TOPOGRAPHIC INFORMATIONS AND ARCHIVING SOFTWARE (TOPIAS)

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Abstract: 85% of Austria is covered by a digital terrain model with the point distance of 30 to 120 meters. The paper presents an overview of the method and software applied to archive the data. Terrain elevations are stored on sequential mass storage devices managed by an on-line, direct access information system. The information system stores further, readily available information on extensive files (such as the files for aerial photography, for projects, for control points, and others). Information can be inquired by specifying any combination of attributes (such as photo scale, owner, data acquisition techniques, date etc.), and/or limiting polygons of area of interest. The paper concludes with the description of present applications of the system, and of applications expected in the immediate future.

Zusammenfassung: Vor dem Hintergrund, daß in Österreich ein digitales Höhenmodell mit einem Punktabstand zwischen 30 und 120 m bereits für 85% des Staatsgebiets fertiggestellt ist, wird die Archivierung der Geländehöhendaten verwendete Methode und Software erläutert. Neben der Archivierung der Geländehöhendaten auf sequentiellen Massenspeichern werden umfassende Dateien (Bildflugdatei, Projektdatei, Passpunktdatei etc.) in einem Informationssystem auf einem Direktzugriffsspeicher angelegt. Die Anfragen an das Informationssystem können interaktiv in allen Kombinationen der Eingabeparameter (Bildmaßstab, Eigentümer, Datenerfassungsart, Datum etc.) und/oder der koordinatenmäßigen Festlegung eines Interessensgebiets gestellt werden. Am Ende des Vortrages wird auf die Anwendungen eingegangen, die mit den archivierten Geländehöhendaten bereits praktiziert werden und die in unmittelbarer Zukunft beabsichtigt sind.

1 PRELIMINARY REMARKS

The digitally controlled production of orthophotos has been introduced in Austria in 1977. As a by-product of this process, digital elevation models are created /5/. The largest amount of data is processed by the Austrian Federal Bureau of Standards and Surveying in Vienna. Upto this date, the Bureau digitized some 60 million points situated at the distance of 30 to 120 meters from each other and covering 85% of Austria. Private engineering companies also accumulated considerable amounts of data in the process of digitally controlled orthophoto production during the recent 10 years, using in most cases aerial photographs 1:5 000 to 1:15 000. Furthermore, there is an extensive amount of digital terrain data acquired and processed for purposes other than the production of orthophotos.
These developments involve the task of "archiving" the data, and making them accessible for different applications. The Institute of Photogrammetry of the Technical University of Vienna started 1979 the development of an independent topographic information and archiving software, TOPIAS. The original design has been published 1980 /1/. Here, the current state of development of TOPIAS is described including necessary hardware and software specifications, and interfaces to other programs.

2 DESIGN OF THE PROGRAM SYSTEM

The fundamental assumptions in designing the system have been:
- repeated applications of terrain data occur once in a couple of months if not of years, i.e. these data may be stored on media such as magnetic tapes, and the similar;
- in the case of application, the data retrieved should be readily available for a period of days or weeks on storage media directly accessible by programs, such as magnetic ("hard") disc units;
- manifold characteristics of the data as archived should be immediately and permanently available for inquiries, and for purposes of data management.

The directories "flights" and "projects" contain structured characteristics of the data archived. The following description of these directories corresponds to a direct way of describing the systems design as well.

2.1 Parameters of the flights' directory are:

Owner, flight number, company for aerial photography, archive number, date of flight, time of flight (taking off, starting photography, duration of flight and of photography), forward and side overlaps, type of the film, film number, gradation, camera, objective, focal length, aperture, exposition time, aeroplane, number of strips, number of photographs per strip, length of a strip, atmospheric circumstances (clouds, humidity, turbulence, etc.), status (e.g. flight planned or already performed, copies made, etc.), restrictions (e.g. border area to other countries), permitting office and permission number, comments.

These parameters are stored as a record of the corresponding flight, in a considerably comprised and coded form. In order to shorten response times, some pointers are added to these records. For instance, pointers for owners address those flights belonging to the same owner; pointers for date define the sequence of flights' in time. The most important of the pointers solves the task of structuring according to location. For this purpose, the entire area managed by an installation of TOPIAS (e.g. the entire country of Austria) is subdivided into a numbered squares of a location scheme /5/. Pointers for location combine those flights within the same square of this locating scheme. Pointers are set automatically by the program, in the moment of archiving some set of data.
As a rule, inquiries are possible with any combination of the parameters stored. The amount of response can be defined, as well. Inquiries are formulated using the command language DRE /
6/.

For instance, the directives for an inquiry (SELECT) to the flights' directory (FLIGHT) within an AREA of interest:

\[
\text{AREA, LIMIT}=7634; \\
\text{FLIGHT, SELECT, SCALE}=(10000,15000), \text{DATE}=850000, \\
\text{OWNER}=YES, \text{TYPEFILM}=YES, \text{LIMIT}=YES;
\]

where

- **LIMIT**: is the parameter defining the area of interest either by the number of a square within the locating scheme, or by a polygon;
- **SCALE**: defines (a range for) the photo scale, in this case as 1:10 000 to 1:15 000;
- **DATE**: all flights in 1985.

As a result, listed will be the owner (OWNER), the type of film (TYPEFILM), and coverage (LIMIT) for all those flights

- covering fully or partially the square 7634,
- flown in 1985, and
- of a scale from 1:10 000 to 1:15 000. The coverage is shown as a quickplot on alphanumeric screen or as graphics on a graphics screen, or on a vector type plotter.

2.2 Parameters of the projects' directory are:

owner, project number, company for data acquisition, date, coverage (points of a polygon), photogrammetric instrument, way of data acquisition (profiles, contours, break lines, ...), status (aerial triangulation measured or computed, digitizing ready, etc.), comments.

Just as the flights' directory, the projects' directory contains pointers for fast responses. Inquiries may be conducted with any combination of the parameters stored. Additional pointers between the flights' directory and the projects' directory (fig. 1) enable inquiries with parameters of both these directories. As shown in fig. 1, both directories can be organized hierarchically in combining some flights or some projects into MAIN FLIGHTS or MAIN PROJECTS, correspondingly.

As one can see in fig. 1, the projects' directory carries information and control points, and on individual photogrammetric models. This additional information corresponds to a data bank of control points. Control points can be associated with groups with different characteristics (e.g. accuracy, type, etc.); furthermore, they can be associated with individual projects or main projects.

Informations on individual models are deduced in the process of storing these models in TOPIAS. The process is shown in fig. 2. The data to be input usually are recorded on magnetic tapes by photogrammetric compilation. They are transformed into the state coordinate system by the program modul TRANS, and
Fig. 1: Structure of directories for flights, and for projects

stored temporarily on a random access device (disc). The user can avoid this transformation by specifying a corresponding parameter. In this case, TRANS performs just the task of introducing the data into the internal data structure. In storing data in TOPIAS, codes to mark break lines, heights, lows, border lines, etc. remain unchanged.

The models stored temporarily on the random access device will be copied by TOPIAS to magnetic tapes or other mass storage devices. In this process, information is added on each model so stored to the projects' directory (model number, limit, number of points, elements of absolute orientation, and the name of the magnetic tape with the data). Magnetic tapes may be organized according to the owners of data (OWNER) and/or to numbers of the squares of the locating scheme. The way of such organization is recorded on the tapes' directory. The management of this directory enforces the automatic creation of backup copies of all tapes.
Fig. 2: Storing photogrammetric models in TOPIAS

A model HEADER on a magnetic tape contains the following information:
- owner of data, date, model number, limit, number of points,
- elements of absolute orientation with accuracy characteristics, control points in the coordinate system of the model, and in the state coordinate system, units (meters, feet in xy and in z), origin (analytical plotter of the company ...), module TRANS, or other programs for digital terrain models such as SCOP), specification applied for data format and coding such as WINPUT.

2.3 The merits of the system design

Maybe the most striking characteristic of this design is that the original points are stored rather than storing an interpolated grid. Co-ordinates are transformed into the state coordinate system. The reason for this decision are:
- original measurements are more valuable than a grid interpolated using them; TOPIAS is a data bank of observed quantities;
- extracting the observations from TOPIAS for specified area of interest, grids fitting exactly the needs of the user can be derived by application programs, (e.g. grid step, handling break lines);
- in going over to other coordinate systems, no loss of information occurs. The co-ordinates of the original terrain points will be transformed into that system first, and the interpolation of a grid may be performed in it;
- easy adaption to revised state co-ordinates. After the corresponding changes in state co-ordinates of control points, the absolute orientation of the models on TOPIAS should be repeated.

A further unusual feature of TOPIAS is the application of e.g. Gauss-Krüger co-ordinates rather than geographic co-ordinates. In the most topographic information systems, geographic co-ordinates are used in order to avoid the problems of overlapping zones in projections such as Gauss-Krüger or UTM. TOPIAS is applied in the first line to manage data in limited areas. Therefore, it was decided to use the e.g. Gauss-Krüger co-ordinates as known to users working in large scale mapping projects. However, TOPIAS can handle an additional directory of location using a homogenous system of co-ordinates covering the territory of an entire country.

Finally, it should be mentioned that TOPIAS can manage data coming from sources other than photogrammetry, such as geodetic data acquisition or digitizing existing maps.

3 HARDWARE REQUIREMENTS, AND PARAMETERS OF INSTALLATION

TOPIAS is written in FORTRAN. It has installations on VAX 11/780, CDC CYBER 74, IBM 3033, and HP 1000 (with a special loader, address space 64KB). An installation on an IBM PC is in preparation.

The program needs: a memory of about 128 KB; a magnetic tape driver (or corresponding mass storage device); for each set of data stored in TOPIAS, some 200 bytes of disc space on every information file (e.g. the flights’ directory); and for each control point, 20 bytes of disc space.

There will be defined at installation time:
- the numbered squares of the locating scheme, and
- the names and meaning of parameters on the flights’ and on the projects’ directories.

4 ELEVATION DATA FOR USER PROGRAMS

Fig. 3 shows the data flow between TOPIAS and its surroundings. The area of interest is entered as a polygon, or as numbers of squares of the locating scheme. The corresponding models will be copied by TOPIAS from the magnetic tapes to the interface to user programs realized in the form of a direct (random) access file. The models can also be retrieved in specifying project and model numbers directly.
Successor programs can open and access the direct access interface file provided by TOPIAS. Examples of such programs are SORA to derive control information for orthophoto and stereo-orthophoto production, and SCOP to create and explore digital elevation models. Other forms of syntax for this interface can be written by the interface manager of TOPIAS: XMAN. It can be extended according to the needs of different users.

Considering the capabilities of the successor program system SCOP, the modules EDIT and PLOT should be mentioned first. With these models, data delivered by TOPIAS can be prospected, and changed. The data so changed can be replaced in TOPIAS using an internal interface channel between both systems. Editing data in SCOP is most convenient when conducted from a graphics screen. However, using an alphanumeric screen, individual pieces of data still can be efficiently addressed. Graphic output to terminals or vector plotters can be controlled by the user in very individual ways. At this point, the graphic interface of SCOP contains more than 15 different plotters and graphics terminals /4/.

The successor program SCOP contains, as most important tool, refined means of grid interpolation taking into account break line information. The result is a digital elevation model (DEM) — an interface containing, in addition to the grid points, points of intersection between grid lines and break lines etc. The data structure of this raster interface is characterised by random access to data blocks of constant length, and a two-level hierarchical index of addresses. It enables addressing of a group of points in some tens of a second, within a total area of interest covered by some hundreds of thousands of points. A set of FORTRAN-callable subroutines accessing this data structure is provided with the system.

The DEM with this data structure is accessed by different modules of SCOP. Products created by these modules include:

- contour lines taking into account break lines and close-off areas; intermediate contour lines can be derived depending upon local slope;
- profiles along curves, and the corresponding cross sections. This module can, in addition, read input files of different syntax containing XY co-ordinates of points, and interpolate the corresponding elevations; or to input points defined by all three co-ordinates, and output the differences between the elevation as read in and as interpolated on the DEM (e.g. an accuracy check of the model);
- central perspective views of the DEM from arbitrary points, including break lines, with handling hidden lines /2/. Fig. 4 contains an example in large scales;

5 CONCLUSION

Next to the basic modules of aerial photography, direct and indirect projection, and projection parameterization, for the complete process development of an aerial photography program an additional element is the use of computers and programming equipment.

Although the problems of aerial photography plotters and data processing should be considered,
Fig. 4: Central perspective view of a digital elevation model

- slope maps; these attained importance recently for judging the agricultural value of selected areas, for erosion studies, etc.;
- volume computation between two terrain models, where first the intersection of them should be derived /3/.
- fall-lines representing orthogonal trajectories to the contour lines /8/ (see fig. 5);

5 COMING VERSIONS

Next, two directories will be added to TOPIAS: the directory of aerial photographs, and of orthophotos. The directory of aerial photographs will contain pointers to and from the directory of flights. Photographs will have the following parameters:
- for groups of photographs - interior orientation (calibration protocol), and comments on quality of photographic developments, cloudiness, availability, etc.; for individual photographs - photo number, exterior orientation (results of an aerial triangulation tend to be in the future these elements, rather then control point co-ordinates), pointers to and from the corresponding photogrammetric models, pointers to and from orthophotos.

Although data on situation can be stored in TOPIAS - especially in the form they are recorded on analytical plotters - formats, interfaces, and modules of data management for these data in the sense of a topographic information system should still be developed.
Fig. 5: Contour lines at the top and fall lines at the bottom.
TOPIAS can store the contents of the raster interface, as well (fig. 3). This is necessary in cases where the grid interpolated for larger areas is needed frequently, and in the same structure. Storing and retrieving the grid makes repeated interpolation superfluous. Grid data are stored as subsets of "models in the state coordinate system". Therefore, grid data can be edited within narrow limits only; major corrections should concern the model data as stored in the state coordinate system.

As a closing remark it should be yet mentioned that we started to apply methods of digital image processing to display the DEM, and information as derived from it, with spectacular results. The world of raster graphics using corresponding color screens and photographic plotters should be further explored.

References:


