; \Theta_r, \Phi_r)}{L_e(\Theta_e, \Phi_e) \cdot \cos\Theta_e \cdot d\Omega_e}\ [sr^{-1}] \qquad (2)$$

The reflectance function is dependent from the wavelength of the electromagnetic spectrum and must be defined as a spectral dimension. It can be determined only with an enormous measuring and computation efford.

By an integrated approach of interaction mechanisms between objects and matching colouration on the film emulsion following statesments can be made:

- To predict the colouration of an object or parts of an object on a photograph a lot of parameters (sun radiation, atmosphere, object characteristic, camera objective, camera filter, film emulsion etc.) must be considered, determined or measured.
- Due to the radiometric and spectral characteristics of the above mentioned parameters it is impossible to get a determined transformation between colours of an object on a photograph with a true colour (TC) emulsion and such one of a colour infrared (CIR) emulsion.
- The correlation of reflectance within similar objects classes (e.g. coniferious forests) is very high.
- Distributions of radiation intensities on TC and CIR photographs (e.g. difference between sunny and shadowed areas) are correlated to a high degree.

3. TRUE COLOUR VISUALIZATION

3.1 Field of tasks

Within a water management project in the district of Altheim (Upper Austria) a land-use classification was necessary in order to obtain draining and water management parameters. The classification for the whole area (approximately 300km^2) was done by statistical methods using colour-infrared aerial photographs (photo scale appr. 1:15.000). The positions of - in the ground coordinate system - regular sample plots were distorted for each photograph to the photo coordinate system by the parameters of the interior and exterior orientation, using a digital terrain model (Bartl et al., 1996).
For the visualization of results, such as the location of measured river profiles, potential areas for floods dependent on different disaster levels, orthophotos were produced. Due to the limited financial resources of this project the request of the customer to get true coloured orthophotos by making an own photo flight had to be cancelled and orthophotos were produced using the colour-infrared photo material. To solve the problem that the non photogrammetric or interpretation specialists feels often confused and irritated by the „false colours" of the CIR photographs true colour orthophotos were simulated by the algorithms described in this paper.

3.2 Production of orthoimages

The rectification of the aerial photographs to orthophotos were done by means of digital photogrammetry. First of all the aerial (CIR) photographs - photographed by the Austrian „Bundesamt für Eich- und Vermessungswesen" and by a private photo flight company (Fischer) - were scanned on the photogrammetric scanner ZEISS-INTERGRAPH PhotoScanner PS1 with a pixel resolution of 30µm. For saving disc space the image data were compressed using a JPEG algorithm.
The parameters of the exterior orientation were determined by means of aerotriangulation (measured on the analytical plotter ZEISS P3 and computed with the model adjustment software „PATM" of the Institute of Photogrammetry, University Stuttgart).
The rectification of the CIR aerial photographs was computed on the soft copy station INTERGRAPH ImageStation 6787 of the Institute of Surveying and Remote Sensing, University of Agriculture, Forestry and Renewable Natural Resources. The ground pixel size of the orthophotos was 0.5m $*$ 0.5m. Due to the modest (geometric) accuracy requirements of the orthophoto (only used for visualization purposes) the terrain information was derived from the Austrian-wide digital terrain model of the Bundesamt für Eich- und Vermessungswesen with a ground resolution of 50m.

3.3 Production of Pseudo True Colour orthophotos from Colour Infrared orthophotos

As described in *Chapter 2* there is no unequivocal solution to transform colour-infrared (CIR) pixel values to true-colour (TC) values. A best-fitting relation between CIR values and TC values can be approached. The TC-images simulated in this way are called „pseudo true colour" (PTC) images since the result naturally is not identical with a TC-image.

3.3.1 General mathematical approach: The three bands of a digital colour infrared image (red band corresponding with the natural infrared part of the electromagnetic spectrum, green band corresponding with the natural red part of the electromagnetic spectrum, blue band corresponding with the natural green part of the electromagnetic spectrum) desribe a three dimensional colour space (R_{CIR},G_{CIR}, B_{CIR}). The three bands of a digital true colour image (red band corresponding with the natural red part of the electromagnetic spectrum, a.s.o.) also describe a three dimensional colour space (R_{TC}, G_{TC}, B_{TC}). The relation between the CIR colour space and the TC colour space is approximated by the following linear transformation:

$$\begin{aligned} R_{TC} &= a_{10} + a_{11} \cdot R_{CIR} + a_{12} \cdot G_{CIR} + a_{13} \cdot B_{CIR} \\ G_{TC} &= a_{20} + a_{21} \cdot R_{CIR} + a_{22} \cdot G_{CIR} + a_{23} \cdot B_{CIR} \qquad (3) \\ B_{TC} &= a_{30} + a_{31} \cdot R_{CIR} + a_{32} \cdot G_{CIR} + a_{33} \cdot B_{CIR} \end{aligned}$$

3.3.2 Determination of transformation elements: To estimate the transformation elements described in *equation (3)* identical pixels („spectral and radiometric control points") in both colour spaces (CIR- and PTC-colour space) have to be found. For this purpose true colour photo material of a part of the project area is needed. This reference photo material can be obtained by true colour photos from archives or by taking photographs with amateur cameras along with the CIR-photo flight. To get (geometrically) identical pixels also the reference photo is rectified to an orthophoto with the same ground pixel size and geometry as the CIR orthophoto. Having a redundance of „spectral and radiometric control points“ the transformation elements are determined by the method of a least squares adjustment. Afterwards the PTC-orthoimages can be determined from all the CIR-orthoimages using the transformation elements computed in *equation (3)*:

$$\begin{aligned} R_{PTC} &= a_{10} + a_{11} \cdot R_{CIR} + a_{12} \cdot G_{CIR} + a_{13} \cdot B_{CIR} \\ G_{PTC} &= a_{20} + a_{21} \cdot R_{CIR} + a_{22} \cdot G_{CIR} + a_{23} \cdot B_{CIR} \\ B_{PTC} &= a_{30} + a_{31} \cdot R_{CIR} + a_{32} \cdot G_{CIR} + a_{33} \cdot B_{CIR} \end{aligned} \qquad (4)$$

3.3.3 Classwise determination of transformation elements: As described in *Chapter 2* there is a object specific reflectance of radiation. A second approach is the classwise determination of transformation elements:

$$\begin{aligned} R_{TC,\,cl} &= a_{10} + a_{11} \cdot R_{CIR,\,cl} + a_{12} \cdot G_{CIR,\,cl} + a_{13} \cdot B_{CIR,\,cl} \\ G_{TC,\,cl} &= a_{20} + a_{21} \cdot R_{CIR,\,cl} + a_{22} \cdot G_{CIR,\,cl} + a_{23} \cdot B_{CIR,\,cl} \\ B_{TC,\,cl} &= a_{30} + a_{31} \cdot R_{CIR,\,cl} + a_{32} \cdot G_{CIR,\,cl} + a_{33} \cdot B_{CIR,\,cl} \end{aligned} \qquad (5)$$

For the described project ten object classes were defined (water, needle forest, deciduous forest, traffic lines, roofs light, roofs dark, field with vegetation, meadow, fallow land, field with sparse vegetation). An experienced interpreter visually classified the different classes on the reference orthoimages by delimiting areas of same objects. Within each of the ten classes transformation parameters were determined using class specific „spectral and radiometric control points“ and the method of least squares adjustment.

3.3.4 Land use classification: In order to calculate PTC-orthoimages, the object information for each pixel is necessary. For this purpose a maximum-likelihood classification has been done for all CIR-orthoimages. As training sets for this computer assisted image classification the visual interpreted object areas were used. Afterwards the pixel values of the CIR-colour space were transformed to the PTC colour space for each object class separately:

$$\begin{aligned} R_{PTC,\,cl} &= a_{10} + a_{11} \cdot R_{CIR,\,cl} + a_{12} \cdot G_{CIR,\,cl} + a_{13} \cdot B_{CIR,\,cl} \\ G_{PTC,\,cl} &= a_{20} + a_{21} \cdot R_{CIR,\,cl} + a_{22} \cdot G_{CIR,\,cl} + a_{23} \cdot B_{CIR,\,cl} \\ B_{PTC,\,cl} &= a_{30} + a_{31} \cdot R_{CIR,\,cl} + a_{32} \cdot G_{CIR,\,cl} + a_{33} \cdot B_{CIR,\,cl} \end{aligned} \qquad (6)$$

3.3.5 Calculation of transformation elements by means of class centers: The method described in *Chapter 3.3.1* prefers classes with a higher frequency in the reference orthoimage. This disadvantage can be avoided by computing the center values of each class in both colour spaces. Afterwards all the center values are used as „spectral and radiometric control points“, and the influence of each class by computing the transformation elements is weighted equally. Besides this method also allows an individual ponderation of each class. The transformation of the CIR values to the PTC values will be done class independent using *equation (4)*.

3.3.6 Calculation of transformation elements by means of class centers with subsequent improvement of some classes: The calculation of transformation elements by means of class centers enables on the whole good results. Only the colours of few classes are not transformed correctly into the PTC-colour space.To overcome this lack by a subsequent improvement of single classes can be done. In a first step the transformation parameters between CIR-colour space and TC-colour space are determined using class centers and *equation (3),* and a PTC-image will be calculated. In a second step the quality of the PTC-image will be controlled and for object classes with insufficient colour values the transformation parameters will be calculated individually using *equation (5),* and the class specific pixels are transformed to the PTC-image with *equation (6)*. The class information of the pixels will be obtained as described in *Chapter 3.3.4*.

3.3.7 Simplified methods: Theoretically the transformation parameters between CIR-colour space and TC-colour space must be calculated for all three bands to get a PTC-image. Due to the high correlation of the green band of the CIR-image with the red band of the TC-image (both corresponding with the red part of the natural electromagnetic spectrum) and the high correlation of the blue band of the CIR-image with the green band of the TC-image (both corresponding with the green part of the natural electromagnetic spectrum) the transformation between the two colour spaces can be simplified:

$$B_{TC} = a_0 + a_1 \cdot R_{CIR} + a_2 \cdot G_{CIR} + a_3 \cdot B_{CIR} \qquad (7)$$

and the simulation of the PTC-image can be done by

$$\begin{aligned} R_{PTC} &= G_{CIR} \\ G_{PTC} &= B_{CIR} \\ B_{PTC} &= a_0 + a_1 \cdot R_{CIR} + a_2 \cdot G_{CIR} + a_3 \cdot B_{CIR} \end{aligned} \qquad (8)$$

If there was no yellow filter in use to cut off the blue part of the electromagnetic spectrum during the photo flight for getting the CIR-photographs, the transformation parameters can be calculated using the equation below:

$$\begin{aligned} G_{TC} &= a_{10} + a_{11} \cdot R_{CIR} + a_{12} \cdot G_{CIR} + a_{13} \cdot B_{CIR} \\ B_{TC} &= a_{20} + a_{21} \cdot R_{CIR} + a_{22} \cdot G_{CIR} + a_{23} \cdot B_{CIR} \end{aligned} \qquad (9)$$

The respective transformation equations read:

$$\begin{aligned} R_{PTC} &= G_{CIR} \\ G_{PTC} &= a_{10} + a_{11} \cdot R_{CIR} + a_{12} \cdot G_{CIR} + a_{13} \cdot B_{CIR} \\ B_{PTC} &= a_{20} + a_{21} \cdot R_{CIR} + a_{22} \cdot G_{CIR} + a_{23} \cdot B_{CIR} \end{aligned} \qquad (10)$$

Also within this simplified method there is the possibility to variate the computation algorithms for the transformation elements such as

- classwise transformation,
- means of class centers and
- means of class centers with subsequent improvement of some classes.

3.3.8 Implementation of the algorithms: All described algorithms in *Chapter 3.3.1* to *Chapter 3.3.7* were implemented on a UNIX computer. For a test image all transformations were calulated and investigated. Some of the results (three PTC-images) as well as the original CIR-input image, the TC-(reference)input image and the class map of the classification are illustrated in colour within these proceedings.

4. RESULTS

The quality control of the results of the CIR- to PTC-image transformation and with this a judgement of the chosen algorithm was a weak point within the presented project: The colour infrared photographs and the corresponding reference true colour photographs were not taken in the same year, not in the same season, not at the same time and not with the same camera objective. Due to this fact there are some objects in the photographs which are not identical (e.g. there are some fields that have different vegetation status). This circumstance was considered by delimiting the object classes to determine the transformation parameters, but it was not taken in consideration by the computation of statistical values as presented in *Chapter 4.2*. So the results are made worse.

The quality of the PTC-image depends on following influences:

- ⇒ quality of photographs
- ⇒ contents of photographs
- ⇒ amount of distinguished classes
- ⇒ selection of training areas for the classification
- ⇒ kind of transformation

In the presented paper two possibilities of quality control are outlined. For one test area CIR-images were transformed to PTC-images and afterwards compared with theTC-image of the same area. When judging the results it is to take into account that in this case the CIR and the TC photographs were not taken at the same time, as noted above.

4.1 Visual quality control:

Every visual quality control is subjective: Each person has a different preference of contrast, brightness and colour balance of a photo and so within this paper only the impressions of the authors are outlined in *table 1*:

	class center *(method 3.3.5)*	class center with classwise improvement *(method 3.3.6)*	classwise *(method 3.3.3)*
transformation of one band *(equation 9)*	•	•	-
transformation of two bands *(equation 7)*	•	+	•
transformation of all bands *(equation 3)*	•	+	•

table 1: visual quality control

Legend of table 1: - bad, • neutral, + good

4.2 Quality control with statistical values:

For the quantitative quality control the corresponding pixel values of the colour bands of the PTC-image (orthoimage) and of the original TC-image were subtracted. The mean value of each colour band and the corresponding variance are outlined in *table 2* to *4*. As exspected, due to the high degree of freedom, the classwise transformation of CIR-pixel values to PTC-pixel values gives the best results.

	class center *method 3.3.5*	class center with classwise improvement *method 3.3.6*	classwise *method 3.3.3*
Red band	***-7.4 / 54.6***	***-7.4 / 54.6***	***-7.4 / 54.6***
Green band	***30.2 / 48.4***	***30.2 / 48.4***	***30.2 / 48.4***
Blue band	***10.1 / 38.0***	***10.0 / 37.9***	***-3.1 / 34.0***

table 2: quality control with statistical values - transformation of one (blue) band (equation 9)
(mean value / variance of differences between TC and PTC pixel values)

	class center *method 3.3.5*	class center with classwise improvement *method 3.3.6*	classwise *method 3.3.3*
Red band	***-7.4 / 54.6***	***-7.4 / 54.6***	***-7.4 / 54.6***
Green band	***4.7 / 41.8***	***4.6 / 41.8***	***-3,6 / 37.1***
Blue band	***10.1 / 38.0***	***10.0 / 37.9***	***-3.1 / 34.0***

table 3: quality control with statistical values - transformation of two (blue, green) bands (equation 7)
(mean value / variance of differences between TC and PTC pixel values)

	class center *method 3.3.5*	class center with classwise improvement *method 3.3.6*	classwise *method 3.3.3*
Red band	***5.2 / 51.1***	***5.1 / 51.0***	***-3.7 / 44.0***
Green band	***4.7 / 41.8***	***4.6 / 41.8***	***-3,6 / 37.1***
Blue band	***10.1 / 38.0***	***10.0 / 37.9***	***-3.1 / 34.0***

table 4: quality control with statistical values - transformation of all (red, green,blue) bands (equation 3)
(mean value / variance of differences between TC and PTC pixel values)

5. CONCLUDING REMARKS AND OUTLOOK

Producing pseudo-true-colour orthophotos using colour-infrared-photographs is a possible compromise of having excellent film material for interpretation and getting realistic colour orthophotos for visualization purposes. The presented paper showed a first approach of the determination of transformation parameters between CIR and TC (resp. PTC) colour space.

Within the presented project the efford of producing PTC orthophotos was very low. As the land use classification was part of the contract with the customer, the only

additional task was to rectify a reference TC-photo, to evaluate the transformation parameters, and to transform all the CIR-orthoimages to PTC-images.
To improve the outlined method the reference TC-photograph must be taken simultaneously with the CIR-photographs. Another improvement can be done by using a non-linear transformation between the two colour spaces. At least some investigations will be done for producing PTC-images from a CIR-image without reference images. For this purpose a data set with - object specific - colour values has to be compiled.

6. REFERENCES

Bartl, R., Eichinger, E.V., Schneider, W., 1996. Landnutzungserhebungen aus Luftbildern als Grundlage für wasserbautechnische Planungen. In: Österreichische Zeitschrift für Vermessung und Geoinformation. In press.

Heipke, Ch., 1993. Performance and state-of-the-art of digital stereo processing. In: Fritsch/Hobbie (Eds.): Photogrammetric Week ´93. Wichmann Verlag, Karlsruhe, pp. 173 - 183.

Mansberger, R., 1992. Ein System zur visuell-digitalen Zustandsbeurteilung von Baumkronen auf Farb-Infrarot-Luftbildern. Dissertation. Universität für Bodenkultur. Eigenverlag, 1992.

Reeves, R. G., Anson, A., Landen, D., 1975. Manual of Remote Sensing. American Society of Photogrammetry, Falls Church, Virginia.