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RESUMO - NOTAS / ABSTRACT - NOTES

This paper introduces requirements for an analysis/modelling system of spatial information, aimed at combining remotely sensed data with information from other sources. The work was conceived as an aid for INPE's CBERS Ground Applications Segment, that encompasses development of an integrated system to perform the tasks of reception, production and spatial analysis. Current requirements concerns aspects of visualization, input, storage, retrieval and manipulation of spatial data. A special topic formulates some guidelines for software development.

OBSERVAÇÕES / REMARKS

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ANALYSIS AND MODELLING OF SPATIAL DATA

PROPOSAL OF A SYSTEM FOR CBERS

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SUMMARY

This paper introduces requirements for an analysis/modelling system of spatial information, aimed at combining remotely sensed data with information from other sources. The work was conceived as an aid for INPE's CBERS Ground Applications Segment, that encompasses development of an integrated system to perform the tasks of reception, production and spatial analysis.
Current requirements concerns aspects of visualization, input, storage, retrieval and manipulation of spatial data. A special topic formulates some guidelines for software development.

RESUMO

Este trabalho apresenta requisitos para um sistema de análise e modelamento de informações espaciais, visando permitir a combinação de dados de sensoriamento remoto com informações de outras fontes. Ele foi concebido como subsídio ao "CBERS Ground Applications Segment" do INPE, que preve o desenvolvimento de um sistema integrado para recepção, produção e análise de dados espaciais.
Os presentes requisitos compreendem aspectos de visualização, entrada, armazenamento, acesso e manipulação de dados espaciais. Um tópico específico é dedicado a diretivas para o desenvolvimento de software.

1 - INTRODUCTION

Combination and analysis of data from different sources is a key issue for efficient use of Remote Sensing. Geographic Information Systems (GIS) are tools that assist this task. To emphasize the importance of analysis, these tools has been designated as "analysis/modelling systems" inside INPE's CBERS Ground Applications Segment (MAGS).

INPE developed a family of such systems (02, 07), based on low-cost, 16 bit microcomputers. They are currently in use at INPE and other Brazilian organizations that work with remotely sensed data.

Development of new, complex applications is asking for more powerful systems. Particularly, the problems of mapping large extensions of territory and creating more flexible and intelligent tools leads to adoption of new computer systems capable of manipulating large volumes of data.

On the other hand, MAGS requirements for an integrated system, to support reception, production and analysis tasks will motivate the conception of a new system

This work was motivated by the need to specify requirements for MAGS's analysis/modelling system, based on INPE's previous experience and new needs.

Traditionally, such systems are described according to a four-part division: input, output, storage and analysis (08). We think graphics interfaces and interactive examination of data are very important features for our system, so we chose to consider aspects of visualization, input, storage, retrieval and manipulation of spatial data. Visualization and input focus on topics related to graphics interfaces. Retrieval and manipulation introduce different aspects of interactive data analysis. These topics do not exactly correspond to a system division in modules, but allow to better formulate our requirements.

2 - VISUALIZATION

In this paper, data visualization is intended to allow the presentation of images, maps and other information on graphic monitors. Major features that must be available are described in the following items.

RASTER DATA VISUALIZATION

Raster data include raw, geo-coded, segmented, classified and other forms of images.

Specific features must be provided for visualization of these data, including image colouring, resampling and interpolation.

VECTOR DATA VISUALIZATION

Vector data allows representation of line and polygon features. This includes networks and areal data.

Specific features that must be provided for visualization of these data are colouring and highlighting, polygon hatching and filling and cartographic conventions plotting.

Visualization features are also intended to be used as an aid for examining data. Specifically, it must be possible to identify objects according to different spatial (locational) and attribute (non-locational) criteria and enhance the identified objects on display (see section on "Retrieval and Manipulation").

DTM VISUALIZATION

DTM visualization must allow selection of different options for countour interpolation. Other necessary features include terrain shadowing and 3-D presentation.

COMBINED VISUALIZATION OF MAPS, IMAGES AND DTM DATA

It is highly desirable to combine at least two images by means of transparency displaying, and superimpose any amount of vector data on top of images.

WINDOWING

Windowing comprises the whole set of options that provides for selection of the region under display and display work area definition.

Selection of the region under display must provide options as below:

* Zooming In and Out,
* Panning,
* Region Fitting.

It is highly desirable that display work area definition allow displaying of at least four different regions simultaneously.

3 - INPUT

This work will delineate input requirements that are important for interactive use. Only vector data are considered, focusing on interactive topology construction.

The basic requirement concerning interactive object construction is the possibility of constructing and editing geometric elements on the screen. A list of basic functions for this capability is proposed by Alves (02). In table 1, a simple set of basic options for polygonal line construction is presented to ilustrate the features required for geometric editing.

Create	Create a line from point sequence
Delete	Deletes a line after identification
Translate	Applies a translation to point lines
Rotate	Applies a rotation to point lines
Scale	Applies a scale transformation to point lines
Stretch	Changes position of one point
Join	Joins two lines that have one common point
Break	Breaks one line in two parts
Clip	Eliminates part of line

Table 1 - Polygonal line construction functions

One important aspect of object construction concerns how interaction is to be actually implemented. This work will not present specific requirements about it, but the system will have to provide mechanisms for object identification on screen and incorporate such features as snapping, as described by Bier (04).

4 - STORAGE

Storage is a crucial problem in GIS and all systems that handle spatial data. Stablishing requirements for it is not an easy task, as many different aspects must be considered.

This paper presents only guidelines for further development about the storage problem. Actual requirements are formulated concerning the storage size only.

A major problem concerning spatial data organization is related to the very nature of the data. It is recommended to hold all data within one unique data base, to provide a sole, homogeneous interface to all data and guarantee the independence of physical and logical organization, data integrity and acess control. However, commercially available data base management systems (DBMS) don't provide a satisfactory solution for spatial data. The most crucial problem that appears is the difficulty of conventional DBMS to handle spatial relationships between data.

Several authors presented non-conventional approaches for spatial DBMS (02, 05, 06). However, this problem remains an investigation issue.

As no commercially available DBMS provides a satisfactory solution for this problem, there are two possible solutions that can be analysed:

* using separate data bases for spatial and attribute data;

* adopting recent developments in the area of non-conventional DBMS.

Major problems with the first approach is that using separate management systems will complicate maintenance of data integrity and consistency; attribute data can be manipulated by commercially available DBMS, but treatment of spatial data ought to be developed from scratch. Existing data bases often incorporate powerful query languages. However, extending these languages to handle spatial data is not easy. In the case of adopting the first possibility it is absolutely imperative that powerful tools for linking both data bases be available.

The second solution can be envisaged if new, non-conventional DBMS (e.g. the DAMOKLES DBMS (01)) are actually available. This approach can have the two major problems: unsatisfing support, due to the inexistence of a commercially stablished organization; need to develop the whole interface system with the user. At the same time, the later can motivate and ease development of one unique query/manipulation tool that cope with one unique data base.

Finally, there is a very important requirement to be formulated about storage, concerning volume of data.

Ideally, there should be no restrictions about volume of data. However, if this cannot be guaranteed for any physical reason, it will be mandatory to provide storage of some minimum volume of data.

Considering the practice of work in Brazil, one reasonable criterium about data volume seems to be allowing the storage of 1 degree by 1.5 degrees areas (corresponding to the 1/250,000 scale) mapped in a 1/10,000 detail. It means that each identifiable storage unit must be capable to hold all this data. No restrictions must be imposed on the number of units that can be stored in the system.

5 - DATA RETRIEVAL AND MANIPULATION

Information retrieval involves both report generation (e.g. a table of values related to some objects) and graphic visualization of the objects that satisfy specified constraints. It must be possible to specify different constraints, using spatial and non-spatial (e.g. attribute values) criteria. Combination of both types must be provided.

One basic spatial criterium allows retrieving of data related to some closed area.

Other criteria can depend on the nature of spatial data (02). Considering three types of data - polygonal maps, networks and DTM - different criteria can be aplicable. For polygonal maps, typical criteria can be the intersection with some object and area values. For networks, the conection between nodes and path sizes. Finally, for DTM, it can be useful to recover information related to some interval of height.

Another requirement concerning information retrieval is that the user be able to specify his wishes through some interactive form of operation. It is highly desirable to make available two forms of interaction: query languages and graphic forms of interaction.

Query languages allow definition of queries such as:

"what is the population of towns in region R" or

"which towns have population greater than P".

Graphic interaction is important, as a rule, in the definition of constraints like closed areas. It is also important to allow identification (on the screen) of objects about which the user desires to obtain more information.

Information retrieval tools must also allow calculation of data characteristics, such as maxima and minima, sums, average values, etc. Functions to calculate and plot histograms must be provided.

It is strongly recommended to provide a form of data interchange between the system and some statistic software package that had acquired some public recognition. If possible, such a software package should be integrated with the system.

Several other recommendations could be formulated about data manipulation. Specific options that should be available can be based on INPE experience. This includes image processing, digital terrain modelling and options for information combination.

To finish this topic, we will formulate a last generic requirement about manipulation. It concerns primarily the data model to be adopted and establishes that all information extracted from existing data can be represented properly within the data model.

6 - SOFTWARE DEVELOPMENT GUIDELINES

The following considerations primarily are intended to provide for flexible software, to allow development of new applications.

There is one basic requirement to be formulated about software development, which is that a modular architecture be adopted. It decreases maintenance costs and eases softare modification.

Finallly, the following rules are recommended for software devellopment:

* Use of a standards;

* Use of a structured or object oriented programming language.

Whenever applicable, an attempt should be made to utilize ISO and industry standards, in order to facilitate ease of implementation, international compatibility and long-time support and services. One important characteristic of standards is that they are available from different manufacturers and suppliers.

It is recommended to use object-oriented languages (e.g. C++ (Wiener)) for all software development; these languages assure a high degree of software reusability and eases function prototyping. Reusability and fast prototyping are considered key aspects of software development and increase productivity and flexibility.

7 - CONCLUSION

This paper presented a set of requirements that must be useful for further development in the area of analysis systems at INPE and within the CBERS programme.

As a final remark, it can be noted that it was possible to define requirements for several aspects. From another point of view, it was possible to define only generic guidelines concerning several topics, as storage, software development, and other. For these topics, it will be necessary to work further and final requirements will be formulated only later.

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