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UNION SCIENTIFIQUE TECHNIQUE DES GEODESIENS BULGARES

S Y M P O S I U M
"AUTOMATED PROCESSING OF SURVEYING DATA"

S Y M P O S I U M
"AUTOMATISIERTE VERARBEITUNG GEODÄTISCHER DATEN".

С и м п о з и у м
"Автоматизированная обработка геодезических данных"

Papers, Berichte, ДОКЛАДЫ

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C.C.Tscherning, Denmark

MANAGEMENT OF GEODETIC DATA

Zusammenfassung

Es wird ein Überblich über Methoden zur Dateneingabe und Datenprüfung gegeben. Hierbei zeigt es sich, das in allgemeinen die Ausgleichung nach der Methodé der kleinste Kvadrate zur Datenprüfung benutz wird.

Weiterhin werden der Aufbau und die Funktion einer geodätischen Datenbank und deren Managementsysteme erleutert, verschidene Datenbanken werden vergleichen. Auf zukünftige Problemstellungen (Beziehungen zu andere nicht-geodätische Datenbanken, Optimierung von Speicherstrukturen, Zugriffsmethoden und Datenmodellen) wird hingewisen.

Abstract

Procedures for data entry and validation are reviewed. It is found, that least squares adjustment is generally used for data validation.

Also the establishment and function of geodetic data bases and associated management systems are reviewed, and different data bases are compared. Future problem areas (interrelation with other non-geodetic data bases, optimalization of storage structure, access methods and data models) are pointed out.

1. Introduction

The International Association of Geodesy (IAG) established at its general assembly in Canberra, Australia, 1979 a so-called special study group (No. 4.66) "Management of Geodetic Data". The group has at present 18 members from 9 countries, with the author of this paper acting as president.

The activities of the group will be concentrated on the study of geodetic data bases and data base management systems (DBMS). However also data management problems in general will be studied. Important subjects are e.g. geodynamic information systems, the geodetic part of land information systems and problems arizing when adjusting large geodetic networks.

Geodetic data are born in the field or at geodetic observatories. The data are screened, and corrected or edited, a process which we in the following will call "data validation". The data will then become part of a geodetic data base, from which data will be extracted for the purpose of carrying out computations. The result of these computations (adjusted coordinates, gravity values, potential differences) will also become a part of the geodetic data base. Finally the data base, with its totality of observations and "results" will assist the users of geodetic data (the surveyors, geophysicists, cartographers) in carrying out their task.

The computer has until recently mainly served as a useful tool when carrying out computations (data reductions, adjustments and data transformations). However, the use of the computer for data handling was soon recognized by geodesists (see e.g. Buck and Tanner, 1972).

Since the General Assembly of IAG in 1975, the use of computers for data handling has had a break-through. Before 1975 the number of paper having as their main topic the handling of geodetic data could be counted on one hand. This present report lists nearly 70 papers published since 1975.

In the following we will give a brief survey of the activities in the area of management of geodetic data. In section 2 we will discuss data handling during field data entry and validation. In section 3 we will treat content, structure and function of geodetic data bases and finally in section 4 we will summarize the observed trends and look at the future problem areas.

2. Field data entry and validation. Data integrity.

2.1. Field data entry.

Geodetic data are born in the field or at geodetic observatories. Observations dating back to the end of the last century are still useful and used in computations. Hence, many geodetic institutions have been engaged in the process of bringing huge volumes of old data from field books into computer readable form, see e.g. (Love and Drosdak, 1978).

Technological developments of instruments have or will eliminate this process of key-punching hand-written data from field books. (See (Strasser, 1977, Kahmen, 1979 or Lundin, 1979)). There are different motivations for having data born directly on computer-readable form. These reasons include (1) personnel-savings, (2) elimination or reduction of errors, (3) faster transfer of data to a computer for data validation and processing. However, observation instruments with data recording equipment are still expensive and the equipment is not developed for all types of instruments. Furthermore a solution must (and have) been found for older (otherwise satisfacting working) instruments. Some solutions are:

(a) field data are prepared so that they can be read by an optical reader (Starzmann, 1977)

(b) field data are keyed into a portable general type recording unit (Rüffer et al., 1977)

(c) field data are keyed into a portable mini-computer with data processing and storage capability (and contingently a hard-copy output unit). (Whalen and Balazs, 1976, Beckers et al., 1979, Gubler, 1978, Schulze und Teuchert, 1978, Poitevin, 1979).

It is obvious, that solution (c) is to be preferred when it is desired to carry out control computations on the spot.

As pointed out in Safford (1978) control computations in many cases requires the knowledge of additional information e.g. coordinates of fix-points. This necessitates established procedures for the transfer of field data to a main computer facility. This general problem have been solved at NGS by having prepared detailed instructions for the format of input data (Pfeifer, 1978) and by having developed a <u>Terminal Entry Command Language</u> (TENCOL), (Safford, 1978). TENCOL has data validation capabilities as developed by Whiting and Pope (1976).

I. The general data base supporting all types of geodetic operations (e.g. NGS)

II. The specialized, gravimetric data base serving as a national or global center (e.g. Bureau Gravimetrique)

III. The data base established at a geodetic observatory (IFAG, TU-Berlin) or in a surveying organization or private firm.

The content of the data bases is in nearly all cases very well documented, see e.g. (Pfeifer, 1978). However, one feature which frequently is left out is the one described in (Poder and Madsen, 1978) and mentioned above. Such features, assuring data integrity, should be included in all old and new data bases.

A more detailed account of the data base content can be found in the referenced literature.

3.3. Access methods.

A general discussion of different access methods can be found in (Schwarz and Fury, 1977 and Tscherning, 1978, section 4).

Data bases which only have storage and retrieval functions tend to apply the simple sequential method of access. Otherwise index-sequential or direct access methods are used, cf. Table 2.

The index-sequential method requires the existence of unique identifiers. In cases, where these do not exist already, they must be constructed. Such constructions are not straightforward, and the problems encountered by NGS are very instructive: A first index was constructed using the station positions as given in NAD 1927 see (Alger, 1978). It was naturally simple to assign a number to trigonometric stations. Then other data types (e.g. astro-positions) had to be assigned the same number, however the matching had to be based on non-unique station names. This caused severe problems for which an interesting solution is described in (Fury, 1978).

Examples of unique identifiers for different data types are listed in Table 3.

3.4. External and conceptual schemas. Data models.

A discussion of different conceptual schemas or data models can be found in (Schwarz and Fury, 1977, Tscherning, 1978). These concepts are also discussed by (Kremers, 1979). External schemas does not seen to have been explicitly discussed in the geodetic literature.

Three data models are today generally used:

(1) The network model,
(2) the hierachical model and
(3) the relational model.

The model (3) can be regarded as a special case of (2), and model (2) as a special case of (1), see e.g. (Date, 1977).

The models differ mainly by implying to the DBMS different preferred way of accessing data. In the relational model it may be difficult to find out whether a specific instrument have been used in a specific station, while such information might be readily available in a suitably designed network model.

3.5. Data validation and check procedures.

Data validation during entry has been discussed in section 2.2. No further data validation and check procedures have been reported.

3.6. Back-up and recovery.

Back-up and recovery procedures are discussed in (Alger, 1978).

3.7. Supporting utility programs and routines.

The DBMS will perform the basic operations on the data like selection of data according to different criteria, see e.g. (Tscherning, 1978, Schwarz and Fury, 1977, Alger, 1978, Kremers, 1979). However it is frequently necessary to develop supporting utility programs and routines in order to achieve an optimal performance of the DBMS.

The most important supporting utility routines, which have been reported, are procedures for reference system transformation (Poder and Madsen, 1978) and gravity field interpolation or prediction (Poder and Madsen, 1978, Franke, 1979, Fila and Chamberlain, 1978).

Reference system transformation procedures permit that coordinates of points in different mapprojection coordinate systems can be readily computed. Coordinates resulting from different adjustments can not generally be transformed in a simple manner, but empirical interpolation-type techniques can be applied.

Instead of storing for each trigonometric and levelling station quantities like gravity, deflections of the vertical and geoid height, prediction procedures can be applied, if the horizontal and vertical position of the station is known. Such features reduce storage requirements, but may not necessarily be cost-effective as the prediction process can be very time-consuming.

4. Trends and prospects.

(Alger and Gurley, 1975) have investigated the possible use of commercially available DBMS. They concluded, that such systems were not feasible, because of the huge amount of data they had to deal with. NGS, therefore chose to develop its own system of which a detailed account is given in (Alger and Gurley, 1975, Schwarz, 1975, Schwarz and Fury, 1977 and Alger, 1978).

However, commercial systems have been used with success for smaller data bases as described by (McConnel, 1976, Madsen and Poder, 1978, Bayerische Landesvermessungsamt, 1978, Degerstedt and Schölin, 1979). (Some of the employed systems do not include all the facilities, which constitutes a DBMS).

The use of a central data base and the exchange of data between different data bases requires the standardization of data. The most important thing to agree upon is the content. Format standardizations are generally unnecessary, but may constitute reasonable guidelines.

Data standardizations are described in (Lepretre, 1976, Arbeitsgemeinschaft der Vermessungsvervaltungen, 1975, National Geophysic and Solar-Terrestrial Data Center, 1977, DMAAC, 1977, NASA, 1974 and most important: Pfeifer, 1978).

A future international exchange of geodetic data is necessary in order to create geodynamic information systems (see e.g. NASA, 1979). The further development of standards, which are agreed upon internationally, will therefore be an important task in the future.

Another important trend is pointed out in (Riordan, 1978, Smith, 1979): Geodetic Data will become part of other data bases, which primary functions are the support of non-geodetic activities like land management or military weapon systems. (See Table 2). On the other hand, geodetic operations require the access to non-geodetic data bases containing e.g. digital topography or geological data (e.g. for terrain correction computation). The problems of the future development of geodetic data bases, therefore, have many non-scientific, but for the society important aspects.

- Finally let us note that there still are many unsolved problems in the field of geodetic data handling:

  Which access methods and which data models are most suitable ?

  How can data-validation procedures be improved ?

  What are the best ways of data entry ?

The solution to these problems should be possible during the coming years.

Acknowledgment: Members of SSG 4:66 and several other colleagues have contributed to the preparation of this report by submitting literature references or other information.

Table 1. Content of various geodetic data bases.

Agency	Horizontal		Vertical		Gravity		Astron. azimut		Station description	Other (code)*	Source Reference
	obs.	pos.	obs.	pos.	obs.	val.	obs.	pos.			
National Geodetic Survey, U.S.A.	x	x	x	x		x		x	x	6,8-12 18	1,2,31,4 52,54,56 58
Canadian Geodetic Survey		x		x					x	11	44
Danish Geodetic Institute	x	x	x	x	P	x		x	x	6,11, 16,17	42
Vermessungsvervaltungen, BRD		x		x					?		3
Bayerische Landesvermessungs Amt	x	x	x	x		P					5
Bundesamt für Eich und Vermessungswesen		x		x					?		22,68
National Land Survey Sweden		x		x		x			x	12	14
Maritime Provinces Canada	x	x	x	x		P		P	?	11,18	17
Defence Mapping Agency (HTC) U.S.A.		P		P				P	P	12,14, 17	Persona communi
Org. f. Geodesy and Kart., Budapest		x							?		40
Inst. f. Angewandte Geodäsie, BRD.		x		x						~~2-6~~	65
National Ocean Survey, GRDL, U.S.A.										1	12
Tech. Universität Berlin										4,7	27
VEB Kombinat Geod. u. Kart., DDR.			x	x		x					19
Earth Physics Branch Canada					x	x			(Base Stations)	11,15	11,35
Defence Mapping Agency (AC), U.S.A.						x			"	1	16
Bureau Gravimetrique International						x			"	11,15	29
Nat. Geophys. S.T. Data Center, U.S.A.					x	x				11	39

* Codes used: Satellite altimetry = 1, Laser = 2, C-Band radar = 3, Meteorology = 4, Satellite orbit elements = 5, Doppler = 6, Earth-tide registrations = 7, Historical = 8, Cross-reference = 9, Geoid height = 10, Survey equipment = 11, Digitized topography = 12, VLBI = 13, Landsat = 14, Geological = 15, Photogrammetry = 16, Map-sheet reference = 17, Network connectivity information = 18.

P = planned, ? = not confirmed, by very likely.

Table 2. Access methods and function of various geodetic data bases.

Agency	Maintenance Storage Retrieval	Adjust-ment	Cadastral Landregi-stration	Mapping	Other	Access-method	Source Reference
National Geodetic Survey, U.S.A.	x	x				MI+S	1,2,31,41, 52,54,56,58
Canadian Geodetic Survey	x	x				IS	44
Danish Geodetic Institute	x	x		x		IS+S	42
Vermessungsvervalt-ungen, BRD	x		x			unknown	3
Bayerische Landes-vermessungs Amt	x	x	x			IS	5
Bundesamt f. Eich und Vermessungswesen	x	x	x	?		unknown	16,48
National Land Survey Sweden	x	P	x	x		IS	14
Maritime Provinces Canada	x	x	x	?		unknown	17
Defence Mapping Agency (HTC) U.S.A.	x			x	x	"	47
Org. f. Geodesy and Kart., Budapest	x	x				"	40
Inst. f. Angewandte Geodäsie, BRD	x	x				D+S	65
National Ocean Survey,GRDL, U.S.A.	x	x				D	12
Tech. Universität Berlin	x	x				IS+S	27
VEB Kombinat Geod. u. Kart., DDR	x	x				IS	19
Earth Physics Branch Canada	x	x				IS+S	11,35
Defence Mapping Agency,(AC),U.S.A.	x				x	S	16
Bureau Gravimetrique International	x					S	29
Nat.Geoph. S.T. Data Center, U.S.A.	x					unknown	39

? = not confirmed, but very likely, P = planned.

Access methods: Sequential = S, Index-sequential = IS

Multi-indexed = MI, Direct = D.

Table 3. Some currently applied indexing techniques.
(Methods for the assignment of unique station numbers or unique keys for observational data).

Agency	Station number derived from:	Key for observation or group of observations derived from:
National Geodetic Survey	a. Position b. State, Survey project, consecutive number	Station number, date/time observation type
Danish Geodetic Institute	Administrative area + concecutive number	Station number, field-book page, observation type
Institut f. Angewandte Geodäsie		Station number, Satellite number, time, observation type
NOS/GRDL, U.S.A.		Pass number, 5° Block number, geographical area boundary
National Land Survey, Sweden		
Canadian Geodetic Survey	Degree-square, project number, consecutive number	

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DISCUSSIONS DISKUSSIONEN ДИСКУССИИ

Deme, Hungary

Mr. Tscherning's paper on Management of Geodetic Data is an important and excellent representation of these activities. Some thoughts have arisen in conjunction with Mr. Tscherning's problem approach. Firstly - we should clearly distinguish the concept of data base and that of data bank. In my opinion data base is a temporary set of data which is necessary to almost all computer operations, for example automated mapping, digital models, data transfer operations etc. The data base should be created within the framework of the computer operation in question, and when the computer operation ends, the data base is unnecessary, perhaps can be eliminated or archived and replaced by other data base. As for data bank, the problem may have different ways of approach. Computer operations can be done in several places in the country. Apparently it shall need stable official data recorded on centrally or regionally located computer. This type of data stored and data management system can be referred as data bank.

P. Zafirov, Bulgaria

1. What has been effected in Denmark of the data base shown in the table? I am interested in this as I can see from the table that Danish Geodetical Office is establishing data base including for mapping.

2. What is the application of photogrammetry in creating data base?

C.C.Tscherning, Denmark

In our data base we have a number of files - photogrammetric and distance observations and any other kind of information which could be taken as an observation in order to produce coordinates. Gravity is assumed to be one specific coordinate which you have for a point. All names which are on the map are a part of our data base. Ortophotos in Greenland, made by 5/10km altitude are put in files too. Their rational use requires a good coordination between photographic data base and geodetic data base.

I. Trenkov, Bulgaria

Here actually we are discussing not a data base but an information system. The very concept of information system removes some contradictions between base and data bank. The information system model, shown by Mr.Tscherning lacks the euristic function of the system.

C.C.Tscherning, Denmark

Thank you for this very interesting remark. We are in unfortunate situation that with geodetic data we have to check that there must be consistency between our observations and the results. It's much worthwhile with topographic data base. I'll give you an example. We received from the US a part of their hard data base and what happened was we used it to compare to our gravity data, and some gravity data suddenly got a very large correction. We then went back and looked at the topographic and the digital model terrain in fact and found a 600 m big hole in the ground which naturally was not there and then we checked the data from our gravity data, again you see we have this problems in practice but there are also ways and we should think of such technics for checking the consistency and the correctness of our data.