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THE DEVELOPMENT OF AUTOMATIC MAPPING TECHNOLOGY AT THE DEPARTMENT OF SURVEYING

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Abstract

During the last 20 years our Department have had research projects in the field of digital mapping. We developed technologies for high-quality digitising. Our experience and results are summed up in this paper.

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There have been researches and experiments based on different tools and technologies on the use of computers in automatic mapping at the Department of Surveying at the Technical University of Budapest since the late 70s.

The development of computing accelerated significantly in the 70s, its effect could be felt both in hardware and software. Since there has been a desire for the automatization of map construction, which demands a lot of time consuming manual work, it seemed to be logical to conduct experiments in this field. In 1979 the department got a **Digigraf 1612** plotter made in Czechoslovakia, however, with weak software and hardware conditions at the beginning. The input periphery was a paper tape reader device, outdated even at that time. The basic software for the plotter should have been installed on a computer not available at the Technical University at that time. Therefore the first step was to establish the necessary work conditions. After obtaining and connecting a magnetic tape unit, we developed the basic software for the plotter, which made it possible to drive the plotter from Fortran programs. Then came the first attempts to automate map construction.

The first stage was a program to draw symbols on the map sheet from a coordinate list. This made the construction work easier and better because the plotter resolution reached or passed the accuracy achieved by drawers (0.05 – 0.1 mm). Later on the program was completed with a sheet frame and cross marks, thus, the drawer only had to make the connections, draw the annotations and symbols. Then a program system was developed to process field surveying or photogrammetric data to draw the whole map.

Parallel to this, there were researches for further updating of construction, with the aim to make connecting automatic. It was a very difficult task because there were no interactive graphic devices at that time. To describe connections we had to work out a code system, which was usable at field surveying and made error correction easy at the same time. Its development was accelerated by the project of the National Computing Service about the control drawings of their digital map containing parcel borders only. The data file made by the National Computing Service was displayed by the help of a program developed at our Department. These drawings served as basis to improve the numeric data file.

The above mentioned developments and technology made the map drawing partly automatic but they showed as well that without interactivity compilation of accurate digital maps was very expensive and time consuming. That is why it was of great importance when our Department obtained an up-to-date interactive map constructing and drawing system, the **GRADIS-2000**. Digitisation was helped by an A0 digitising table and a high resolution storage tube graphic display, and the software had all the interactive constructing functions that could occur during mapping. The externally financed projects of our Department helped a lot to learn about the possibilities of this system. In the frame of these projects we could demonstrate the mapping functionality of the **GRADIS-2000** system in different applications.

GRADIS-2000 was first used to prepare the digital facility management map of the Nuclear Power Plant of Paks. Some of the maps had already been available from the beginning, they had to be digitised, at the more important places digitised data were replaced by numeric co-ordinates. The newly built buildings were constructed based on field sketch. To create the map structure we used the key number system of **GRADIS-2000**, this way we managed to ensure the inquiring needed by the users. Later on it became necessary to gather and display attribute information together with graphical data. The system supports it by handling alphanumeric attributes. After finishing the task, we converted the data into the necessary format and we handed it to our customers, where – as far as we know – it is still in use and is updated.

Our next task implied research on the registry peripheral track establishments, charged by VÁTI. Before starting the work a lot of questions had to be cleared. The main problem was how to handle the graphical and attribute data together. Because there was no proper tool, the problem was to be solved with graphical maps and traditional card index. On **GRADIS-2000** system we presented a sample data file for 1:100 000 and 1:10 000 map sheets. To achieve this we worked out the necessary key number system as well as the structure of attributes. The sample system served as a basis of the operating computerised registry.

On commission of the National Computing Service and the Land Office of Budapest, as part of a research we digitised four 1:1 000 sheets of the first district of Budapest, given in the stereographic projection system. Our task was to examine the possibility of transformation between the formerly used stereographic projection and the unified countrywide projection system (EOV). The EOV co-ordinates of the parcel border point were given on magnetic tapes and we also had at our disposal the four stereographic sheets. We connected the parcel borders on screen using the given parcel border points and we digitised the inner content of parcels (buildings, other lines, etc.) using affine fit in transformation. We calculated the area of the parcels and compared it with the original registered areas. We examined each contradiction and made the necessary corrections. Finally we created the map sheets according to the Unified Countrywide Map System.

The practical use of this technology followed this task: we had to process the digital file of the parcel borders of the 13th district in Budapest. The file contained a lot of geometric and structural errors. It would have been an enormous job with a high error percentage to separate and correct them without an interactive system. We converted the data into our **GRADIS-2000** system and digitised the missing content to it. We converted the file containing all the data of the district into IDS structure and handed it over to the National Computer Service. Since there has been no further updating, we suppose that the data are more or less outdated nowadays.

The next experiment covered digitising the service maps of the Danube Oil Company. The available maps were very dense with a lot of modifications. To handle them in the traditional way became very clumsy. We managed to make a better structure using the key number system of **GRADIS-2000**. We digitised some service blocks, which we presented partly in plots and partly in AutoCAD DXF format. The digital map data are still used for planning and registry.

In Germany, in Schleswig-Holstein county the local electricity company started to register its network on **GRADIS-2000** system more than a decade ago. The basis of the registry is the digital cadastral map. Of course it is not available for the whole area of the county, so the company digitised them for its own purposes. Since digital registry needs a lot of work, they get involved affiliated companies to solve the problem. It means that the digitisation of base map was partly done here. At the beginning there were a lot of difficulties caused by the different form and content of the German surveying base map compared with the Hungarian standard. The base maps available are of two kinds: on the one hand, it is an island map in Soldner projection, on the other hand, it is in a standard Gauss-Krüger sheet. The scale can be between 1:500 and 1:4 000. The final product has to be a 1:2 000 scale digital Gauss-Krüger sheet. For the transformation of island maps we use at least four fit in points given in the Gauss-Krüger system. We use affine transformation before digitalisation. When digitising each clicked point is automatically converted into the Gauss-Krüger system. The customer gave us detailed instructions to create the structure, the key number system and the objects. To have a faster and faultless digitalisation we prepare each map sheet and denote the lines belonging to different objects and object borders. To get a nicer output on screen even in larger scales we square the buildings and correct it by construction where it is necessary. We make a test plot of each sheet to examine the accuracy of digitalisation. To detect the structural errors we made a controlling program. Finally we cut out the necessary Gauss-Krüger sheets with the commands of **GRADIS-2000**.

In another part of Germany, in Giessen the situation is different. Here the digital cadastral map is at our disposal and the town would like to register the canal lines attached to it, which will operate on the GRADIS-GIS system. As GRADIS-GIS is a real geographical information system, a very strict rule system must be followed. We digitise with the help of the **GRADIS-2000** system, according to the necessary structure for GRADIS-GIS. We input a lot of non-graphical information, partly as annotations, partly as attributes. The control is many-sided, we examine the graphic on plots, and the attributes and the structure on alphanumeric lists. We have the necessary program to convert **GRADIS-2000** data into GRADIS-GIS system. That is how a simple interactive graphic workstation can serve as an input tool for a more complex geographical information system.

As it can be seen from the above mentioned topics, a lot of experiments made it possible to create technologies that can be well used in automatic mapping. We would like to report this experience gained during the last mentioned work in Germany. The steps of the technology are similar to the described ones with other work as well.

We summarised the process of digitalisation in the enclosed flow chart, both in the manual (table) and head-up (on screen) digitisation. Let us have a look at how we could fill the flow diagram with content to have a good quality, faultless product. The description refers to manual digitalisation but similar methods are needed for scanning, too.

We examine each paper or foil sheets in each step of process. Although we can calculate with similar quality during the whole work, the step-by-step examination is necessary because the sheet quality may change, e.g. due to copying errors. The examination starts with a survey when we check the general quality, foldlessness, damages. We examine two perpendicular directions of size of the sheets with length measurement. It is necessary to have enough fit-in points. We make an approximate orthogonal transformation to check dual errors of fit-in points. If two fit-in points have the same offset, the affine transformation used during digitisation is not sensitive for this error, and the digitised points will have blunder error.

Preparation starts with the construction of the overview map. As Gauss-Krüger sheets and island maps (Soldner) come together it will be impossible to join the sheets without an overview map. The digitalisation of sheets is done in a strict order by settlements, locations, scales, projections. To ensure the order we assign an ordinal number to sheets. The most important part of the preparation is the qualification of the lines of sheets. We add colours to the lines. This way we can ensure that it does not depend on the operator which line goes into which object. To decide it can be quite difficult sometimes, e.g. the well-known problem of yard or building. We can decide on the function of some lines only when following them through several sheets. As the sheets may overlap and not all the lines have to be digitised, we erase them. We try to replace the missing fit-in points, picking up points from the neighbouring sheets or calculating new points. Our experience shows that it is worth spending time on preparation because a skilled person can qualify in good circumstances, which decreases the number of errors and increases the utilisation of the expensive digitising work stations.

Before digitalisation a transformation has to be done. It has several aims: it denotes the position of the sheet on the digitiser table, corrects the sheet errors, it converts between the digitiser co-ordinate system and the surveying co-ordinate system, and projection can be switched in this case between the Soldner and the Gauss-Krüger projections, but we can have similar problems with Hungarian maps,

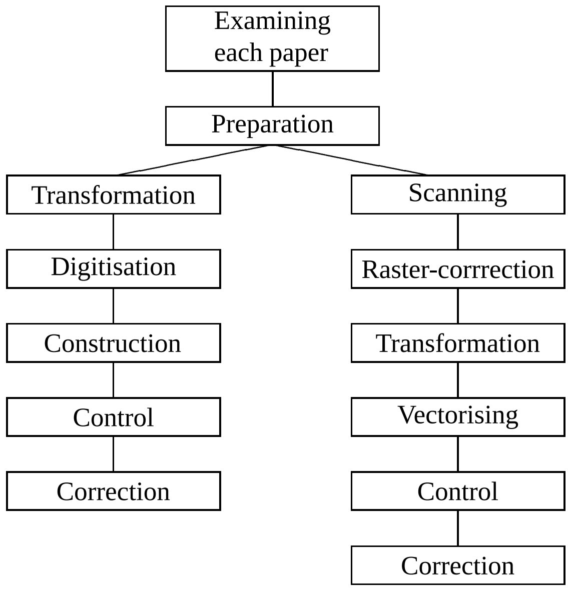

Fig. 1. Process of digitalisation

too. The transformation is always done with the affine method. There is a strict error limit for the standard deviation calculated from the contradictions. If we exceed it we have to pick up new fit-in points, at the worst case the sheet can be sent back. We make a list of the transformation of each sheet, which has to be enclosed as a quality certificate.

Digitisation is done on a high-quality digitiser table with an object oriented software. Lines of different colours get into different object groups. Since the ultimate aim of establishing a digital file is to create an object-oriented geographical information system, there are strict rules for the inner structure, too. E.g. the two banks of the river get into one object, but two elements, digitised in the direction of flow and the arrow showing the direction of flow get into the same object but into a different symbol element.

We can make certain constructions during the digitisation. The buildings (especially displayed in very large scale) can be roughly distorted during digitisation. This has to be corrected partly by the available squaring software, partly (especially in the case of supplementary buildings) by manual construction. We have to pay attention to the fitting and parallelism of the buildings at the border of the parcels. The numbers of the houses and other annotations have to be well placed, etc.

To ensure the quality, it is essential to work out the control system. In our case it is manysided. We have a data form of each digitised sheet, to follow the continuity of the work and the present state. The operators are partly directed by the technology. They can activate any digitising command from the menu, following the instructions. It ensures that only the necessary elements, drawing keys, symbols or annotations get into the given object. The menu helps the operator in finding the errors. The drawing is displayed on the screen with the same colour as on the map. This is the first step of control. We make a test plot of each sheet on a transparent foil. It is compared with the original one, so the errors of content and structure, the incompleteness and inaccuracy of digitisation can be filtered. The faulty plot is given back to the operator, several times, if necessary. Fortunately nowadays the operators are so experienced and disciplined that correction is often unnecessary. The last faultless test plot proves the good quality of our work and it is handed over to the customer. This is the second step of control.

The faultless neighbouring sheets are joined at the borders. Since the key number and the drawing key are displayed joining two lines, there is a repeated structural control (3rd step of control).

We have to make the new (in our case the Gauss-Krüger) sheet from the joined faultless original sheets. Since this is done by the command of the digitizer software which checks the inner structure of the map, another fault filtering happens (4th step of control) .

We run control programs on ready data files. These control programs were developed at our Department for each work depending on what kind of file is needed. With these we check the correctness of structure, the necessary object and drawing keys and the contradictions. If it is necessary we examine the topologic correctness of each element, e.g. dangle nodes, non overlapping areas. (The software is able to generate such areas from border lines.) We make statistics of the faultless sheets, to give an account and to check our performance (5th step of control.)

The final faultless digital maps are handed over to the customer according to its need, including the magnetic media and the format. We make the DXF conversion, which is the most common demand nowadays, taking into consideration the special need of different softwares.

With the help of the described technology not only the given work but any mapping – digitization task can be done with great reliability and controls in required number. This description is based on the experience and experiments of the last 20 years showing the significant intellectual capacity of our Department.

References

[1] CSEMNICZKY, L. – DEÁK, O. – HOMOLYA, A. – SZESZTAINÉ, SZ. E.: Budapest I. ker. földmérési alaptérképeinek digitális átdolgozása az EOTR-be; Kutatási jelentés, BME Általános Geodézia Tanszék, 1984.

[2] MASLOV, O. – HOMOLYA, A. – KIS PAPP, L. – MÁRKUS, B.: Automated Computerized Production of Operative Maps; *News Letter,* IV. 1986. 3.

[3] HOMOLYA, A.: GRADIS-MOSKITO; *Térinformatika,* 1995. 5.

[4] CSEMNICKY, L. – HOMOLYA, A.: A digitális térképfeldolgozás minőségi kérdései; *VI. Országos Térinformatikai Konferencia,* Szolnok, 1996.