LARGE SCALE MAPPING USING UP-TO-DATE PHOTOGRAMMETRICAL TECHNIQUES

EQUIPMENT FOR PHOTOGRAMMETRIC DATA PROCESSING /FAB/

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Introduction

The advantages of using the computational data processing and automatical plotters are well known. One of the important preconditions of introducing this advanced technique is, that the primary data acqusition information systems /in our case the geodetic and photogrammetric surveyings/ can be directly linked - by use of a computational data carrier - to equipments performing the forther processing.
Similarly also the requirement is not to be neglected, that in the phase of information acquisition /surveying/ each elements of data mass to be registered should be provided with complementary information /code/, on which the further processing is based and which possibly eliminates the necessity of an intermediary phase /manual coding, eventually digitizing/.

Among the different surveying techniques the photogrammetric one - due to its economy, speed and last but not least its accuracy - has remarkably gained ground. Without repeating the known numerical values reflecting the percentage of use, the role of photogrammetry can be considered reaffirmed to be one of the effective tools of numerical processing techniques in introducing the automatical mapping methods. Obviously before introducing the new technique also the possibility of use of the photogrammetry is to be effectively examined. It was aimed also by the research project of the Hungarian Institute of Geodesy and Cartography "Automatical Mapping Technique" in 1972-73 at /1/. In course of the research it was found, that using the stereophotogrammetric method, a technique differing slightly from the traditional one, a mass of numerical data suitable for production of planimetric elements of large scale maps by using automatical plotters can be produced /the control instructions keys - were determined in course of measurement of models/. The data gained this way meet the accuracy requirements demanded by maps of given scale, in addition there is a possibility for generalization and further information supply

by appropriate forming of point number. Our experiments have justified that the production of extra information /coding/ in course of the measurement has constituted a percentage of 15-30 % in loss of time by modell in city surveying compared with the traditional technique.
The conclusions drawn on the base of the researches are as follows:

1. The photogrammetric techniques can advantageously serve the automatical mapping methods, numerical processing.
2. In the span of time the research work had been carried out,the registration instrumentation in Hungary was not appropriate for reliable production of masses of numerical data of large volumen, at the same time it was not apt to meet the requirements of new measurement ways, as e.g.distance time interval registration.

To introduce automatical mapping techniques practically the following problems are to be resolved:

1. automation of terrestrial surveyings;
2. automation of data supply of photogrammetric surveyings;
3. putting in operation of an automatical plotter;
4. putting in operation of a digitizer;
5. Working out and adopting of computer programs processing the surveying results and controlling the automatical plotters;
6. Working out techniques for the whole process;
7. Taking into account of possibility of further developement /E.g. establishment of a data bank/ partly in purchasing the instrumentation and partly in shaping the techniques, computer programs.

Of the tasks listed above, we are at present dealing exclusively with the third one, one of the possibilities of automation of

the photogrammetric data supply. While to automatize the surveying totally new instrumentation /registration theodolite, registration tacheometer etc./ is needed, a similar level automation of photogrammetric surveying can be reached even by data recorders properly designed and attachable to instrumentation now available as an extension. Just in order to adopt our photogrammetric instrumentation now available for up-to-date processing ways, purchase or manufacturing of suitable data recorders is needed.
Starting from the base of different economical considerations it seemed to be reasonable to produce domestically an up-to-date data recorder.

1. Theoretical structural ground of photogrammetric data recorders, tasks related to their development

The photogrammetric data recorders consist of three fundamental units:

1/ in the case of analoge operational way 3 /x,y,z/, in the case of stereocomparators 4 /x,y,px,py/ devices coupled with the measuring instruments, sensing the coordinates measured by the measuring spindle of the instruments and furthering the results of sensing as well.

2/ control unit interpreting and providing the coordinates supplied by the instrument with key-numbers and symbols, which is apt to carry out other operations in addition and besides controls.

3/ the peripherals /type writer, paper tape punch, magnetic tape etc./

It must be noted, that the above list is valid only for data recorders attachable to photogrammetric instruments with measuring spindle.

The researches aiming at the development of the data recorder have been conditioned by the above structural division and this triple division was that, which has partitioned our tasks to be achieved into three separate processes. For us the task of interest was shaping the control unit described in point 2., since the immaginations enabling the data recorder to meet the requirements of the automatical mapping are first of all here realized. Taking all these into account a project has been prepared for data recorder /2/, in compilation of which the results of research-work mentioned before, the specialists' opinion from the enterprises, the experiences gained in course of the so far operation of data recorders /3/, and the related international professional literature available.
Upon the data recorder draft was based the research-development work of Müszeripari Kutató Intézet /Institute of Instrumental Researches/ charged to perform the development.

As to point 1./ /sensor units/ we had the possibilities, as follows:

1/ either to purchase the sensor units marketed by the firms manufacturing photogrammetric instruments and relying upon these the control unit will be developed, or

2/ trying to purchase sensor units appropriate to our goals from inland-market.

The Institute of Instrumental Researches presented its incremental analoge digital converter /3/ named Andimik at the Budapest International Fair in 1974, which satisfies the requirements claimed to sensors of up-to-date photogrammetric data recorders. It is an equipment sensing the rotation of a glass disc bearing a scale of 1000 divisions by photo-transistors and passing electronical signs to indicate the extent of the rotation.

As for its size, it corresponds to an American made similar device applied to the instrument WILD EK-8, and its resolution satisfies that of the Stecometer. /One rotation on the measuring spindle of Stecometer is of 1 mm, that is one division corresponds to 1 µm/. It must be noted, that Andimik is manufactured also with a resolution 3600 and 4000 lines/rotation, the use of such an Andimik, however, is of interest only, if the resolution power of measuring spindle is in agreement with that of the sensor.

So our troubles related to the sensor of data recorder has been over and what is more, through a purchase from inland market. The requirements claimed to peripheral of point 3 are as follows:

1/ speed,
2/ reliability,
3/ low noise level,
4/ computer compatibility,
5/ possibility to present the data in printed form,
6/ economy in purchasing.

Accordingly, the use of following peripherals seemed to be reasonable:

1/ paper tape punch 150-200 characters/sec
2/ magnetic tape or cassette data recorder
3/ typewriter or matrix printer

Though the computational processing considers the use of punched paper tapes to be secondary or tertiary, our data recorders are still provided with paper tape punch. So as a possibility, also we had to consider the use of paper tape punch to be able to join to computer programs.

Having as our primary goal to automatize the planimetric content of the map the use of more compact, economic and easyly handling cassettes has been chosen.

Simultaneously with starting the researches concerning the development of the registration equipment the BRG has completed the cassette data recorder LK-4, so the problem of its purchase could be resolved by using home sources. Problems can obviously arise in the transfer of data fixed in cassettes to computer, the BRG, however, manufactures a converter /EK-9006/,which transfers

the data registered on cassettes to computer compatible magnetic tape. To get the data in written form a Polish-made matrix printer and a typewriter CONSUL, product of GDR have been chosen. The latter can be used even for manual data input and preparative works.
Accordingly, the Institute of Instrumental Researches has got the equipment for photogrammetric data processing /FAB/ ready, which started operating last year.

2. Objectives and main technical features of FAB

The equipment for photogrammetric data processing /FAB/ is a digital data acquisition and registration system destined for numerical plotting purpose performed by monocomparators, stereocomparators, analoge plotters operating with measurement spindle, which:

a/ receives the photogrammetric measurment results coordinate data converted into electric impulses, as well as identification data determined by the operator;

b/ stores the entered /digital/ data and performs some kind of arithmetic operations;

c/ enables the operator to check the data visually, to make the eventual corrections, to set in the desired operation way and to start the registrations;

d/ to convert the treated data in a form treatable by the peripherals and to control their function;

e/ indicates the instrumental and operational errors to the operator with sound and light signals, contributes to eliminating the error by an encoded error-message referring to the characteristic of the error.

The FAB can primarily be used in solution of plotting tasks of photogrammetric models. In addition it can be applied in digitizing of the data of great precision of different plans /maps, technical drawings etc./ and in registration of the data gained on different kinds of digital data-carrier.

Besides it can be adopted in fixing of data entered from typewriter onto punched paper tape or magnetic tape, in copying of data by programed controlling of cooperation of desired peripherals.
Being the operation of FAB controlled by programs stored in memory units, it can be programed for other special tasks.

The FAB consists of the following units:

1/ Control box, which includes the
- incremental interpreting unit
- unit setting the initial coordinate values, distance-time-interval values, tolerance values
- switches for peripherals
- control unit,
- power supply and
- ventillator box.

2/ Control panel /manual keyboard/, which can be placed on rolling wheels for the operator in a comfortable position to ease the execution of functions to be carried out. This panel contains the digital display unit of coordinates and point numbers, as well as operational way switches.

3/ Analoge digital converters are in fact sensor units attachable to the measuring spindles of photogrammetric instruments.
At present two types of sensor can be used for the equipment:

- Sensor unit Andimik /made in Hungary/, which is apt to be coupled with the measuring spindles of both Zeiss, and WILD instruments because of its dimension;

- sensor units placed in the digitizing box of Coordimeter-F, by use of which any instant junction to Zeiss instruments provided with selsyn connection is possible.

4/ Peripherals

- Typewriter Consul 260 /15 char/sec/;
- Paper tape punch DT 105 /150 char/sec/;
- Cassette memory LK-4 /140 byte/sec/ Storage capacity of on side of the cassette /C90/ is 1000 records;
- matrix printer DZM-180 /char/sec/;

The peripheral units are optional. The registration speed, however, is always determined by the slowest peripheral unit actually functioning.

The equipment functiones in the operational ways as follows:

1/ Standard recording. In this case the traditional measurement technique can be applied. The registration can be made either by using the foot plate, or pressing the proper button of keyboard.

2/ Averaging operational way. The equipment refers the difference of coordinate values of two consecutive registrations to a given data as tolerance. If the difference of coordinates does not exceed the tolerance value, the mean value gets into the peripherals. The excess of the tolerance value is indicated by a sound signal, as well as an error code appearing on the display.

3/ Distance-interval operational way. In the control unit the coordinate increments x,y,z can be set, in the case of excess of which automatical registration takes place. In this case the point numbering automatically increases or decreases after each recording.

4/ Time - interval operational way. The desired interval can be set between 0,1-9,9 sec with steps of 0,1 sec in the control box. The registration can be started by pressing the foot plate and the time-generator installed in the equipment is turning on permanently the registration according to time interval set is, until the foot plate is kept pressed down.

5/ Memory /storage of coordinate/ operational way. By using this operational way the point numbers and coordinates of maximum 4 points can be stored in 4 memory sections. These point numbers and coordinates can arbitrarily be stored and reregistered, eventually after the exchange of certain data.

By using the switches on the control box programs can be chosen to operate the equipment. These are as follows:

Program 0: it can be used for service works, with printing of the RAM content of the microprocessor /INTEL/4040/ built in

Program 1: Copying of information entered through typewriter onto punched paper tape or cassette. Compilation on heading.

Program 2: for the case, we intend to work with only two coordinate sensors /for instance use of coordinatographs as digitizer/ or for the case of monocomparator measurements.

Program 3: for the case of junction to analoge stereophotogrammetric instruments.

Program 4: for the case of junction to stereocomparators

Program 5: Transfer of the content of cassette onto punched paper tape and/or typing and/or printing. The transfer, printing can be carried out through steps by record or in continuous way.

In the case of using the programs 2-4 the decimal-digits of the measured coordinates can be arbitrarily changed. One coordinate consists of 6 characters. The keyboard of FAB is rather comfortable, it can be placed easily accessible for operators. Also for changing of point numbers it has a variety of possibilities. For example the total point number previously registered can be erased, or what is very often needed - only one digit can be changed in the previous

point number. The FAB enables us to attach to one point a point number /code/ consisting of 2x6+1x4 characters /N_1, N_2 and N_3/, of which in the digital section N_2 and N_3 "A", "F" and "-" signs can be written, so the variation possibilities of code numbers is increased. The digital section N_1 can be set to automatical counting.

From the keyboard also the sign "F" which is intended to indicate the erroneous records can be written to the typewriter, paper tape punch and cassette.
Using a switch placed on the keyboard the sequence of coordinates X and Z can be interchanged.
The memory operational way of FAB can be advantageously used for instance in registration for automatical mapping of planimetry. It namely occurs here very often, that some points have repeatedly to be measured, e.g. the corner point of buildings, at which the registrational had started, so that the plotter will finish at this point drawing this building.

By doing so not only time can be saved in measuring, but even it can be ensured, that each point to be measured takes part in the mapping possessing equal measurement weights.
The FAB has even the advantageous feature to have an extended error alarming system. The error made in course of the operation and the faults of the equipment respectively is indicated by its own error code and this way the error occured the operation or the instrumental faults can be corrected with ease.
By using the data recorder put into operation at the Institute of Geodesy and Cartography reseau measurement was carried out on the Stecometer. The reseau measurement was made using the Coordimeter-F, as well. The accuracy provided by FAB is of $\pm 2{,}2\ \mu m$, whereas that of Coordimeter-F is of $\pm 2{,}3\ \mu m$. Also these results reaffirmed, that the FAB does satisfy the accuracy requirements. According to view of operators working with FAB, operating the equipment is easy to learn, and comfortable.

3/ Development possibilities for the FAB.

Due to its system design, mechanical structure, and versatility the photogrammetric data processing equipment offers a possibility for multiplex further development. These further development possibilities do not affect the ground structural elements and function of FAB, but enable us in fact to build up a special computer for photogrammetric purposes by use of exclusively extension units, devices, and by compiling the program parts necessary to having the developed system function.

The further development can be basicly realized in two directions

1/ Extension of the peripherals

2/ On-line /eventually off-line/ operational way transformation of the measurement data into geodetical coordinate system

At present we are dealing - in the framework of the task point 1. - with junction of magnetic tape data storage.

R E F E R E N C E S

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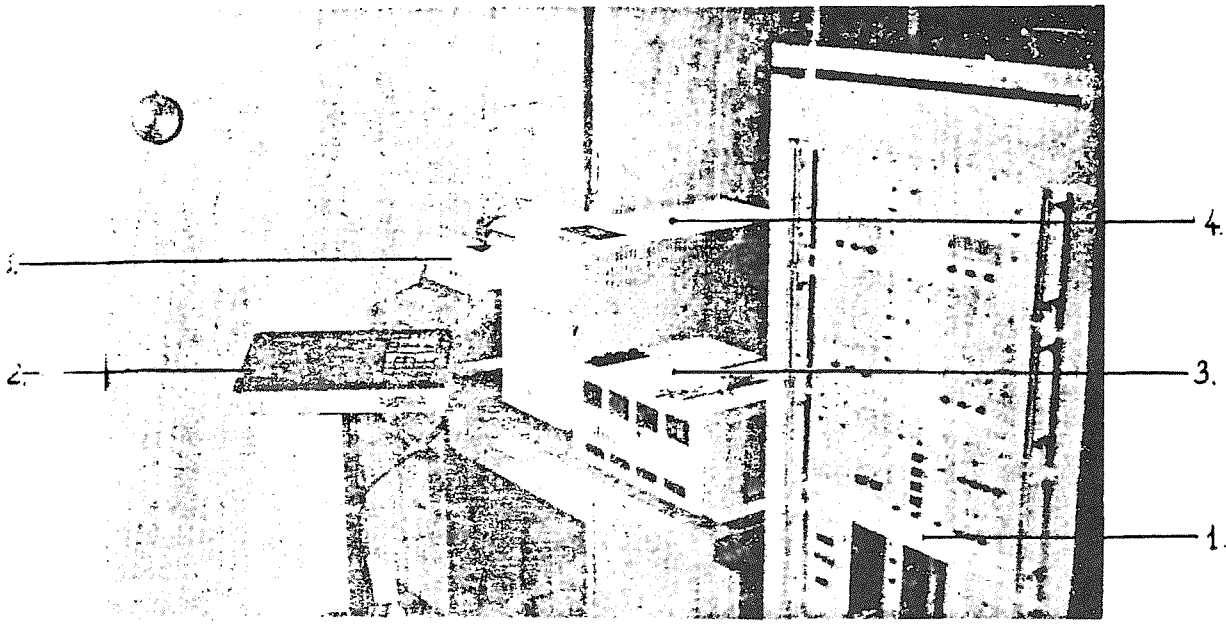
2/ P.Schreiber - P.Winkler: Data Recorder Project

3/ Description of The Data Recorder WILD EK-8

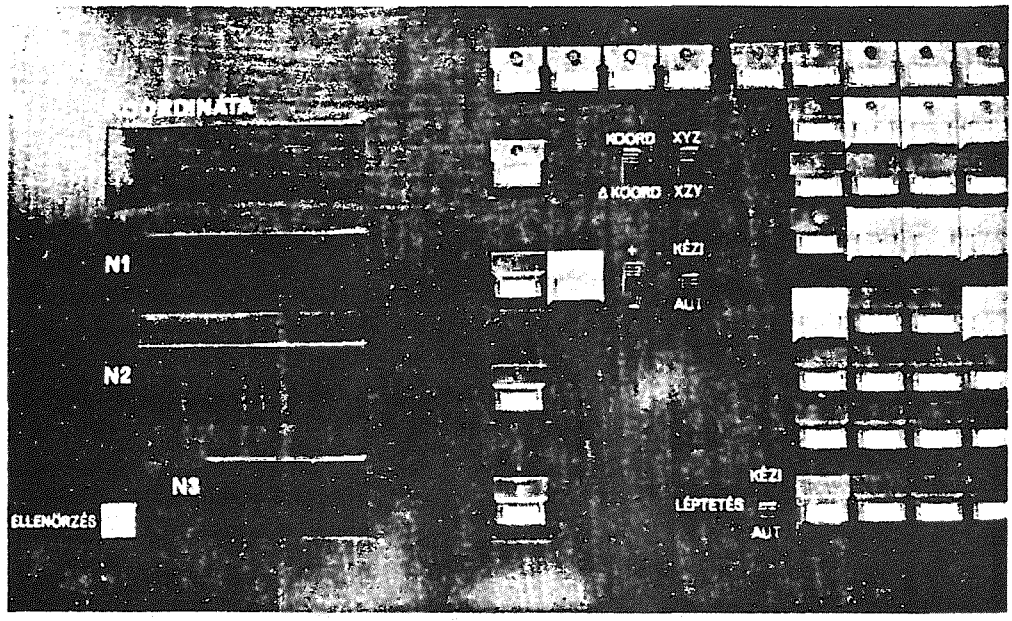
4/ Description of The Incremental Sensor ANDIMIK 1974. Müszeripari Kutató Intézet, Budapest

5/ M.Nagy: System Concept of a Photogrammetric Purpose Data Recorder. 1976. Müszeripari Kutató Intézet, Budapest



Equipment of photogrammetric data processing
/FAB/

1. Control box
2. Control panel
3. Paper tape punch
4. Cassette memory
5. Typewriter "CONSUL"



Control panel