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Geographical Techniques Used For Digital Image Map Building

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ABSTRACT

Nowadays Geographic Information Systems (GIS) have to fulfill an increasing number of new requirements announced by many map users during the last few years. Most of so defined tasks only can be solved, if raster techniques are used in GIS as well as vector data processing. Raster data, especially digital image data, offer an enormous information quantity, so that the usage for GIS purposes is really helpful. In some cases of course, satellite images represent the only available geo information. And finally, using existing topographic maps for building up GIS, scanning these maps is a quick possibility to produce GIS levels with topographic information.
Keywords: GIS, topography, map building, digital image, geography, techniques

I. INTRODUCTION

Digital Image Map Building

A modern GIS fulfilling all demands of vector- and rasterprocessing needs not only the administration of digital data but also reliable software tools for the optimal preparation of map products. In this context the processing of airborne and satellite images is of increasing importance. Such data are in use for many purposes, e. g. for the combined representation of raster and vector data or even for updating existing maps.

In the next years new remote sensing satellite sensors with higher geometrical and spectral resolution will be developed allowing the use of image data for mapping at greater scales. Today mostly the following sensor types are in use for mapping in different scales:

Sensor	Resolution	Appropriate Scale
Landsat-MSS	80 m	1: 250 000
Landsat-TM	30 m	1: 100 000
SPOT-XS	20 m	1: 100 000
SPOT-P	10 m	1: 50 000
KFA-1000	5 - 10 m	1: 25 000 - 1: 50 000

If greater scales are concerned the integration of aerial images or aerial scanner data is required. In order to use these data in a GIS with high flexibility it is necessary to offer a software system which allows the processing of satellite data from delivering the data on magnetic tape until the final product is integrated in a GIS layer structure.

II. System Overview

The concept of the integration of satellite image data has to be digitally. Only this way guarantees a high flexibility of handling remote sensing data independent of the used sensor type (satellite scanner, scanned photographs, aerial images). The described methods of digital image map production are realized as a software package mainly developed at the Technical University of Berlin, Department for Photogrammetry and Cartography (ALBERTZ et al. 1987 and ALBERTZ et al. 1990). The software system is now used by FPK for its duties with great success.

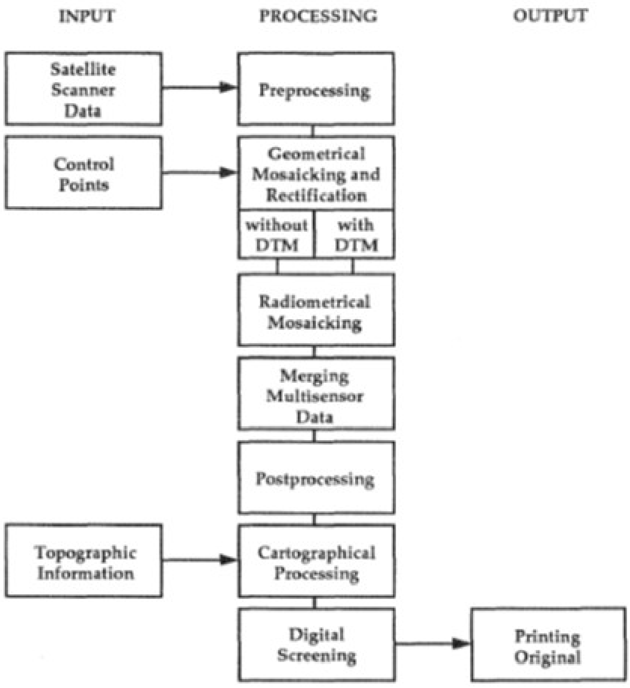

Figure 1. System overview for digital image map production

2.1 Preprocessing

The preprocessing of the raw satellite image data is a prerequisite for all following processing steps and influences the quality of the final results remarkable. The preprocessing of the data depends on the used sensor system.

2.2 Geometrical Mosaicking and Rectification

It is essential for the integration of image data into a GIS to mosaic several scenes in order to fit the requirement of free map sheet administration of the data. The mosaicking must be carried out in a way that geometrical and radiometrical differences between the images disappear. For this purpose a method is used which takes advantage of the double information of adjacent scenes. The input information is achieved by measuring a few ground control points (GCP) in all scenens and tie points in overlapping regions. All transformation parameters for all scenes of the mosaic are then calculated simultaneously in a least squares adjustment.

2.3 DTM-Generation from Satellite data

It is obvious that a DTM is one necessary layer in a GIS. However, particularly in developing countries the availability of DTM's cannot be assumed. In this case the generation of a DTM with stereo-images takes place. Especially stereo-SPOT data play an important role in this context. With the capabilities of SPOT satellite DTM's with height accuracies better than 10 m can be achieved.

2.4 Radiometrical Mosaicking

The result of the geometrical processing is a data set of several rectified images with high accuracy but those are single files. These scenes can differ significantly in radiometry due to different acquisition dates, atmospheric effects, etc. Hence it is necessary to compose one image within a common gray scale system. In order to acquire a homogeneous mosaic the information content in overlapping regions of adjacent scenes is used again (KAHLER 1989).

2.5 Combination of multisensor data sets

In order to make available the full information content of satellite image data it is often very useful to merge the advantages of different sensor image data. In particular the combination of panchromatic SPOT data with multispectral Thematic Mapper (TM) data provides high geometrical resolution merged with a lot of possibilities in spectral band combination. This offers wide application possibilities for various map and GIS-users.

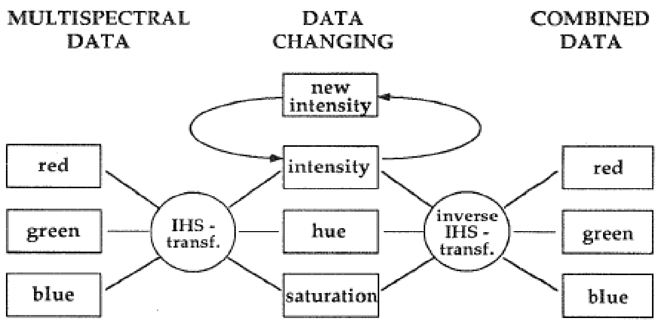

Figure 2. Principle of combination multisensor data

2.6 Postprocessing

The final processing steps of the preparation of satellite image maps concerns the optimal radiometrical contrast. For this purpose in most cases simple histogram modifications are sufficient. Furthermore special filters are used to enhance the edge elements in order to improve the visibility of details in the final product (TAUCH & KAHLER 1988). The result of all described processing steps is a satellite image database which now can be used as a layer in a GIS or which can be completed with cartographic elements used as map.

III. Basic Data Structure of an Hybrid GIS

In order to the needs of scientists, planners and other GIS users for actual information, the above described methods have to be integrated into GIS. For this purpose the graphic database must include vector data as well as raster graphics in a so called hybrid system. The basic data structure of a hybrid GIS will be introduced in the following:

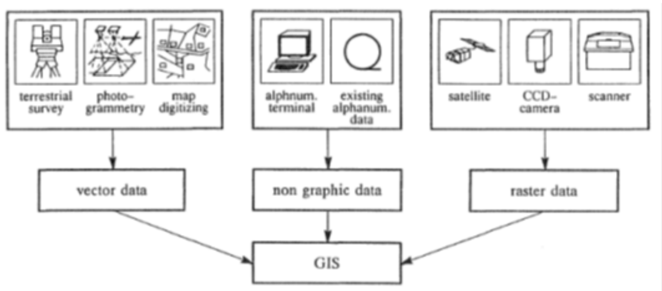

Figure 3. GIS Input Data

3.1 Data Types

Generally the input data for hybrid systems vary in a large field (see figure 3). Besides scanned topographic maps different types of data are expected, like: satellite image data, digital orthophotos, image data from airborne scanner systems, digital elevation models, vector data from map digitizing, from photogrammetric systems and terrestrial survey. Finally non graphic data complete the GIS input. These data are needed to support tasks like map revision, production of printing originals, data interpretation and analysis for many scientific and commercial applications, environmental protection e.g. tools to solve the actual tasks.

3.2 Data Reduction

Another particular problem in hybrid GIS in context to the large amount of raster data represents the disk capacity. By that data compression methods have to be integrated. The worldwide available compression algorithms are divided in two main groups: Bit level reduction methods achieve a decreased need of bits per pixel. Compression techniques of homogeneous data transform the data from pixelmatrices to pixel counting structures.

3.3 Layer Structure

Independant to the amount of geographic data another database structure principle is performed by sub layering of the continuous GIS according to the applications. Even analog topographic maps are organized in different layers respectively map foils. For example the foil of a topographic map 1:50.000 (TK50) of the Federal Republic of Germany includes:

- ✓ planimetric,
- ✓ Script level,
- ✓ Vegetation,
- ✓ Waters,
- ✓ Contour lines,
- ✓ Hill shading
- ✓ Special level for hiking, cycling, touristic institutions and so on.

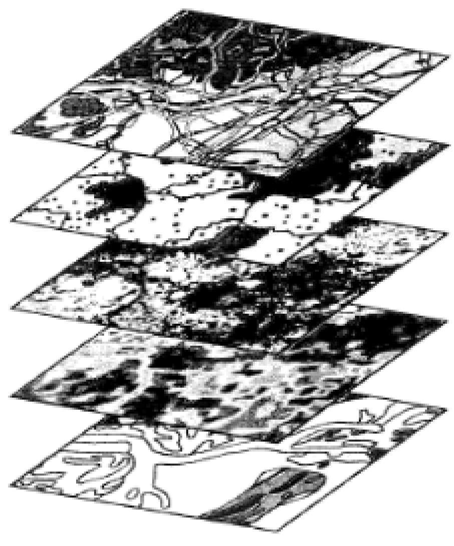

Figure 4. GIS Layer Structure (Goepfert, 1987)

IV. Integrated Hybrid GIS

Additionally to the introduction of the basic data structure the principle system architecture of a hybrid Geographic Information System will be discussed in the following. It is shown how the different input data are connected to the database itself and also to the output data as results of applications with GIS. The complete system is separated into five subsystems:

- ✓ input data,
- ✓ processing techniques for integration of several data types into GIS,
- ✓ Hybrid GIS database,
- ✓ Processing and enhancement techniques for building new GIS levels as well as output data,
- ✓ Output data as results of application questions.

These subsystems contain many other second order subsystems which are connected sometimes or not. A much more detailed separation of the subsystems will not be described now, but figure 5 illustrates how the system architecture can be seen in principle.

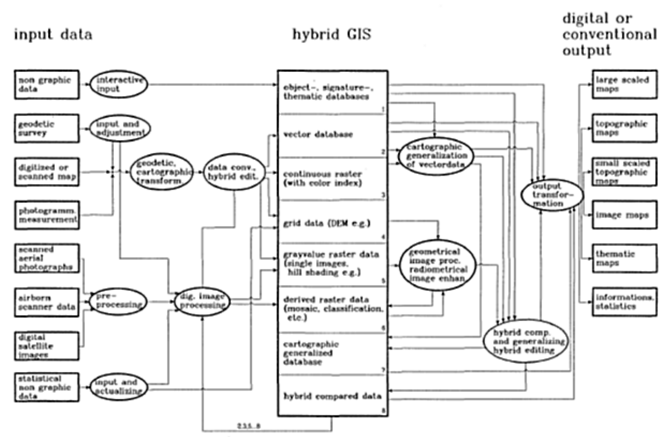

Figure 5. Hybrid GIS system architecture

V. Decentralized GIS hardware

The decentralized GIS hardware like shown in figure 6, including workstations, plotter-scanner-systems, retrieval systems and the decentralized database hardware itself will be connected via local area network (LAN) for example. All these workstations are necessary for interactive usage, updating, retrieval and managing the hybrid data, and most of them are available from different vendors worldwide.

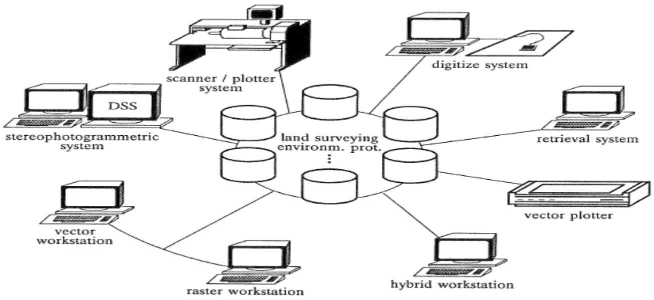

Figure 6. Decentralized hardware architecture including workstations

VI. Conclusion

So in nutshell, concluded that the actually excellent raster workstations of different vendors are known as well as outstanding cartographic CAD systems including database management systems. Also interesting hybrid workstations, so called live links between raster- and vector-systems e.g. and the first digital photogrammetric workstations are offered. Hence many of the requirements to GIS workstations are realized nowadays in the existing cartographic GIS and CAD-systems.

The user requirements nowadays as well need raster-, vector- and non graphic data in actual geographic information systems. So in this study the question of integration of such data have been discussed including the integration of methods for digital image map production and also techniques for digital image enhancement into hybrid systems.

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