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Photogrammetric Mapping systems supported by computers.

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Abstract:

For a long time the mapping systems in photogrammetry have been analogue by reason of the large number of the data involved. Interactive computer systems replace analogue by digital mapping rapidly.

This development gives new possibilities and forces us to start over again studies of the whole mapping procedure and the aim and use of the endproduct.

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Introduction.

Already for a long time photogrammetry is a well accepted mapping method.
In many cases it is the only method possible, e.g. for small scale mapping in inaccessible area's. But also for large scale mapping in developed densily populated area's photogrammetry is a qualified method for making various types of maps in different scales.
In the last few decades the photogrammetric methods have been improved rapidly as a result of instrumental development and last but not least by the influence of the electronic computer. This technical development can not be ignored.

In order to evaluate the stage of development we can distinguish:

- aerial triangulation;
- mapping process.

In the past the universal triangulation instruments and the instruments for detail measurements, the plotters, were quite different. Although this difference still exists it is now not so explicit anymore.

Aerial triangulation.

The determination of control points for absolute orientation of three-dimensional models or rectification of photographs is mostly done by aerial triangulation followed by block adjustment.
In former days the machine coordinates were read off the drums of the instruments and the operator made long lists of machine coordinates.
The strip or block coordinates were computed in one way or the other using deskcalculators.
This method is strongly influenced by:

- recording instruments of machine coordinates;
- electronic computers used.

Nowadays block adjustment with statistical analysis and detecting errors is possible and block coordinates are reliable endproducts.

Triangulation and block adjustment are essential links in the whole photogrammetric process.
Two notes must be made here:

- universal triangulation instruments have been simplified because analogue computations are more and more replaced by digital computations;
- photogrammetric data and terrestrial data can be introduced in one block and in this way an homogeneous group of points is built up.

Especially the combination of photogrammetric and terrestrial data in one system of adjustment as comparable quantities improves the accuracy of strip or block coordinates.
Such improvements by combination of data is only possible if both terrestrial and photogrammetric data are digital and well defined.

Mapping process.

The mapping process have been for a longer time analogue. The operator draws the first drafts on the drawingtable of the plottinginstrument and after that the cartographer finishes the map.

A large number of data are needed to describe digitally the terrain details.
Without special tools such large numbers of data are difficult to handle; the large list of codes and coordinates are unmanageable.
A graphic system supported by a computer can conveniently arrange the large number of data and make them visible on a screen. Besides, it can update these data if the systems is interactive. Such an interactive system gives new possibilities for photogrammetric plotting.
In the next section such a system will be outlined. It will be refered to the system installed recently at the Geodetic Department of the Delft University of Technology. Afterwards the interfaces with the photogrammetric systems will be discussed.

Interactive graphic system.

An interactive graphic system can be made up in different ways and with different peripheral equipment. The main parts of the system in our department are:

- computer PDP 11/70 with disk
  - console and line printer
  - terminal
  - tape reader and puncher
  - card reader
- graphical workstation
  - dubble graphic display screen
  - digitizer, menu-tablet and cursur
  - hardcopy unit
- software
  - RSX-11 operating system
  - standard I/O services
  - graphical application software

An electronical plotter, off-line, with punchtape reader is available in order to draw the maps.

The interactive sytem will be used for education and research in different fields in our department: cartography, photogrammetry, land information systems, etc. The introduction of such a system demands of course adaptation of the systems in the other fields. Because a system is only profitable if the different systems, for example the graphic and photogrammetric systems, are adapted to each other and last but not least the method of measuring and computation and the data management must form a balanced unit.

Photogrammetric systems.

In order to adapt the hardware of the photogrammetric system to a graphic system the peripheral equipment, here the most important

part, can have different components.
In our photogrammetric laboratory we will realize the following combinations with photogrammetric stereo-instruments:

a. alphanumerical display and punchtape output;
b. microprocessor and teletype;
c. graphical display.

For the sake of completeness the following are mentioned here; a. will be combined with the Planicomp of Zeiss; b. with the Wild A7 and c. with the Wild A10. The latter combination will later on be connected on-line to the graphic system.
Both the Wild A7 and Wild A10 still have a drawing table analogue on-line to the instrument.
These three components are choosen on account of the already available photogrammetric instruments and with the intent to have different possibilities for education and research.
Figure 1 gives a diagram of the photogrammetric station and the graphic station on-line with the computer.

In the preceding section the computer supported drafting tables, the on-line digital mapping systems, are not mentioned, just like many other possible combinations of microprocessors, displays, I/O equipment, etc. Here only a brief outline of the system in our laboratory is given and what's more a fully overall picture is hardly possible for this process of growth has not crystalized for the time being.

Mapping procedure.

The development of hardware and software rapidly influences the procedures in photogrammetric mapping and triangulation. The interactive graphical system in particular influences the mapping procedure and it gives new possibilities for digital mapping.
Introducing such a system changes the task of an operator collecting the data.

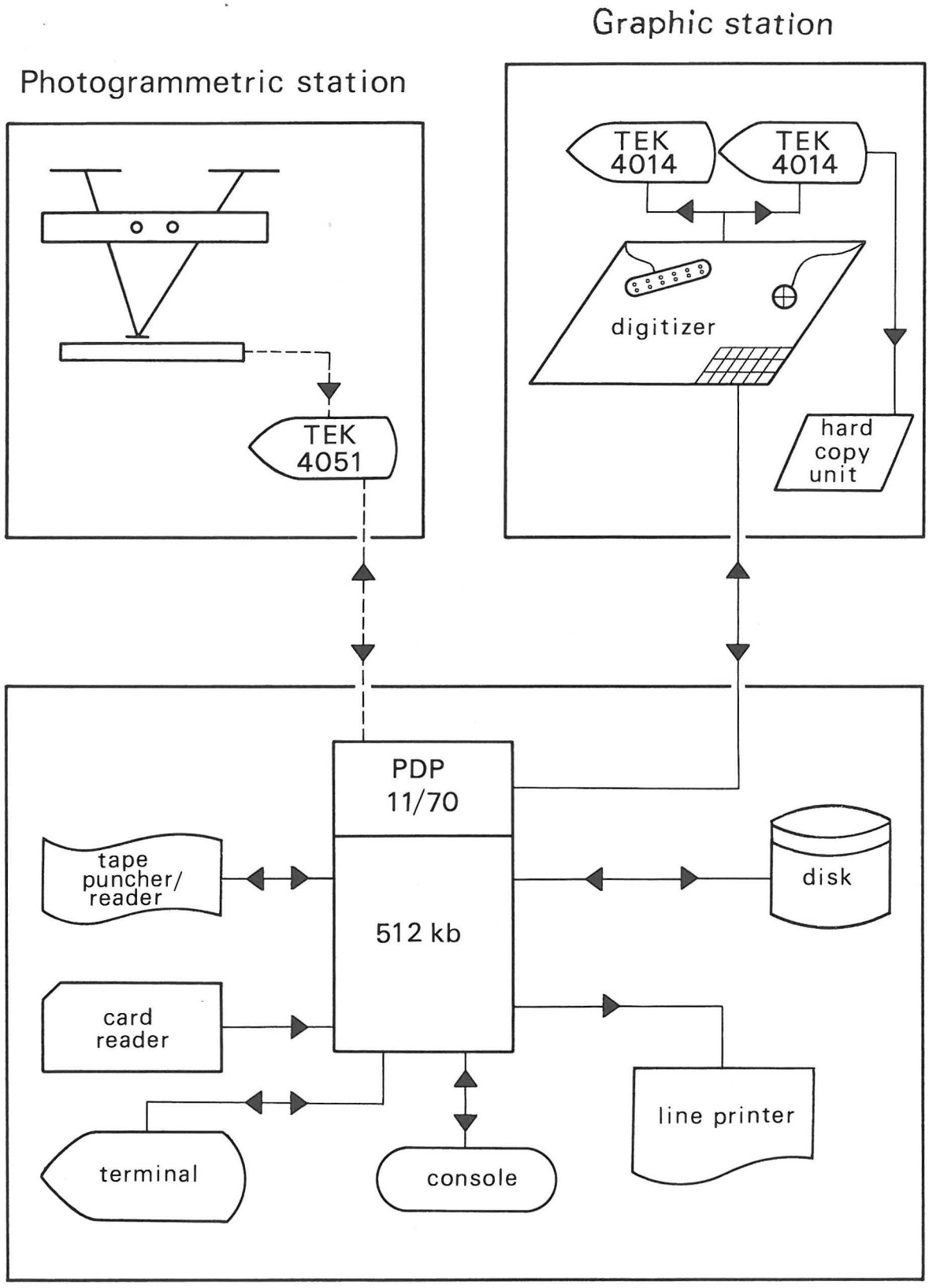

Figure 1: The on-line graphic and photogrammetric station

He has now other tools for:

- registration of the measured data and that means e.g. continuous drawing is impossible;
- indication the points, lines or objects with different codes; that means e.g. he must know the relation between classification and codes;
- checking the data on errors, completeness, connection of the models, etc.

The peripheral equipment as mentioned in the previous section as the 3 components a., b. and c. gives different solutions. Which of them is the most adequate depends not only on the experiences and quality of the operator but also of different aspect, e.g.;

- type of terrain details;
- contents of a map in relation to scale.

Attention will be paid to one task of the operator in particular:

- checking the data on errors, completeness, connections of the models etc.

The peripheral equipment in our laboratory is choosen in such a way that at least some control of the measured data and/or codes can be done by the operator himself in one way or the other.

It is very important to detect an error as soon as possible for two reasons:

- more trouble and/or more time is needed when errors must be found in a later stage;
- probably more important is that some errors can not be found in a later stage.

It must be noted here that in most cases it will be impossible to detect all errors during the measuring-stage or it will take up too much time, but a number of errors can easily and objectively be found dirctly by the operator, depending on the available hardware and

software:

- the forward and backward measuring;
- number of points;
- completeness of the model;
- parts of the codes;
- connection with preceding models;
- etc.

A good weighing one against the other is essential in order to get a faultless product as good as possible on one side and on the other side the operator must continue his measurements without loosing too much time and without too complicated an instruction. The operator who is doing the measurements is an important link in the whole process and must primarly pay attention to the observations.

Advantages of digital mapping.

Digital photogrammetric mapping has different advantages. It can not only give a product of higher quality but it also speeds up the mapping procedure and, probably more important, it leads to new possibilities for photogrammetric products.

A better quality can be realized by advanced checking-systems and by statistical testing of the digital data in relation to the method of measuring.

Speeding up can be realized by automatic drawing replacing the manual method which takes up much time.
However a wider use of the digital photogrammetric data is probably more important. The society demands more and more recent information presented in such a way that it is usable in different branches. If advanced hardware and software is available digital data are flexible and can easily and simply be merged in other digital data refering to land-use, recreation, environment conservation, public utility services, etc. A well thought out combination of different data must be presented to the user in such a form that it is convenient for his

purpose. It will then give him valuable information.

Closing remarks.

In photogrammetry just like in surveying and in cartography the introduction of computer techniques and computer graphics is increasing rapidly. This development forces us to redefine the process more systematically and strictly and it will result in common interest and similar problems. In consequence the boundaries of the disciplines fade out and this is not surprising because a common part of scientific and technical activities is to describe the physical surface of the earth or the objects on or in the neighbourhood of the earth surface.

The activities can be devided in two main parts:

- collection of data;
- presentation and design of data.

Both parts concern in mangement of data.
To describe the earth's surface metrically and non-metrically data must be collected, e.g. by means of:

a. measurings and observations in the fields;
b. measurings and observations in the photographs or using remote-sensing data.

Both parts a. and b., data of surveying and of photogrammetry, must be combined to one homogeneous product, just like data of aerial triangulation and coordinates of ground control points in one block adjustment.
Cartography is concerned with graphical design and presentation of the data to the customer.
For both collection as well as for the presentation of the data the technological innovations change the techniques and it forces the different disciplines to co-operate and in response to this process the demands of a larger and larger group of customers will increase. They can no longer carry out their duties without more and up-to-date information.

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