MODERN GEOGRAPHIC INFORMATION SYSTEMS

by

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Abstract

Some theoretical aspects and current developments of modern Geographic Information System are presented In this article. It Includes classification and accuracy of CIS data; database software feature comparison and computerisation of CIS.

l.O Introduction

'Geographic Information Systems' Is a phrase which first occurred In common application In the late 1960's. It Is usually used to describe computer facilities which are used to handle data referenced to the spailal domain. A GIS has the ability to Inter-relate datasets and to carry out functions to Improve their analysis and the presentation of the results.

2.0 Definition Of Geographic Information Systems

Geographic Information Systems (GIS) have many deflnitons. There is still no total uniformity In the deflnlton of GIS. Geographic information Is Information which can be related to specific locations on the Earth. A GIS may be defined as (Burrough. 1986):

> "a *set of tools for collecting, storing, retrieving al will, transforming and displaying spatial data from the real world for a particular set of purpose".*

The essence of a modern GIS Is (SMITH. 1989):

> *"Its ablllly to use the power of the computer to help others make better decisions through the use of many different types of spatially-related information, enabling them to be compared, merged and analysed, and to do this cheaply and quickly and In as many different ways as the user may think* desirable".

However, according to the Standards Commltee of The Association for Geographhlc Information (Shand, et al, 1989), an overall deflnlton of GIS is:

> *"a system for handling data which Is directly or Indirectly spatially referenced to the* Earth, ft may *be used for capturing, storing, validating,* maintaining, *manipulating . analysing, displaying or managing such* data. *It is normally considered to involve a spatially referenced computer database and appropriate software. A primary Junction of a GIS is its ability to intergrale data from a variety of sources".*

3.0 Why Geographical Information Is Important?

An increasing ratio of the administrative and economic practice, especially in Malaysia, requires geographical information. This is to handle assets that are geographically distributed, to arrange marketing or assist in decisions on where to locate daily activity.

Management decision-making relies on information that is referenced to a location, area, or land corridor and this dependence will increase in the future.

Therefore, there is a need for organisations from all divisions of the administration and economy to enhance their perception of the Geographic Information concept and the technology used to manage it. This can be achieved by sharing experiences and data which has been proven as one of the best ways.

4.0 Developments With Modern GIS

Modern GIS developments are based on a data theory. It is because of some interesting developments that present themselves in GIS. Several aspects are considered in these developments as discussed below.

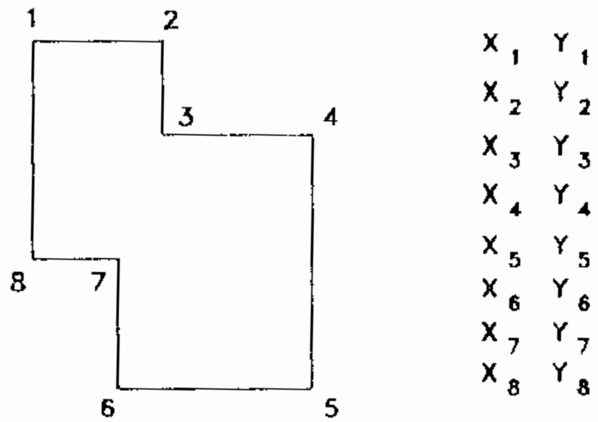
4.1 Changes From Analogue To Digital

It is not something specific for GIS in the change-over from analogue to digital. Everybody knows examples in his/her surroundings, such as digital wathes. Human perception is accustomed to observing and processing analogue pictures and because of this, it is often difficult to interpret a digital picture. A map is an analogue picture of the reality. Comparing or combining more than one analogue maps is not too difficult. A digital system can hardly be interpreted by anyone. This means that data interchanging, combining, aggregating, etc. has suddenly become much more challenging. Figure 1 shows the difference between an analogue and a simplified digital picture of a topographical element, e.g. a house.

For further processing these digital pictures are often translated again into analogue pictures. If the object would have the same name in every data system then the complication of digitalisation would not be insurmountable. However, in most cases this is not so. The example in figure 1 indicated various systems with different names : building, residence, house, etc.

4.2 Increasing Demands For Integrated Information

In this case, the integration refers to the place, the time and certain perspectives of the geographic information. A definite amount of geographic accuracy is required for a feed-back to a specific place. Such a feed-back is necessary to compare data for the measurement of alterations that have occurred in a period of time, e.g. for measuring concentration of pollution. In the case of land and town renovation there is a increasing demand for information which is integrated according to certain functions. These immovable functions are, for example, the use, value and quality of land.



Analogue picture of a house | **Simplified digital picture of a house**

Figure 1: The difference between an analogue and a simplified digital picture

In conclusion, there is a growing demand for integrated information i.e. there is a greater need for data exchange. Recognising data is more difficult because of the digital presentation. This has created the requirement for a uniform "language" for the data in GIS. The elements of this language are: data classification, data accuracy, spatial data structuring and conversion techniques.

4.3 Data Classification

Relatively little attention has been given concerning classification in GIS. This may be due to the fact that during the presentation of the information much use is made of maps. Maps can be very well understood and easily interpreted by anyone. The increasing digitalisation of the pictures will result in the necessity to arrive at a uniform classification.

If, in a data system, the qualities which are fundamental and can be split up, are mixed up, the usability is reduced and the updating costs are increased. Therefore, classification is also required to be able to update the information in automated systems. If there is no adequate classification, it will be difficult to retrieve relevant data from a digital system.

In most cases geographic data are coupled to topographical object (e.g. buildings, land parcels). Therefore, these topographical objects have to be classified in the first place because they are common data in different geographic information systems. In the classification of these objects the use that is made of them should not be considered, if possible.

This advantage of the topography classification is that it is possible to classify first according to singular characteristics. A complicated position will be created, if classification is made according to more characteristics, in which case, it is necessary to resort to the cluster analysis.

4.4 GIS Data Accuracy

The data accuracy in GIS should be more than a positional accuracy because GIS data consists of spatial and attribute information. It must include the descriptive data accuracy. A positional accuracy is referred to the closeness of an estimated position to the actual location.

Positional accuracy is classified into two types: absolute and relative. The position of a point as defined by the co-ordinate system is referred to the absolute accuracy. However, the relative accuracy is referred to the position of one object relative to another.

The descriptive data accuracy is defined by many factors and some of them are (DATE, 1986);

i. **its currency**. Accurate and up to date data should illustrate the current value. For example, the current temperature reading given by a thermometer is more accurate than the broadcast by radio a few hours ago.

ii. **its detailed description**. The information will be more accurate if detailed description is given.

iii. **consistency**. The data consistency can be applied to supervise inaccurate information resulting from redundancy.

iv. **satisfying the applied standard**. Data must satisfy any applied standard. The standard could be at departmental, regional, national, or international stages. If data does not agree with the applied standard, the data will be confused.

4.5 Spatial Data Structuring

The usage of geographic units can represent real objects in GIS or LIS. These are units to which the different kinds of data are related. They may vary from large administrative areas to topographical objects (e.g. buildings). The geographic units are made up for the function for which the data serve. GIS/LIS may distinguish between the statistical information and registrative systems. Statistical information concerning larger regions is important. This information may be intended, for example, for land and town renovation and spatial plans. With the registrative systems, detailed information on particular objects is important such as land parcels or buildings. Examples of such systems are land registry offices serving for the protection of legal security or to levy land-taxes.

i. Identifying Geographic Units

The data are supplied with identifiers in every information system. They organise the finding , arranging and coupling the data in the system. The identifiers must encounter certain requirements. Fingerprints and passport photos may serve as excellent identifiers of persons. In the identifier of geographic units, they often deviate from the policy, because it is very tempting to add to the identifiers information on the situation of units. There are two possibilities to identify geographic units:

a) **co-ordinates**. Spherical and flat plane co-ordinates. This geographic unit is classified as spatial information.

b) **nomical identifiers**. These do not include direct topographical indication, but have to be used together with a map: e.g. address, registration record. This unit is classified as attribute information.

ii. Geographical Data Structures and Computer Representation

The computer needs to be instructed precisely how to handle and display spatial patterns. There are two contrasting ways of representing spatial data in the computer which are referred to as implicit and explicit methods of describing spatial entities. Figure 2 (Burrough, 1986) shows the different methods in which a chair can be explicitly or implicitly represented in the computer.

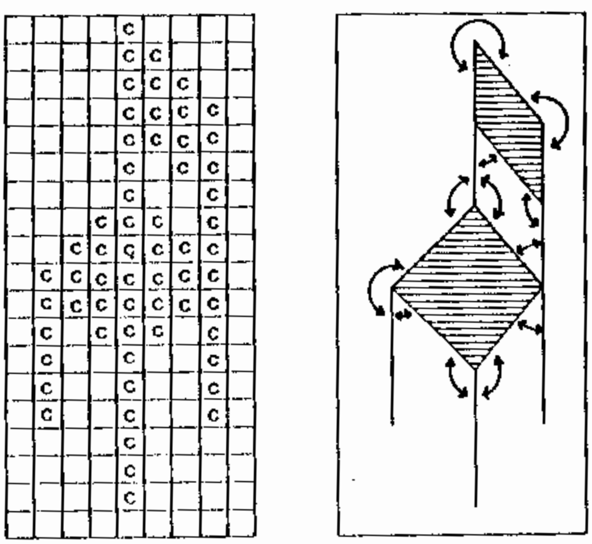
Entities in the implicit representation are described by a set of lines. This is defined by starting and end points and some form of connectivity. The starting and end points of the lines define vectors that illustrate the form of the object (e.g. chair); pointers between the lines specify to the computer how the lines link together to form the object. The data structure for the above example is:

chair attribute → set of vectors → connectivity

Explicit representation means the entities are built up from a set of points on a grid or cell (pixel). Each cell is given the same shape and size, for instance, code value 'C' in figure 2. In practice, the C's would be represented by a numerical value or a colour or grey scale. The simple data structure for the above example is shown below:

chair attribute → symbol/colour → cell X

Figure 2 also displays various other differences between the two representations.



(a) (b)

Figure 2: A chair in (a) raster and (b) vector format

In conclusion, topological data can be represented in at least two fundamental techniques which are summarised as follows:

a) Vector representation - three main geographical entities, points, lines and areas; points are simiiir to cells, except they do not cover areas; lines and areas are sets of interconnected co-ordinates that can be linked to given attributes.

b) Raster representation - set of cells or pixels located by co-ordinates in the relevant system.

iii. Recording The Logical Relations Between Geographical Units

The actual situation may suffer considerable deformation when representing geographic units in information systems. Care has to be taken not to upset the relations between the units. The vicinity relations are the most important relations between the geographic units.

In GIS/LIS in which given regions are represented with the aid of geographic units, these vicinity relations are as important as metric data. It is hardly practical to carried out land registration by computer without knowing the vicinity relations.

The indication of the geographic units, the pictures of the units in the information systems and the recording of the logical relations between the units form part of the spatial data structures. These structures have turned out to be an important benefit in the applicaton of computerised land registration. That is why suppliers of interactive graphic systems include in the system software the possibilities offered by these structures.

4.6 Conversion Techniques

In principle there are two types of conversions classified in GIS/LIS:

i. Data Conversion From One Information System To The Other

There are no fundamental problems for establishing communication between different information systems with the present state of technical development. Sufficient agreements in consideration of standardisation create economical and organisational advantages. Agreements have to be made with concern to the classification of data, the accuracy and the spatial structuring of geographic units. For example, conversion from National Transfer Format (NTF) digital data produced by Ordnance Survey to AutoCAD Drawing Interchange File (DXF) file format is easy to be made.

ii. Conversion From Analogue To Digital Data Within One Information System

The analogue to digital data conversion is one of the major jobs with the various GIS in the near future. There are various possibilities to acquire digital geographic data:

a) automatic or manual elements digitalisation from existing maps;

b) digital processing of elements from aerial photographs;

c) conversion of the elements of existing measurements and;

d) taking over length and direction measures without transformation to co-ordinates in digital records.

5.0 Feature Comparison For Database Softwares

There are many database software packages in the market currently used by many organisations. The database software selection is depend on the organisation applications. Any software has advantages and disadvantages according to the feature specification. The comparison is made between Superfile, dBASE IV, Delta, Dataflex and Informix software (all available on micro computer). The summary of these comparisons is shown in table 1.

6.0 Computerised Geographic Information Systems

Traditional GIS (paper maps) are now being converted into a modern GIS with the assist of computer hardware and GIS software. Computer software for GIS is already available and continually developing. In examples are SLIMPAC, ARC/INFO, Computervision, Geo5/SQL, GIS Manager and SYSTEM 9.

The first component of a computerised GIS consists of one or more databases recording land related information. The other is digital mapping information again structured in an adaptable form.

The combination of the two information types creates several advantages provided all data is linked together appropriately. Its permits the cross-referencing of record held in different databases. With the boundary locations of all spatial units types defined with respect to the digital mapping, it becomes possible to cross reference any one data set with one or more other sets. The information presentation; maps and plans created from digital mapping data has several advantages. A range of scales can be used and unnecessary details omitted whilst important features can be highlighted with symbols and colours.

FEATURE	Superfile	dBASE IV	Delta	Dataflex	Informix
Characters per Record	ML	4k	2k	4k	2k
Max. Fields per Record	ML	255	90	255	2k
Max. Records per File	ML	1 billion	32k	64k	ML
Variable length fields	Yes	No	Yes	No	No
Phonetic Search	Yes	No	No	No	No
Add new Fields without reformat	Yes	Yes	No	No	No
Direct interface to programming languages	Yes	No	No	No	'C' only
Multi-user	Yes	DOS only	No	Yes	Unix only
Relational database	Yes	Yes, 10 files	No	Yes	Yes
Julian date	Yes	No	Yes	Yes	Yes
Mail Label	Yes	Yes	Yes	No	No
Mail-merge files	Yes	Yes	No	No	No

'ML' means 'Machine Limit' – imposed by the hardware or the operating system.

Table 1: Features comparison for database softwares

6.1 Advantages Of A Computer Solution

The advantages of a computerised GIS are:

i. a massive reduction in detailed drafting work.

ii. a comprehensive filing system would be inherent to the system. allowing easy extrapolation to other professional interests and allowing easier retrieval.

iii. the accuracy of the recorded information could be very much better than could be obtained with traditional methods.

iv. a rapid response could be available to any inquiry.

v. extensions to any existing features such as water supply pipe lines for public utility services could be designed by the computer and provide optimal utilisation of utility resources.

7.0 Conclusion

The development of a traditional GIS with the assistance of the computer facilities creates a new GIS term; a modern GIS. Several factors must be considered. It involves the change from analogue to digital for creating digital mapping, data classification , data accuracy, spatial data structuring, etc. This development is based on the GIS concepts, funtions, components, subsystems and the Data Base Management System.

Therefore, the combination between digital mapping and database software construct a modern GIS. There are many GIS tools in the market such as SLIMPAC, ARC/INFO, SYSTEM 9, etc. Many advantages can be obtained from the computerised GIS. It includes the advantages of a computer solution.

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