CONSEQUENCES OF THE PHOTOGRAMMETRICAL VIEW OF SOLVING SPECIAL TASKS IN DIGITAL PHOTOGRAMMETRY WITH SERIAL COMPUTERS

DR. ERHARD PROSS

Research Centr of Geodesy and Cartography
Karl-Rothe-Str. 10 - 14, Leipzig, DDR-7022, G. D. R.

1. Development of image structures

Photogrammetric methods use information in the form of two-dimensional representations of facts. In connection with map production and generation of topographic and other thematic information, respectively, part of the Earth's surface is imaged at the same time.

While during the last years mainly photographic images - i. e. analogue representations - had been used, recently digital representations in the form of so-called digital images gained in importance. This process was influenced by the increased employment of digital computers as well as digital image processing.

Figure 1 shows the methodical development from analogue over differential and analytical to digital. This reflects - as typical in photogrammetry - in respective technical devices.

From the point of view of discretization of data, firstly the plane co-ordinates are discretized (differential - one, analytical - two), but then the grey value range too (digital - three). The last transition corresponds to a qualitative jump, because the traditional analysis is not sufficient for the mathematical model, but functional analytical methods have to be applied (see also /1/). This means inter alia, that data and processes basically have to be remodelled in an uniform calculation, whereby analogue, differential and analytical methods are naturally imbedding (/1/).

2. Algorithmization for serial computers

In processing digital images the primary contradiction between the sequential storage of digital images and a logical two-dimensionality of real images becomes obviously. Leaving out future digital two-dimensional storages and two-dimensionally working computers, so at present only an algorithmical solution of this contradiction is possible.

These contradictions can be solved on two levels:

(1) reduction of higher-dimensional algorithms to an one-dimensional principle or

(2) more-dimensional data supply for special array processors.

Most present solutions move on level (1), because these solutions are only limited in regard of the possibilities of computer technology (e. g. main memory size, access time, "free moving" in the data set). Future solutions will more tend to level (2), whereby the processes in the computer are becoming more an more similar to those, proceeding in the human eye-brain-system. Increasingly methods of artificial intelligence will be used thereby (see also /2/). For methods of digital image processing - i. e., for digital photogrammetric methods, too - the position discretization in equal distances is a decisive precondition for constructively reaching algorithmic solutions. This regularity transforms - from the mathematical point of view - the representation form from integrals to series. Exactly this transition provides the functional analytical path to an uniform model of analogue and digital methods. The most important mathematical backgrounds for this are the existence of a discrete eigenfunction system in the form of harmonic functions as well as the HILBERT space equivalence between the spaces of the square-integral functions L^2 and the square-summable series l^2 (see /1, 3/).

3. Examples for algorithmic reduction

In /4/ a row-invariant transformation method is presented. Thereby local scale variations, which shall correct the area distortions, are carried out by local stretchings and shrinkings within the image row - hence realized one-dimensionally. On account of the charakteristics of the correction function (small increase, piecewise linearizable) this transformation can be realized as a direct transformation without extensive resampling. Also in /4/

TIB Hannover

it was shown, how this one-dimensional transformation principle can be extended to two-dimensional transformations. Thereby, using two seccessively performable transformations in row and column direction, in connection with a decoupling of the transforming function, exactly the above mentioned algorithmic dimension reduction is realized.

Orthogonality is the decisive mathematical aid for decoupling the co-ordinate axes. With those orthogonalitiy relations two-dimensional procsses can be divided into two independent one-dimensional processes. A classic example for that are the integral transformations, because the corresponding characteristic functions fulfill exactly this orthogonality. The example of the two-dimensional FOURIER transformation is sufficiently known, which can be realized as twofold one-dimensional FOURIER transformation in each co-ordinate.

4. Prospects

Each problem to be solved has got corresponding data structures, which have a natural dimension. Many problems in photogrammetry and neighbouring disciplines in geoinformatics have got a two-dimensional position reference, completed by a semantic feature. With the help of the stereoscopic principle the terrain altitude can be determined as special "feature", which can also be related to a two-dimensionally structured situation.

Besides the dimensionality of data the basic structuring - raster or vector data - is of decisive importance. Vector-oriented data, which are produced within the photogrammetric plotting process especially during the derivation of cartography-oriented data bases, are naturally unproblematic in regard of the dimension number. Raster-oriented data - e. g. digital image structures - with a sequential order basically contradict former photogrammetric approaches.

The term (μ, x) means, that the feature μ exists in the place x.

The transformation T thereby means, that this is also decomposed in regard of feature and space:

$$T = T(M,G).$$

There is $M = M(\mu)$ und $G = G(x)$.

The attempt of dividing between remote sensing and photogrammetry could lie in assigning these transformations to that range, where they are mainly operating (feature, place):

- remote sensing: transformation of features

$$T_{RS} = T(G,M) = T(I,M) = T(M)$$

-photogrammetry: transformation in space

$$T_{PH} = T(G,M) = T(G,M(G)) = T(G).$$

On this basis can be done the following assignements:

- remote sensing
  classifikation of multispectral images,
  transformation in an abstract feature space (e. g. integral transformations)

- photogrammetry
  correction of geometric differences in multitemporal images,
  digital geometric transformations.

The new possibilities of a fully digital data structure must also lead to basically new approaches within photogrammetry, because the specific photogrammetric instruments lead to special photogrammetric software for universal computers - completed by special processors - with specific input and output devices. In this direction possible data structures as well as algorithmic solutions of photogrammetric tasks have to be viewed.

Literature

/1/ Proß, E.: Beschreibung der Digitalphotogrammetrie durch funktionalanalytische Mittel. Vermessungstechnik, Berlin, 38 (1990) 7, S. 222 - 224.

/2/ Sarjakoski, T.: Artifical Intelligence in Photogrammetry. Photogrammetria, Amsterdam, 42 (1988) S. 245 - 270.

/3/ Proß, E.: Digitale Komponenten der Fernerkundung, Photogrammetrie und Kartographie innerhalb der Geoinformatik sowie deren Beschreibung durch funktionalanalytische Mittel und Methoden. Habilitation (in preparation).

/4/ Proß, E.: Geometrische Verzerrungen in kosmischen photographischen Aufnahmen und Möglichkeiten ihrer Korrektur. Arbeiten aus dem Vermessungs- und Kartenwesen der DDR, Leipzig 1988, Vol. 55.

TIB Hannover

Photogrammetric method	analogue ⟹	differential ⟹	analytical ⟹	digital
Devices	analogue plotting device	differential rectifier	analytical plotting device	digital work station
Discretized co-ordinates	-	1-space	2-space	2-space 1-grey value
Mathematical methods	traditional analysis			
				functional analysis

Figure 1: Methodical development of photogrammetry