



THE PHOTOGRAMMETRIC RECORD

Vol. 19 No. 106
JUNE 2004

**An International Journal
of Photogrammetry**

Published by

THE REMOTE SENSING AND
PHOTOGRAMMETRY SOCIETY
AND BLACKWELL PUBLISHING

ISSN 0031-868X

UNITED KINGDOM

 **Blackwell**
Publishing

MISLEADING INFORMATION FROM DIRECT INTERPRETATION OF GEOMETRICALLY INCORRECT AERIAL PHOTOGRAPHS

DUCCIO ROCCHINI (rocchini@unisi.it)

University of Siena, Italy

Abstract

Remote sensing represents a powerful method to study the change of several phenomena over time. However, useful input data (for example, aerial photos) can produce misleading information if an inadequate geometric correction is applied. Among mathematical models used for this type of correction, orthorectification (differential correction) seems to be the only one that guarantees accurate results. However, many authors are still basing their results on incorrectly transformed images. This phenomenon is especially due to the incidence of several user-friendly tools and interfaces for the rectification of images. This paper tests both polynomial rectification and orthorectification. Aerial photography of 1954 of the same area was acquired and polynomial rectification and orthorectification were applied, using a 1998 orthophoto as a base. An unsupervised classification was performed by utilising the nearest neighbour method for the resampling of images. The area occupied by each class was calculated. A multitemporal analysis was then performed, considering the overlap between the 1954 orthophoto and the 1998 orthophoto as the base of reference. An overestimate up to 21% of class area was found. When multitemporal analysis was carried out, an overestimate up to 100% of class area change was found.

KEYWORDS: aerial photos, DEM, differential rectification, geographical information systems (GIS), multitemporal analysis, orthorectification, polynomial rectification, remote sensing

INTRODUCTION

SINCE THE 1920s, aerial photography has represented an important data source for the detection of landscape patterns and their change over time.

Multitemporal analysis represents a powerful method for the study of all ecological and geological processes that change over time. The literature involves several fields of study: from soil loss (Disperati et al., 2001) to natural resources assessment (Gerard et al., 2001) to vegetation and ecological dynamics (Jensen et al., 1995; Pan et al., 1999; Pärtel et al., 1999; de Blois et al., 2001).

Multitemporal data are, in fact, easy to acquire and analyse, particularly with recently developed geographical information system (GIS) software (ESRI ArcInfo, ArcView and ArcGIS, Idrisi, GRASS).

However, the uninformed use of GIS and remote sensing can lead to misleading results. For example, manually digitised maps from geometrically uncorrected photos result inevitably in *uncorrected* maps. This might look like a paradox: remote sensing data represent, in fact, the most objective (and so *correct*) data for quantifying landscape change, because they derive from sensors and not from humans (see Walsby, 1995 for a description of problems in manual digitisation).

In order to be able to overlay remotely sensed data, their geometric correction is needed. Novak (1992) presented a review of the methods used for geometric correction of remotely sensed data. He classified mathematical correction models used for the correction into three classes: *polynomial*, *projective* and *differential rectification*. Put briefly, the first two classes use polynomial functions, namely, mathematical algorithms, which define, for the same point, the transformation between the original coordinates of the point and its rectified coordinates.

Transformation is achieved by recognising a point (ground control point, GCP) on the uncorrected image and the same point on the map or on an orthorectified image. The order of the rectification is defined as the exponent used in the polynomial. For example, equation (1) shows the polynomial of first order. This type of rectification can model six distortion types (Jensen, 1996) including translation in X and Y , scale changes in X and Y , skew and rotation. All six operations can be combined into a single expression, to give the following (Jensen, 1996):

$$\begin{aligned} X^I &= a_0 + a_1X + a_2Y \\ Y^I &= b_0 + b_1X + b_2Y \end{aligned} \quad (1)$$

where X^I , Y^I are the coordinates of the point of the input uncorrected image, X , Y are the coordinates of the rectified image and a_0 , a_1 , a_2 , b_0 , b_1 , b_2 are the six coordinate transform coefficients.

Polynomials cannot correct relief displacements, because no information concerning the elevation of the GCPs is used. In an ideal case the transformed X and Y coordinates must be equal to X^I and Y^I coordinates, but this is rarely the case (Jensen, 1996). The deviation between these values represents the geometric distortion and can be measured by the root mean square error (rmse) as follows:

$$\text{rmse} = [(X^I - X)^2 + (Y^I - Y)^2]^{1/2}. \quad (2)$$

Differential rectification, commonly known as orthorectification, takes into account both the elevation of the area, by using a digital elevation model (DEM), and the camera parameters, namely, the focal length and the centre of the camera with respect to the photo taken. Novak (1992) should be referred to for algorithms.

The aim of this paper is to test polynomial rectification with respect to orthorectification and to observe how the effect of relief can produce distortion of the results.

STUDY AREA

The study area is the nature reserve of Poggio all'Olmo in Tuscany, Italy (11° 28' 26"E, 42° 51' 45"N, WGS84 Datum). It is located on the side of Mt. Amiata, comprising 440 ha, with elevations ranging from 650 to 1016 m above mean sea level (m.s.l.) and slopes from 0° to 55°.

METHODS

Grey scale (1 band, 256 colours) aerial photos (approximate scale 1:6000) of the reserve of Poggio all'Olmo and the neighbourhood (covering a total area of 830 ha) taken in 1954 were acquired and scanned at an image resolution of 3.9 pixels mm⁻¹.

A DEM was generated with the 3D Analyst extension for ArcGIS 8.1 (ESRI) by means of contour lines and elevation points derived from a topographic map (scale 1:10 000). The mean absolute error (MAE) of the DEM was 2.06 m (standard deviation equal to 1.9 m). This index was calculated by means of 20 randomly selected additional elevation points, measuring the difference in height between them and the DEM points (absolute values) and by computing mean and standard deviation.

Both polynomial rectification (by registering images to a 1998 orthophoto) and orthorectification to 1954 photos were then applied by means of ERDAS IMAGINE 8.5 software. In both polynomial rectification and orthorectification cases, 20 GCPs based on the 1998 orthorectified image were used. First- and second-order polynomial functions were applied. No higher order polynomial functions were applied, because they could produce large distortions of images (Richards and Jia, 1999). Pixel dimensions for all resampled images were set to 1 m. Therefore, we obtained three final photos for the following analyses (Fig. 1). Positional accuracy was assessed by means of 20 randomly distributed points and by measuring the distance between their locations in the 1998 orthophoto and the 1954 rectified images (both polynomial and orthorectified images). Positional accuracy was 18.6 m (mean) for the first-order polynomial function image (standard deviation equal to 11.7 m), 15.1 m (mean) for the second-order polynomial function image (standard deviation equal to 8.5 m) and 2.9 m

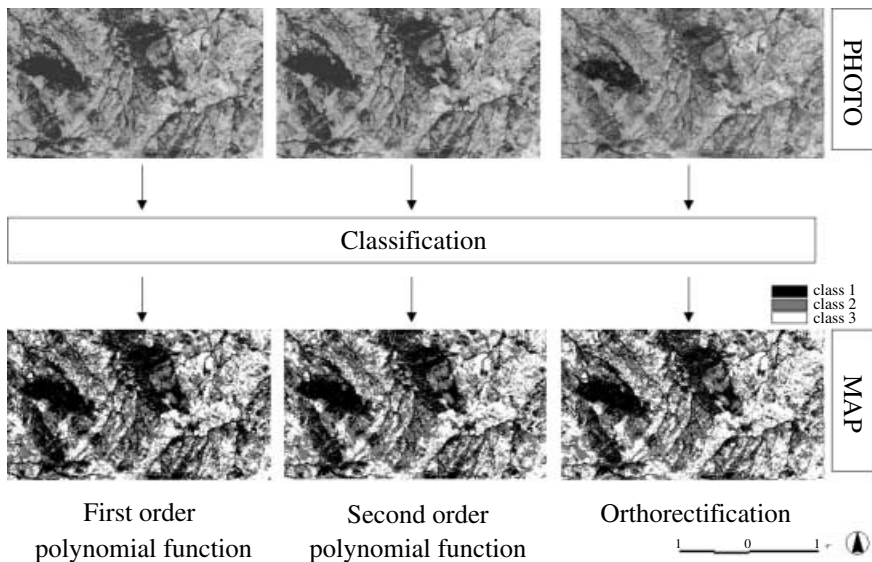


FIG. 1. Photos derived from different rectification methods and maps derived from their unsupervised classification.

(standard deviation equal to 1.5 m) for the orthorectified image. For the resampling method, a nearest neighbour method was chosen, because this does not alter the original pixel brightness (Duggin and Robinove, 1990).

An unsupervised classification was then performed to obtain three derived maps with a pixel dimension of 1 m (which were named POL1_1954, POL2_1954 and ORTH_1954) with three classes each, which were named class 1, class 2 and class 3 (Fig. 1).

The area occupied by all three classes in 1954 and the deviation among polynomial and orthorectified values were calculated. Two measures of deviation were calculated: the first in hectares, equation (3), by simply subtracting the area values of the same class; the second in percentage, equation (4), by normalising values and calculating the percentage.

$$D = Aclassk_p - Aclassk_o \quad (3)$$

where D is the deviation, $Aclassk_p$ is the area in hectares occupied by class k in the polynomial rectified image and $Aclassk_o$ is the area in hectares occupied by the same class in the orthorectified image.

$$ND\% = (Aclassk_p - Aclassk_o) * 100 / Aclassx_o \quad (4)$$

where $ND\%$ is the normalised deviation.

The maps derived were overlapped to perform a multitemporal analysis. That is, POL1_1954, POL2_1954 and ORTH_1954 were superimposed in succession on the 1998 map (ORTH_1998, derived from the unsupervised classification of the 1998 orthorectified photo).

The matrix obtained from the overlap of ORTH_1954 on ORTH_1998 represented the base, or reference, with respect to matrices obtained from the overlap of POL1_1954 and POL2_1954 on ORTH_1998.

Matrices were converted into 3D points, x values representing the class value in 1954, y values the class value in 1998, z values the change in area (hectares). As an example, if 150 ha of class 1 (1954) changed to class 2 in 1998, the 3D point conversion supplied coordinates (1, 2, 150). A network of points was then obtained and triangulated to obtain a triangulated irregular network (TIN), based on the Z values.

A comparison between Z values (which represent the change of every class in hectares) was carried out and the deviation between POL1_1954–ORTH_1998 and POL2_1954–ORTH_1998 from ORTH_1954–ORTH_1998 values was calculated. Deviation values were calculated by applying equations (5) and (6).

$$D = Zpk_p - Zpk_o \quad (5)$$

where D is the deviation, Z is the value of the change in hectares, pk_p is the point of the POL1or2_1954–ORTH_1998 matrix and pk_o is the corresponding point of the ORTH_1954–ORTH_1998 matrix.

$$ND\% = (Zpk_p - Zpk_o) * 100 / Zpk_o \quad (6)$$

where $ND\%$ is the normalised deviation.

The area and volume of TINs were calculated for all three models and compared by calculating the deviation with equations (7) and (8). In the case where the two TIN models do not agree, the area and volume would necessarily be different. However, if

two TIN models do not agree but are simply mirror-like (quite a strange but possible result), area and volume could be the same. Next, a graphical overlay was performed to detect this disagreement.

$$D = mTIN_p - mTIN_o \tag{7}$$

where D is the deviation, m is the measure under study (TIN area or volume), TIN_p is the POL1or2_1954–ORTH_1998 TINs and TIN_o is the ORTH_1954–ORTH_1998 TIN.

$$ND\% = (mTIN_p - mTIN_o) * 100 / mTIN_o \tag{8}$$

where $ND\%$ is the normalised deviation.

RESULTS

Table I shows the values of the area occupied by the three classes in 1954, with respect to the different rectification methods. The deviation of POL1_1954 and POL2_1954 values from ORTH_1954 values ranges from 11 ha to 60 ha (considering absolute values) and from 13 ha to approximately 40 ha, respectively. With respect to errors identifiable over the complete area of the photo (approximately 830 ha) POL1_1954 reached 7% (class 3), decreasing to 4% in POL2_1954.

In the first case, the normalised deviation from ORTH_1954 reaches 20 to 21% (class 1 and class 3). That is, class 1 and class 3 are overvalued by 20 to 21%. The rectification by means of a second-order polynomial function can reduce the error threshold, but maintains a high error level (13% in class 3). Moreover, for the same class, the error threshold obtained with a second-order polynomial function can exceed the first-order polynomial function (class 2).

The results of multitemporal analysis are demonstrated in Table II which shows the change of each class (column x) in the other (column y). Values (column z) are in hectares. This table also shows the absolute and the normalised deviation of the matrices obtained from the overlap of POL1_1954 and POL2_1954 on ORTH_1998 with respect to the overlap between ORTH_1954 and ORTH_1998.

First of all, large differences between POL1or2–ORTH_1998 values and the ORTH_1954–ORTH_1998 values can be observed. Absolute deviation reaches 27 ha (class 3 to class 3) for POL1. POL2 overlap shows a decrease of this value, but only up to 18 ha. The normalised deviation reaches 103% (class 1 to class 3) in the POL1 overlap, namely, double the correct value. POL2 overlap again shows a decrease in this value, but only up to approximately 40%.

TABLE I. Area values of each class with respect to different rectification methods and deviation of polynomial values from orthorectified image values.

Class	POL	POL	ORTH_1954	Deviation	Deviation	Normalised	Normalised
	1_1954	2_1954		of POL	of POL	deviation	deviation
	(ha)	(ha)	(ha)	1_1954	2_1954	of POL	of POL
				(ha)	(ha)	1_1954 (%)	2_1954 (%)
Class 1	278	243	230	48	13	21	6
Class 2	312	327	301	11	26	4	9
Class 3	233	253	293	-60	-39	-20	-13

TABLE II. Change of each class (column *x*) in the other (column *y*) with respect to different rectification methods.

<i>x</i>	<i>y</i>	<i>z</i> POL1_1954- ORTH_1998 (ha)	<i>z</i> POL2_1954- ORTH_1998 (ha)	<i>z</i> ORTH_1954- ORTH_1998 (ha)	Deviation of POL1_1954- ORTH_1998 (ha)	Deviation of POL2_1954- ORTH_1998 (ha)	Normalised deviation of POL1_1954- ORTH_1998 (%)	Normalised deviation of POL2_1954- ORTH_1998 (%)
1	1	179	166	162	18	4	11	2
1	2	72	59	54	18	5	33	9
1	3	25	18	13	13	5	103	39
2	1	124	133	128	-5	4	-4	3
2	2	109	116	107	2	9	2	8
2	3	82	82	69	13	13	20	19
3	1	73	78	86	-13	-8	-15	-9
3	2	75	82	95	-20	-13	-21	-14
3	3	83	92	110	-27	-18	-24	-16

On evaluating the TINs (Fig. 2), no agreement occurs between POL1_1954-ORTH_1998 and ORTH_1954-ORTH_1998 TINs; the same phenomenon is found for POL2_1954-ORTH_1998 and ORTH_1954-ORTH_1998 TINs. If the points (change of classes) discussed previously are considered, Fig. 3 shows various views of the deviation among all TINs, with POL1_1954-ORTH_1998 (yellow) the less fitted to the ORTH_1954-ORTH_1998 TIN (green). As mentioned previously, the POL2_1954-ORTH_1998 TIN can only increase the amount of agreement, however, it is far from being complete agreement.

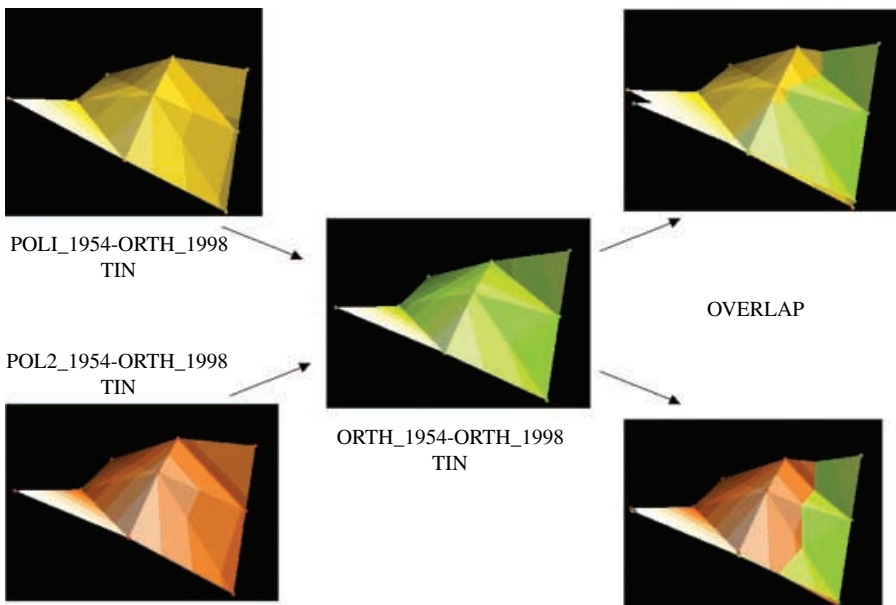


FIG. 2. Graphical overlap of TINs derived from matrices of multitemporal analysis.

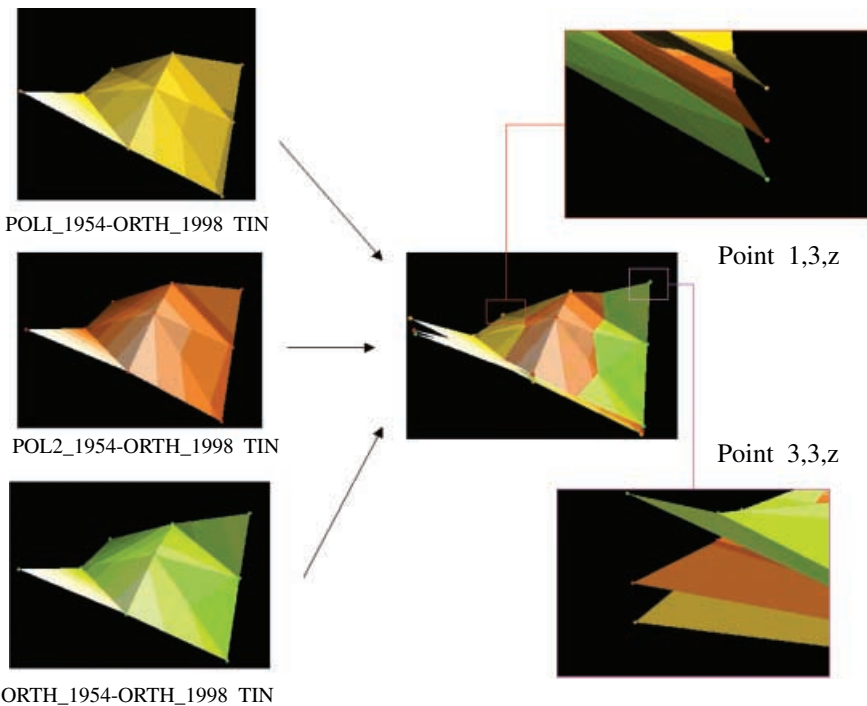


FIG. 3. Various views representing the agreement between the three TINs.

Table III shows the values of surface area and volume calculated above the minimum height for all TINs. Naturally meaningful units cannot be assigned to these measures, because of the lack of definition of x, y units. However, we can discuss these measures in a relative manner. POL1_1954-ORTH_1998 TIN does not agree in surface area with ORTH_1954-ORTH_1998 for 0.92% of its surface, while POL2_1954-ORTH_1998 for 1%. Where volume is concerned, this measure better explains the amount of disagreement of POL1_1954-ORTH_1998 with respect to POL2_1954-ORTH_1998: 15% of its volume and 3%, respectively.

TABLE III. Surface area and volume of the three TINs and deviation between polynomial TINs and orthorectified TIN.

	<i>POL1_1954- ORTH_1998</i>	<i>POL2_1954- ORTH_1998</i>	<i>ORTH_1954- ORTH_1998</i>	<i>Deviation of POL1_1954- ORTH_1998</i>	<i>Deviation of POL2_1954- ORTH_1998</i>	<i>Normalised deviation of POL1_1954- ORTH_1998 (%)</i>	<i>Normalised deviation of POL2_1954- ORTH_1998 (%)</i>
Surface area	46 355	47 260	46 783	-427	478	-1	1
Volume	2 618 833	2 970 000	3 063 333	-445 000	-93 833	-15	-3

DISCUSSION

As Novak stated in 1992, polynomial functions do not take into account relief displacement, creating spatial errors that lead to misleading information. Our results completely fit with this assertion. In fact, in this work, *absolute error* in area assessment was low, for a study area of 830 ha, reaching 60 ha (7%) with a first-order polynomial function and 40 ha (4%) with a second-order polynomial function. However, with respect to the real area values of an orthorectified image, the *relative error* reached 21% for a first-order polynomial function and 13% for a second-order polynomial function.

The recent development of user-friendly tools and interfaces to perform simple rectification (see the ESRI website: <http://arcsripts.esri.com>) could give rise to misleading input information. As has been amply shown, great care must be taken when making such an analysis. This is an important issue for decision makers and natural resources managers: an overestimate or an underestimate of a phenomenon could lead in fact to an inappropriate intervention.

Despite this, many studies still base their results on uncorrected photos. A typical piece of evidence of this phenomenon is the citation of the term “rectification” or “georeference” and the utilisation of the *rsme* as an index of accuracy, *without specifying the number of GCPs used*. This is especially true taking into account the sensitivity of GCP errors to their number and positioning (Campbell, 1996).

Although it may not be necessary to orthorectify images simply to identify the change between two images (Jensen, 1996), no quantitative measures must be used in this particular case. The results demonstrate that the change in some classes could be overestimated by up to double the occupied area, with a relative deviation from the real value reaching 100%.

Several other problems are related to the geographical data and their analyses, for example, the spatial resolution (Jelinski and Wu, 1996; Wu et al., 1997; Liu et al., 1999; Wu and Qi, 2000) and class definition (Lightbody and Irwin, 1996; Cross and Firat, 2000). However, without correct input data these problems cannot be resolved at all.

The process of simple rectification (non-orthorectification) has been accepted by several authors (Chen and Lee, 1992; Jensen, 1996) in the case of an image-to-image rectification. In this case, the final distortion is accepted because its geometric characteristics will be the same in the two rectified photos. However, if this type of data is used in further multitemporal analysis, the dynamics of a process over time can only be assessed qualitatively, not quantitatively. That is, the question “*how?*” can only be answered not the question “*how much?*”.

Several authors, however, use this method and furthermore present measures in hectares or acres or landscape shape metrics! This clearly leads to misleading results and trivialises discussions based on their data.

REFERENCES

- DE BLOIS, S., DOMON, G. and BOUCHARD, A., 2001. Environmental, historical and contextual determinants of vegetation cover: a landscape perspective. *Landscape Ecology*, 16(5): 421–436.
- CAMPBELL, J. B., 1996. *Introduction to remote sensing*. Second edition. Taylor & Francis, London. 622 pages.
- CHEN, L.-C. and LEE, L.-H., 1992. Progressive generation of control frameworks for image registration. *Photogrammetric Engineering & Remote Sensing*, 58(9): 1321–1328.

- CROSS, V. and FIRAT, A., 2000. Fuzzy objects for geographical information systems. *Fuzzy Sets and Systems*, 113(1): 19–36.
- DISPERATI, L., SALVINI, R., CIALI, A., FANTOZZI, P. L., CARMIGNANI, L., FIORI, A. P., BOCCI, M. and PARANHOS FILHO, A. C., 2001. Land cover and soil loss multitemporal analysis: an application of geoinformatics in the Pantanal Wetlands (Brazil). *Proceedings of the First International Workshop on the Analysis of Multitemporal Remote Sensing Images*, Trento, Italy. 440 pages: 217–224.
- DUGGIN, M. J. and ROBINOVE, C. J., 1990. Assumptions implicit in remote sensing data acquisition and analysis. *International Journal of Remote Sensing*, 11(10): 1669–1694.
- GERARD, F. F., PLUMMER, S. E., NORTH, P. R. J. and VAN ROOYEN, A., 2001. Natural resource in southern African drylands: determining spatial availability and variability using ATSR2 time series. *Proceedings of the First International Workshop on the Analysis of Multitemporal Remote Sensing Images*, Trento, Italy. 440 pages: 129–140.
- JELINSKI, D. E. and WU, J., 1996. The modifiable areal unit problem and implications for landscape ecology. *Landscape Ecology*, 11(3): 129–140.
- JENSEN, J. R., 1996. *Introductory digital image processing: a remote sensing perspective*. Second edition. Prentice-Hall, Upper Saddle River, New Jersey. 318 pages.
- JENSEN, J. R., RUTCHEY, K., KOCK, M. S. and NARUMALANI, S., 1995. Inland wetland change detection in the Everglades water conservation area 2A using a time series of normalized remotely sensed data. *Photogrammetric Engineering & Remote Sensing*, 61(2): 199–209.
- LIGHTBODY, G. and IRWIN, G. W., 1996. Multilayer perception based modelling of nonlinear systems. *Fuzzy Sets and Systems*, 79(1): 93–112.
- LIU, H., WANG, Y. and ZHANG, X., 1999. Effects of spatial measurement unit on calculation of landscape indices. *Proceedings of the Geoinformatics '99 Conference*, Ann Arbor, Michigan. 639 pages: 1–9.
- NOVAK, K., 1992. Rectification of digital imagery. *Photogrammetric Engineering & Remote Sensing*, 58(3): 339–344.
- PAN, D., DOMON, G., DE BLOIS, S. and BOUCHARD, A., 1999. Temporal (1958–1993) and spatial patterns of landscape use changes in Haut-Saint-Laurent (Quebec, Canada) and their relation to landscape physical attributes. *Landscape Ecology*, 14(1): 35–52.
- PÄRTEL, M., MÄNDLA, R. and ZOBEL, M., 1999. Landscape history of a calcareous (alvar) grassland in Hanila, western Estonia, during the last three hundred years. *Ibid.*, 14(2): 187–196.
- RICHARDS, J. A. and JIA, X., 1999. *Remote sensing digital image analysis: an introduction*. Third edition. Springer, New York and London. 363 pages.
- WALSBY, J. C., 1995. The causes and effects of manual digitizing on error creation in data input to GIS. *Innovations in GIS 2: selected papers from the Second National Conference on GIS Research UK* (Ed. Fisher P.). Taylor & Francis, Bristol. 257 pages: 113–124.
- WU, J., GAO, W. and TUELLER, P. T., 1997. Effects of changing spatial scale on the results of statistical analysis with landscape data: a case study. *Geographic Information Sciences*, 3(1): 30–41.
- WU, J. and QI, Y., 2000. Dealing with scale in landscape analysis: an overview. *Ibid.*, 6(1): 1–5.

Résumé

La télédétection constitue une méthode puissante pour étudier les changements qui interviennent dans le temps sur de nombreux phénomènes. Toutefois, si utiles que soient les données utilisées en entrée, comme par exemple les photographies aériennes, elles peuvent conduire à des résultats erronés si on ne leur applique pas des corrections géométriques correctes. Parmi les processus mathématiques utilisés pour effectuer ces corrections, il apparaît que seule la rectification orthophotographique (ou redressement différentiel) puisse garantir la précision des résultats. Toutefois, nombre d'auteurs continuent à baser les conclusions de leurs travaux sur des images incorrectement transformées. Ce fait tient en particulier aux incidences des nombreux outils ou interfaces conviviaux disponibles pour la rectification des images. On rapporte dans cet article des essais comparatifs effectués entre la rectification polynomiale et la rectification orthophotographique. On a

appliqué sur une même zone d'une photographie aérienne de 1954 ces deux rectifications, polynomiale et orthophotographique, en se basant sur une orthophoto de 1998. On a ré-échantillonné les images en utilisant une classification non-dirigée basée sur la méthode du plus proche voisin. On a déterminé la surface de chaque classe. On a effectué ensuite une analyse multirate, en considérant la zone de recouvrement entre les orthophotos de 1954 et 1998 comme référence de base. On a trouvé une sur-estimation de 21% sur la surface des classes. Avec l'analyse multirate, la sur-estimation sur la surface des changements a atteint jusqu'à 100%.

Zusammenfassung

Die Fernerkundung ist ein sehr leistungsfähiges Verfahren, um temporale Veränderungen der verschiedensten Erscheinungen zu studieren. Allerdings ist festzustellen, dass nützliche Eingabedaten (z.B. Luftbilder) irreführende Informationen liefern können, falls eine ungeeignete geometrische Korrektur angewandt wird. Unter den mathematischen Modellen für diese Art von Korrektur ist die differentielle Orthophotoentzerrung wohl die einzige, die genaue Ergebnisse garantieren kann. Dennoch gründen viele Autoren ihre Ergebnisse auf fehlerhaft transformierte Bilddaten. Dies wird besonders durch das Auftreten verschiedener nutzerfreundlicher Werkzeuge und Schnittstellen für die Bildentzerrung hervorgerufen. In dieser Untersuchung werden die Ergebnisse der Entzerrung mit Polynomen und mit differentieller Orthophotoentzerrung vorgestellt. Luftbilder aus dem Jahr 1954 wurden vorbereitet. Sie zeigen dass gleiche Gebiet wie ein Orthophoto aus dem Jahr 1998, das als Grundlage für eine Entzerrung mit Polynomen und eine differentielle Orthophotoentzerrung diente. Eine unüberwachte Klassifizierung wurde durchgeführt, wobei die Methode der Nächsten Nachbarschaft für die Umbildung der Bilder verwendet wurde. Die Fläche jeder Klasse wurde bestimmt. Danach wurde eine multitemporale Analyse durchgeführt, bei der die Überlappung zwischen dem Orthophoto aus 1954 und dem aus 1998 als Referenz diente. Die Fläche der Klassen wurde um bis zu 21% überbestimmt. Bei der multitemporalen Analyse wurde eine Überbestimmung der Flächenänderung der Klassen von bis zu 100% festgestellt.

Resumen

La teledetección es una técnica eficaz para el estudio del cambio de distintos fenómenos a través del tiempo. Sin embargo los datos de partida utilizados (p.e. fotos aéreas) pueden dar lugar información errónea si se aplica una inadecuada corrección geométrica. Entre los modelos matemáticos usados para este tipo de corrección, la ortorrectificación (corrección diferencial) parece ser el único que garantiza resultados exactos. Sin embargo muchos autores todavía basan sus resultados en imágenes transformadas incorrectamente. Este fenómeno se debe especialmente a la incidencia de varias herramientas e interfaces de fácil uso para la rectificación de imágenes. En este artículo hemos ensayado la rectificación

polinómica y la ortorrectificación. Se ha obtenido una imagen aérea de 1954 de la misma área y se aplicaron la rectificación polinómica y la ortorrectificación, utilizando una ortofoto de 1998 como base. Se llevó a cabo una clasificación no supervisada utilizando el método del vecino más próximo para remuestrear las imágenes. Se ha calculado el área para cada clase. Posteriormente se llevó a cabo un análisis multitemporal, considerando la superposición entre la ortofoto de 1954 y la de 1998, tomando ésta como base de referencia. Se ha encontrado una sobreestimación de hasta un 21% comparando las áreas de las clases. Cuando se ha hecho un análisis multitemporal, se ha encontrado una sobreestimación de hasta un 100% de cambio en las áreas de las clases.