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ANALYTICAL SYSTEMS AND COMPUTER SCIENCES

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1. Introduction

Computer science is a young and rapidly developing science. At the University of Stuttgart it is officially 13 years old. Certain areas belonging to computer science today however are considerably older.

Computer science is the science of handling information, especially with the use of digital computers. The main subjects are storing, processing and presentation of information with regard to physical, technical as well as functional, formal aspects.

The fields in computer science are manifold and grow continuously. As classical areas one can see:

- Theoretical Computer Science
- Programming Languages and Compilers
- Operating Systems, Systemprogramming
- Information Systems, Data Bases
- Processcontrol, Real Time Systems
- Computer Graphic
- Computer Aided Design and Manufacturing
- Artificial Intelligence
- Computer Architecture

Like many computer applications, analytical systems cannot be assigned to a certain field. Possible ones are "Processcontrol","Information Systems" and "Computer Graphic".

2. Today's Analytical Systems

Analytical systems are computer assisted systems for processing geographic terrain information received from aerial photos. These photos are the proper data for processing by means of a computer.

There are graphical and numerical processing modes. Numerical processing is the aerial triangulation, the calculation of geometric magnitudes and the building of a digital terrain model. Graphic processing is plotting various maps.

The real data for the different processing modes are coordinates of terrain points. According to the mode, the input are individual points or a sequence of points. The coordinates are received from the photos by means of the analytical plotter, handled manually by an operator and assisted by a computer.

With the analytical plotter two photos are stereoscopicly regarded with a special optical system (Fig. 1). In the centre of the stereo photo there is a measuring mark. The coordinates of the terrain point, where the measuring mark can be seen, are stored in the computer as model coordinates. If the operator changes the coordinates, normally by turning handwheels or the veltropolo, the computer moves the photos in front of the optical system, so that one can see the measuring mark at the point with the new coordinates. The task of the computer is, besides moving the photos, putting in the parameters, doing the interior, relative and absolute orientation and error correction.

The task of the operator is to produce the input data for the different processing modes. According to the mode, the operator positions the measuring mark on single points or follows lines. The registration of the coordinates will be done by the operator or automatically in fixed time or space intervals.

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3. Development Tendencies in Computer Science

For the further considerations some development tendencies in computer science are important:

- The performance and memory capacity of computers are sufficient.

  The computer hardware becomes more and more cheaper, as you can see with microprocessors and memory chips. So one can realize each function of a system with an own processor.

- Sofware becomes more and more complex and expensive.

  Cheap hardware enables to execute large programs. With the aid of new methods and tools for programming one tries to solve the problems.

- Computers have to serve the human needs.

  The programmer's work bench should be shaped according to ergonomic aspects. The times, where the man had to adapt himself to an expensive computer, are gone.

- Tasks, which have to be executed today by men, will be executed in the future by computers.

  The high requirements on processing speed and memory capacity of picture processing, pattern recognition, robotic and artificial intelligence can be satisfied more and more. One can expect great progresses on these new areas.

- More persons without special knowlegde in computer science will work with computers or with things containing computers. Examples are videotext systems, information systems for rail road lines, microcomputers in cars, sewing-machines and washing-machines.

These development tendencies, mainly basing on the progresses in the area of very large scale integration of semiconductor curcuits, cause new research activities in computer science.

4. Structuring Complex Software

Structuring complex software is a problem of the new field, called software engineering. Known by exerience, each person writing programs at some time will be concerned with this problem. Therefore we will have a closer look at this topic. A well known structuring concept, i. e. modularization, but under a new aspect, will be presented.

If a problem as a whole is unsolvable, it will be divided into individual parts. Those parts of the problem still remaining unsolvable are divided again, and so on until the whole problem is divided into solvable parts. Then the solution of all parts is a solution of the originate problem. The difficulty is to find an appropriate partition.

This structuring concept means for solving software problems, that a program has to be partitioned in several modules.

Up to now the partitioning of a program into several modules usually is done arbitrarily. Criterions for modularization often are of technical or organizational type, as for example the memory requirements or the number of programmers. Also, similar or seldom executed program parts are grouped into a module. To increase execution speed, the data are not passed as parameters between the modules, but by means of a common used area (f.e. COMMON in FORTRAN). This leads to disadvantageous, strongly interlaced modules. The replacement of an existing module by a new one is nearly impossible.

Modularization of a program should be done only under functional aspects. Each module should execute a special function independently from another. How the function is realized by the module, is hidden to the other (function hiding). Therefore common data does not exist.

To define the modules it is of use to imagine, that each module is executed by an own processor. For data exchange between the modules a protocol has to be defined. A protocol determines the data format and the rules for the data exchange in normal and error situations. In computer science the term "protocol" was intro-

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duced for data transmission in computer networks. The later realization of a module and a protocol depends on the facilities of the computer hardware and the operating system.

Functional modularization will be shown by means of the example of the block adjustment for aerial triangulation. The block adjustment is realized as a module. Besides the main function, i. e. block adjustment, the data exchange between other modules has to be defined. The appearance of errors is also to be considered. If the block adjustment module when processing the received coordinates finds out, that an acquisition error occurred at one terrain point, it informs the module providing the coordinates. This module now can react upon the message and correct the data, or it can ignore the message and provide new coordinates. In both cases the block adjustment module has to go on correctly. Thus doing block adjustment online or offline does not depend on the program code, but on the use of the block adjustment module. With the offline block adjustment, stored coordinates will be provided by an other module to the block adjustment module. In this case an error correction during processing the data is impossible. With the online block adjustment, the coordinates will be provided directly by the operator's input at the analytical plotter. Here the data can be corrected during processing.

5. The Analytical Plotter

When compared with conventional stereo systems, in the analytical stereo plotter mechanical functions are replaced by programmed functions. In front of a fixed optical system the aerial photos are moved by servos. The control of the servos and thus the motion of the photos is done by a computer. It calculates the ground coordinates from the received model coordinates for positioning the photos. With today's analytical plotters, however, not all possibilities of computer aided viewing of stereo photos are explored. Indeed, it is possible to build analytical stereo viewing systems without movable parts, motors and servos. The structure of such an analytical system is presented in the following (Fig. 2).

The aerial photos are first scanned by means of a high resolution video camera. It is also possible to take the photos directly with a video camera. In this way each photo is divided in single pixels. The number of the pixels defines the resolution of the picture. It must be adequate enough not to lose information. Each pixel has a certain brightness and possibly a certain color. The pixels of a photo are stored in the computer together with their attributes brightness and color. Thus a digitalized photo is received, which now can be processed and displayed by the computer.

For viewing the photos, sections are displayed by the computer on high resolution video monitors. The measuring mark is copied into the picture by the computer. The pictures on the screen can be regarded with a suitable optical system. The photo sections or the measuring mark can be moved according to the operators desire, on the screens. The screens represent a window, through which the photos can be seen. The computer is able to change the displayed sections, so it seems like moving the photos behind the window. Also the measuring mark in the photo section is movable.

This suggested stereo viewing systems, where the photos are moved electronically, avoids any mechanical parts. So all problems escape, which mechanical systems have, for example inertia, wear, temperatur dependence, precision, troubles and maintenance.

The computer assisted photo displaying has the following advantages:

- rectification, correction of projection errors and of film shrinking can be done before viewing the photos.
- Any enlargement and reduction of the photos for rough and fine positioning of the measuring mark are possible.
- Registrated points, scanned lines can be made visible directly in the stereo picture.
- Any information like point numbers or coordinates can be shown in the picture.
- The computer can amplify the contrast or display wrong colors to facilitate the positioning of the measuring mark.
- Orientation tasks, for example finding the frame marks and calculating the interior orientation, can be executed by the computer.

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A new construction of an analytical stereo plotter should also be done under ergonomic aspects. The unit should be constructed in a way, that no fixed seating position of the operator is necessary. Using stereo monitors regarded with special glasses would offer more liberty to move to the operator. Other input facilities for the coordinates than handwheels or the veltropolo, for example joystick or a mouse - a little box movable on a tablet where the measuring mark follows its movement - can already be bought on the market.

6. Computer Assisted Processing of Geographic Terrain Information

Two features of processing geographic terrain information are evident:

- The information being processed is static. It is valid for a long period of time. Depending on the terrain, the up-to-date period of the photos is varying.
- The different types of processing, in computer science called methods, require only a special part of information. Data reduction by selection is manually done by the operator with the analytical stereo plotter.

Computer assisted systems for processing and presentation of long-term information in different methods are called information systems. They mainly consist of a data base and a method bank (Fig. 3).

Stored data, which according to a selected schema are in an organizational context, are called a data base. The retrieval of the data is done by data base administration programs. These programs enable for example to select data from the data base according to given criterions.

A method bank mainly is a collection of programs for processing occurring data. The user of a method bank selects an individual method with a video terminal in a dialog with the computer. A typical application of a method bank is processing selected data from a data base. The output of one method can be put in again for another method. For example a map is prepared by a first method, by another method the map is displayed on a screen and can be edited, by a further method the final map is drawn on a plotter.

The content of a data base in an information system for geographic data could be a universal digital terrain model of the whole area inspected. From this universal digital terrain model, all existing digital terrain models ought to be derivable. Producing such a terrain model is the task of the data base administration programs. The processing of the gained terrain model, for example preparing a map, is done by a method selected from the method bank.

The data base and the method bank can either be realized on a single computer, to which the user terminal is also connected. Or these components can run distributed on local computers connected by a computer network.

Whereas the input of information into the system is a task for a special trained person, the evaluation of stored information should be possible without special knowledge of computer science and photogrammetry. The information system has to adapt itself to users with different knowledge. For persons working rarely with the system a computer guided dialog is preferable, by which methods and parameters are selected from a given menu. This kind of communication with the computer is simple, but time consuming. Well trained persons should have the possibility to specify their wishes also in form of short commands.

Comfortable use of the system, adapting the system to different users becomes more and more important in the future. With the development of new methods also the number of users increases, especially of those users working rarely with the system. Possible are for example the display of perspective terrain sketches, where the standpoint and the viewing direction of the viewer is selectable, or the plotting individual maps according to personal requirements for architects, travelling managers or also privat persons.

In this context, the analytical plotter is of lower importance. It only serves as data acquisition device for the information system. To use devices of different producers, a standard interface and a unique protocol for data exchange between data acquisition and evaluation is needed.

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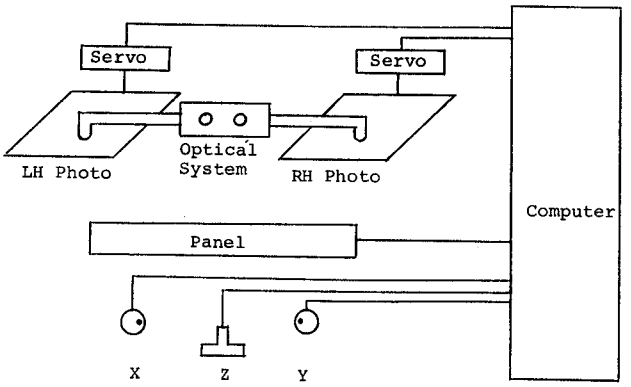

Fig. 1
Principle of today's analytical systems

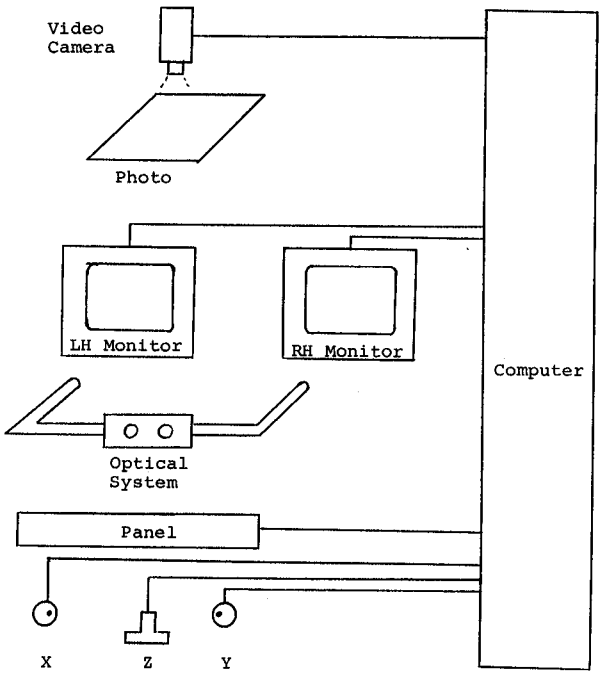

Fig. 2
Principle of an analytical system without motors and servos

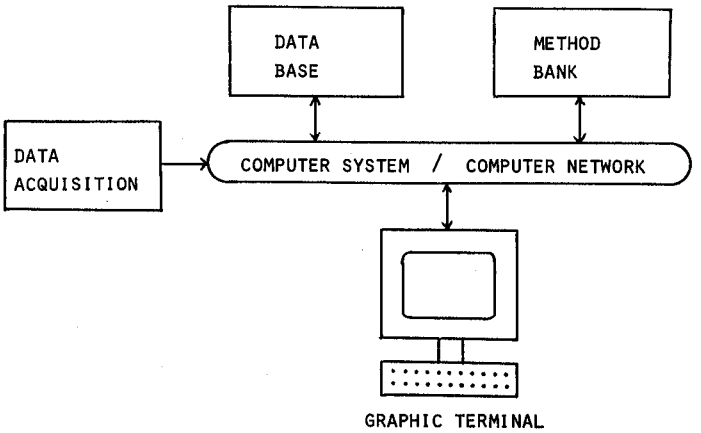

Fig. 3
Principle of an information system

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7. Final Remark

The idea of the analytical plotter is older than the computer science, as we understand it today. From the point of view of photogrammetry, the analytical plotters have reached a high level. From the point of view of computer science, they are at the beginning of their evolution.

Abstract

Analytical plotting systems are computer-supported systems for plotting geographic terrain information. For historical reasons there is still a close link in present-day equipment between information acquisition from aerial photographs by an operator and information output, e.g. in the form of a map on a plotter. The focus of future development ought to be a standardized data base for terrain information. For plotting, an interactive data base is suggested that should enable even non-experts to plot the terrain data as desired using selected graphical and numerical methods. The difficult and complex job of data acquisition from aerial photographs should be handled separately by a separate computer system that is connected to the data base through a standard interface.

ANALYTISCHE AUSWERTESYSTEME AUS DER SICHT DER INFORMATIK

Zusammenfassung

Analytische Auswertesyteme sind rechnerunterstützte Systeme zur Auswertung geographischer Geländeinformationen. Historisch bedingt besteht bei den heutigen Geräten noch eine enge Kopplung zwischen der Erfassung der Information aus Luftaufnahmen durch einen Operateur und der Ausgabe der Information z. B. als Landkarte auf einem Zeichengerät. Im Mittelpunkt künftiger Entwicklungen sollte eine standardisierte Datenbank für Geländeinformation stehen. Zur Auswertung wird ein interaktives Methodenbanksystem vorgeschlagen, das auch einem Nichtfachmann ermöglicht, die Geländedaten nach seinen Bedürfnissen mit ausgewählten graphischen und numerischen Methoden auszuwerten. Die schwierige komplizierte Erfassung der Daten aus Luftbildaufnahmen sollte unabhängig von der Auswertung mit einem separaten Rechnersystem durchgeführt werden, das über eine genormte Schnittstelle mit der Datenbank verbunden ist.

SYSTEMES ANALYTIQUES DE RESTITUTION ENVISAGES SOUS L'ASPECT INFORMATIQUE

Résumé

Les systèmes analytiques de restitution sont assistés par ordinateur et destinés au traitement des informations géographiques. L'évolution qu'ils ont subie dans le passé a pour conséquence qu'il existe encore sur les équipements d'aujourd'hui une étroite corrélation entre l'acquisition des informations par l'opérateur dans les aérovues et la sortie des données par exemple sous la forme d'une carte sur une table tracante. Dans les développements futurs, la primauté devrait revenir à une banque de données standardisée contenant toutes les informations relatives au terrain. Pour la restitution, on propose un système interactif de banques de méthodes, permettant à toute personne, même non-spécialisée, de traiter les données du terrain selon ses besoins, avec des méthodes choisies, graphiques ou numériques. L'acquisition des données a partir des aérovues, opération complexe et difficile, devrait être exécutée indépendamment de la restitution sur un ordinateur individuel relié à la banque de données par une interface normalisée.

SISTEMAS ANALITICOS DE RESTITUCION, CONTEMPLADOS DESDE EL ASPECTO DE LA INFORMATICA

Resumen

En el caso de los sistemas restituidores analíticos se trata de sistemas apoyados por computadores, destinados a restituir informaciones geográficas del terreno. Por razones históricas, en los instrumentos actuales existe todavía una estrecha relación entre la recopilación de las informaciones a partir de aerofotografías por un operador y la salida de estas informaciones, por ejemplo como mapa en un trazador. El desarrollo ulterior debería enfocarse sobre una base estandardizada de datos para las informaciones del terreno. Para la restitución se propone una base interactiva de datos que permita incluso al no experto en la materia restituir los datos del terreno según su deseo, con ayuda de métodos gráficos y numéricos seleccionados. La tarea difícil y complicada de la recopilación de los datos del terreno a partir de aerofotografías debería llevarse a cabo independientemente de la restitución, mediante un sistema de computadora separado, conectado a la base de datos por un interface normalizado.

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