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The Role of Geodetic Data in Land Information Systems

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ABSTRACT

Land Information Systems are a special kind of Geo Information Systems. By investigating into the common properties of these systems we notice the importance of geodetic theory for the definition of a uniform spatial referencing system (i.e. a co-ordinate system), which plays a central role in all Geo Information Systems.

1. INTRODUCTION

Before we can describe the role of geodetic data in Land Information System we have to investigate into some more basic problems. The terminology should be clarified and Land Information System separated form other types of Geo Information Systems (e.g. Geodetic Information System). This could be done through a classification of different types of data, stored in such information systems.

An analysis of the different functions such a system must fulfil leads to the need for a Uniform Spatial Referencing System based on a co-ordinate system. There we will identify some Geodetic problems which are theoretically very complicated but of eminent practical importance to all Geo Information Systems and therefore to Land Information System as well.

2. DIFFERENT TYPES OF DATA

A rough classification of different types of geometric data in earth science could include

- points and data related to points,
- observation-type data related to one or two points,
- parcel-type data related to an exactly geometrically delimited part of the surface of the earth (or a three dimensionally delimited part of the earth) (e.g. ownership to land parcels),

- raster-type or statistical data; generalized attributes related to a certain , very often regularly shaped area (e.g. land-use data stored in raster cells),
- function type data; to each coordinate point a related value exists but limitations in data collection and data storage make it impossible to store all these values—therefore only certain values are stored and others are interpolated (e.g. digital terrain model)

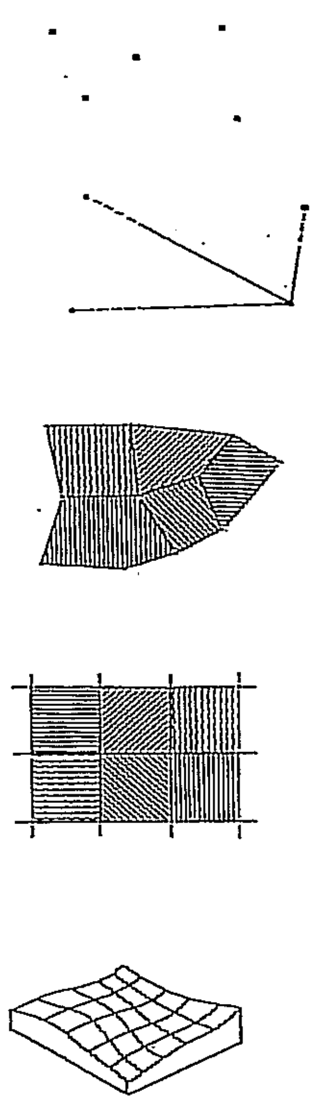


Fig. 1

3. DIFFERENT IMFORMATION SYSTEMS FOR DIFFERENT USES

Different users store data in information systems. The term 'Geo Information System' could be used to include among all information systems those intended to store data concerning the earth.

An attempt to classify such systems could make use of the different data types identified in the previous chapter.

Without completeness we could differentiate:

- Land Information Systems for administration and planning, using mainly parcel-type data,
- Geographical Information Systems for large scale planning and statistics, using raster-type data,
- Geodetic Information Systems dealing with observation and function-type data (Frank 80).

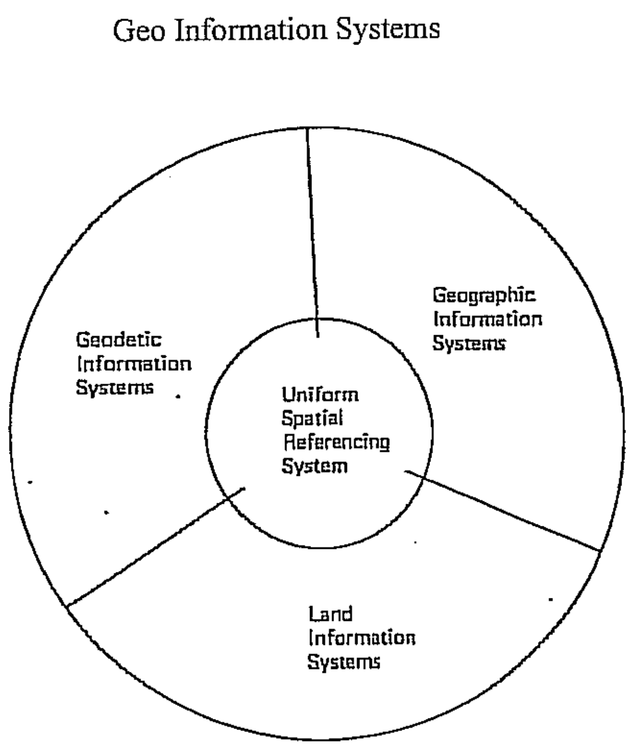


Fig. 2

The intention of this classification is not to form strictly separate classes but to point out predominant features. Most systems will contain elements of other systems depending on the needs of the users which can hardly be separated in mutually exclusive classes!

In spite of the differences between different types of Geo Information Systems, all these systems have many points in common. They address a similar problem area, namely geometric data, its storage, manipulation and retrieval. The problems in common shall be treated here first before Land Information Systems and some of their specific problems are introduced.

4. STRUCTURE OF A GEO INFORMATION SYSTEM

For our practical implementation of Land Information System we had to analyze the programme structure of Land Information System (Frank 81).

Based on this work a generalized structure for Geo Information System can be outlined:

The basic idea is to divide a large software system into layers with specific functions where each layer fulfils certain tasks for the higher layers using services of lower layers. To each layer a data abstraction of a certain level may be attributed.

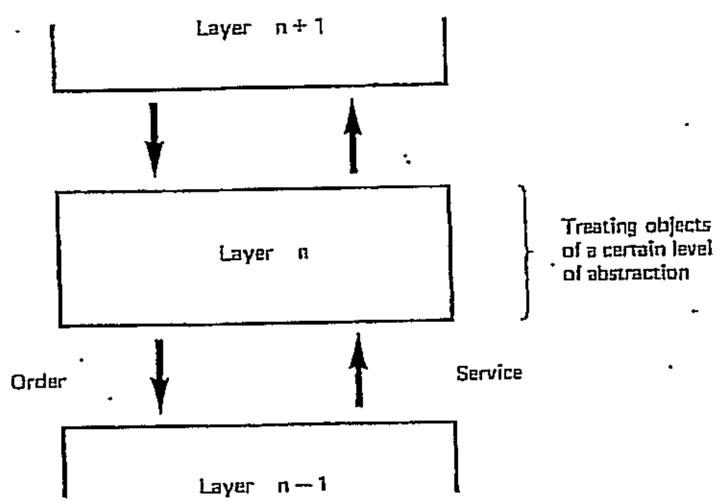
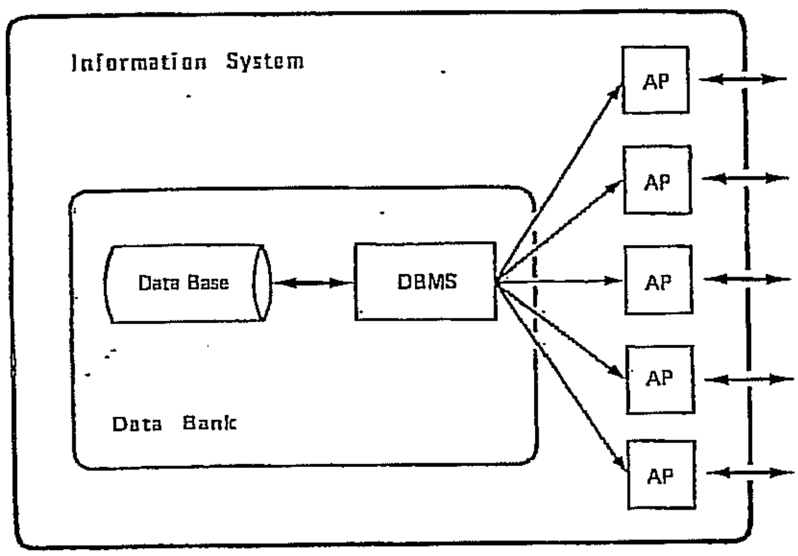


Fig. 3

4.1 Data Bank

It goes without saying that an information system has an innermost layer of a data base management system. This layer does the actual storage of the data in the system and contains procedures for storage and retrieval of data. Such a system is usually called a 'data bank' and is currently defined in computer science as a collection of data in machine-readable form and the procedures required for storage and retrieval of these data.



DBMS = Data Base Management System
AP = application programmes

Fig. 4

The experimental LIS we are currently developing in Zurich is based on a commercially available Data Base Management System in accordance with the CODASYL-Standard (e.g. Digital Equipment's DBMS-10).

In order to achieve a system which may be maintained over a long time and despite changes in computer hardware, it is indispensable, I believe, to use such a standardised system—together with a standardised high level programming language.

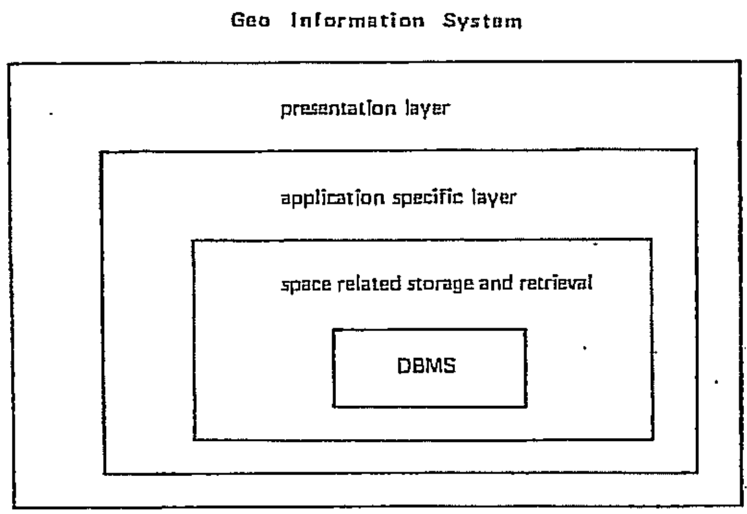


Fig. 5

4.2 Space Related Storage and Retrieval

The next layer is typical for Geo Information Systems. Data in a Geo Information System are related in some way or other to space: data objects with a certain extension and position in space.

Abstracting from many peculiarities our data objects are pairs of some attribute values and an indication of position and extension in space.

These data objects have to be stored and retrieved in data base, whereas retrieval should be possible on location in space. Queries acting for all data objects related to location in some areas are very important. Such a facility can be called "a space related data bank".

To make this point somewhat clearer from a programmer's point of view, let me point out that this layer offers mainly two entry points:

store (< data-type-name >,
< data-attribute-value >,
< min-max-value-of-objects >,)

and

retrieval (< list-of-data-type-name >,
< min-max-value-of-window >)

We have actually implemented such a layer in our experimental LIS in Zurich which makes use of the commercial DBMS' services and is especially suited for fast retrieval of data closely related in space (neighbourhood data).

It caters for clustered storage and fast access not only for point-related data but for data regarding objects of arbitrary shape and can manage cases where many data are gathered on a small area while in other places data are scarce. The time for retrieval and the number of accesses to disk are linear in the amount of data retrieved but nearly independent of the total amount of data stored; e.g. if a system grows access times (grow) only slowly.

Finally, the access method is not based on artificially distributing data to sheets or grid cells.

4.3 Application specific layer

The next layers must treat the individual object types of the different information systems. It should be possible to find building-blocks which may be used in different systems—as it should be possible to do documentation and programming in such a way that such blocks may be exchanged among different systems. This could be a very much appreciated help to build new systems.

4.4 Presentation

The presentation of results in tabular of graphical form is critical for the usefulness of an Information System. Therefore this function must be extremely well adapted to the task to be fulfilled. Further investigation will show if certain common procedures may be generalized for use in different systems.

5. UNIFORM SPATIAL REFERENCEING SYSTEMS

All Geo Information Systems intend to store data about objects in relation to space. It is of prime importance that spatial relations between the different objects may be easily expressed. A general and most widely accepted solution to this task leads to the use of some sort of co-ordinates: to every point in space a vector of two (or three) co-ordinate values is attributed indicating its position in space.

From these co-ordinate values; distance between objects, bearings and surfaces etc. may easily be calculated.

In order to facilitate the transfer of data from one Geo Information System to another, the different systems have to be on the same spatial reference system or at least on systems for which the transformation of co-ordinates of one system into co-ordinates of another system are known.

It is exactly this possibility of combining data stemming from different sources but containing identical place indicators that makes Geo Information System very attractive for many uses:

It would be highly advantageous to be able to combine a digital terrain model with information gathered by remote sending or to compare statistical census data with land use planning etc.

In the ideal world of mathematical perfect co-ordinate systems there are no hindrances to combine any data as long as transformations between the systems are known.

In real (imperfect) world we have no way to determine absolute co-ordinates without dependence on points (datum problem). Were our measurements which determine these relations between points (e.g. length, direction) exact and without error, the transformation rules between co-ordinate systems could easily be determined if only the co-ordinate values of some points in both systems were known.

But, as all of us are well aware, our measurements are, alas, never free of some errors. Statistical methods allow us to estimate best, or most probable values for measurements. We also calculate co-ordinate values for the points measured but these values are not estimable; the error indication given (e.g. standard deviation) is only applicable for a certain accepted datum.

If another datum is chosen as a base, the calculations not only yield generally different values for the co-ordinates but also different error indicators.

Baarda (Baarda 73) has shown how it is under certain circumstances possible to transform indicators for errors of co-ordinate values from one datum system to another (S-transforms).

One has always to bear in mind that co-ordinate values for a point have not only some statistical errors due to the statistical errors in measurements but they are also influenced by the datum used.

Our measurements are relative, giving relation between points or, as Baarda says, determine the form of (small) spatial elements (Baarda 81). To arrive at co-ordinates we have to introduce into the calculation some base values for some points (datum). Co-ordinate values resulting from different sources—often using datum values—are not easily commensurable.

A practical solution for this problem is not yet known; further investigation into this problem is of great importance to all different types of Geo Information Systems.

6. <u>DIFFERENT USES OF A GEO INFORMATION SYSTEM</u>

These Geo Information Systems may be used in different ways:

- as a sort of library to secure storage of data,
- as a part of an application system,
- as a tool for the storage of data related to a certain project.

A geodetic information system is especially suited for all of these three forms of use:

6.1 In order to collect all data concerning a certain area a Geodetic Information System may be established. This seems a perfect solution to make such data available for future research projects which is a very important matter for geodetic data. In Switzerland, we are in the process realizing such a national geodetic data base.

6.2 A geodetic data base can be used in many geodetic application programmes, e.g. in a triangulation programme where point-co-ordinates and measurements have to be stored and retrieved during the computation of triangulation networks, based on a space related data base (Conzett, Frank 81).

6.3 A geodetic data base may also be used to organize the storage of data related to a certain project e.g. doppler measurement campaign. Experience shows that the administration and storage of data even for projects of smaller size cause considerable problems. A member of our team in Zurich is currently working on a system for storage of geodetic measurement data from different sources which, of course, is based on a space related data base. We use a small micro computer for data input, plausibility tests and correction of measurements—these data are transferred to a larger computer where they are stored for use in computations.

The same (or at least very similar) software packets may be used for these different uses. A uniform logical structure makes exchanges of data extremely simple and will eventually be fully automatic over computer networking.

7. THE TASK OF A LAND INFORMATION SYSTEM

A Land Information System is in our opinion mainly oriented towards administrative purposes (Frank 80). At the FIG Congress in Montreux a definition of Land Information Systems was adopted which summarizes the discussion of the last years:

"A Land Information System is a tool for legal, administrative and economic decision-making and an aid for planning and development which consists on the one hand of a data base containing spatially referenced land-related data for a defined area, and on the other hand of processing and distribution of the data.

The base of a Land Information System is a uniform spatial referencing system for the data in the system which also facilitates the linking of data within the System with other land-related data." (FIG Comm. 3, 1981)

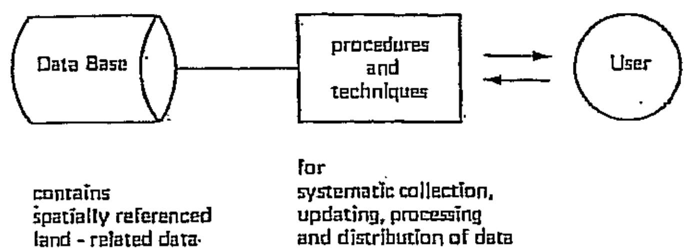


Fig. 6

Its data is therefore concerned with

- land ownership,
- land use,
- utility facilities,
- buildings,
- roads etc.

i.e. parcel type of data (cf. point 2) which may be based on exact surveying.

Here geodetic data enters namely

- observation of distance and direction,
- co-ordinates of control survey points,
- co-ordinates of detail survey points

and the corresponding operations.

8. THE ROLE OF GEODETIC DATA IN LAND INFORMATION SYSTEMS PROPERLY SPEAKING

It is debatable whether these data in Land Information System are geodetic data according to certain definitions of geodetic data.

Not the fact that geodetic data are included in a Land Information System is determining the role of geodetic data in a Land Information System, but other influences are overwhelming.

Land Information System must be based on a uniform spatial reference system, and it is certainly one of the most noble tasks of Geodesy to establish such a system for a certain area. Through this work Geodetic data enters a Land Information System!

Superficially one could think that co-ordinate values for a few base points are the only geodetic data in a Land Information System.

But the role of geodetic data is not limited to these data elements but is more general and more important:

Geodetic data defines the Uniform Spatial Referencing System on which all Geo Information Systems are based; this is a most fundamental role leading to two different tasks:

- to supply numerical values (e.g. co-ordinate values) for base points,
- to propose procedures to transform co-ordinate systems, possibly based on different datum values.

9. CONCLUSION

The Uniform Spatial Referencing System is the base for all Geo Information System. It is based on geodetic measurements and calculations. Therefore the role of geodetic data in a Land Information System, a special kind of Geo Information System, is two fold.

First, geodetic data supply numerical values for base points of the co-ordinate system which serves as a Uniform Spatial Referencing System.

Second, geodesy prepares theoretically sound procedures to treat co-ordinate values especially for transformation between different Uniform Spatial Referencing Systems.

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