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GIS as spatial decision support system

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Abstract

This paper describes the possibility of the Geographic Information Systems (GIS) as a means to support decision making in solving spatial problems. Spatial problems accompany every human activity, of which agriculture is no exception. The solutions to these problems requires the application of available knowledge in the relevant decision-making processes. GISs integrate hardware, software, and data for capturing, managing, analyzing, and displaying all forms of geographically referenced information. Coupled with GISs, geography helps to better understand and apply geographic knowledge to a host of global problems (unemployment, environmental pollution, the loss of arable land, epidemics etc.). The result may be a geographical approach represents a new way of thinking and solutions to existing spatial problems. This approach allows to apply existing knowledge to model and analyze these problems and thus help to solve them.

Key words

Knowledge, semi-structural spatial decision problem, spatial decision support system, Geographic Information System.

Abstrakt

Tento článek popisuje možnosti geografických informačních systémů (GIS) jakožto prostředků pro podporu rozhodování při řešení semi-strukturálních prostorových problémů. Tyto problémy doprovázejí každou lidskou činnost, zemědělství z toho nevyjímaje. Řešení těchto problémů pak vyžaduje použití dostupných znalostí v příslušném rozhodovacím procesu. GISy integrují hardware, software, data a pro pořizování, správu, analýzu a zobrazení všech forem geograficky pojatých informací. Tyto prostředky pak pomáhají lépe pochopit a aplikovat geografické znalosti na celou řadu globálních problémů (nezaměstnanost, znečištění životního prostředí, úbytek orné půdy, epidemie apod.). Výsledkem pak může být geografický přístup představující nový způsob myšlení a řešení stávajících prostorových problémů. Tento přístup umožňuje používat existující znalosti při modelování a analýze těchto problémů, čímž napomáhá k jejich řešení.

Klíčová slova

Znalost, semistrukturální prostorový rozhodovací problém, systém pro podporu rozhodování, geografický informační systém.

Introduction

A number of current global issues (unemployment, environmental pollution, the loss of arable land, epidemics etc.) currently has geographical specificity. Similarly, this will have any problems accompanying agricultural practices. Most of these problems are ill-structured in the sense that the goals and objectives are not completely defined. Such problems require a flexible approach. Issues associated with them must be adequately addressed. A human subject trying to solve them must be provided with a set of relevant knowledge and apply it in the decision making process. Such knowledge must be codified in such a way that could be used effectively in the decision-making processes. One of the possibilities of support in dealing with such problems may represent the tools for supporting decision-making, the so called Decision Support Systems (DSS).

Material and methods

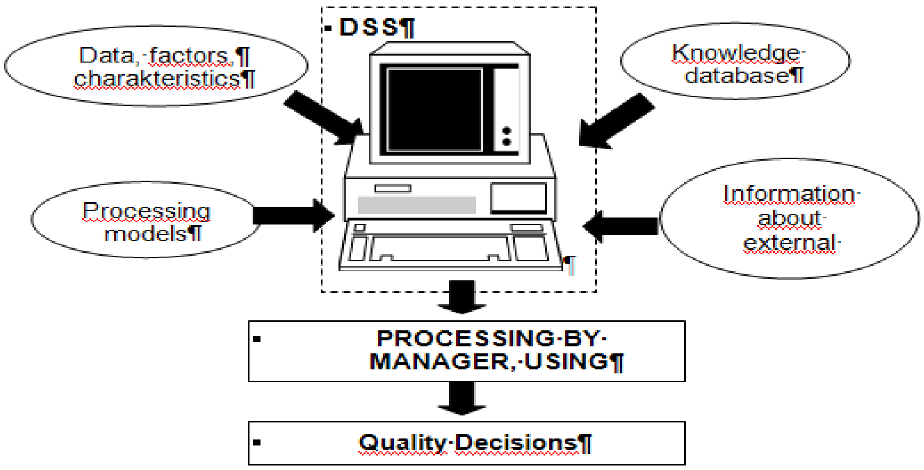
The DSSs are computer-based information systems that support business or organizational decision-making activities. DSSs serve the management, operations, and planning levels of an organization and help to make decisions, which may be rapidly changing and not easily specified in advance (Maxwell, 2008). DSS components may be classified as:

– Inputs: Factors, numbers, characteristics to analyze including user knowledge and expertise.

– Outputs: Transformed data from which DSS "decisions" are generated.

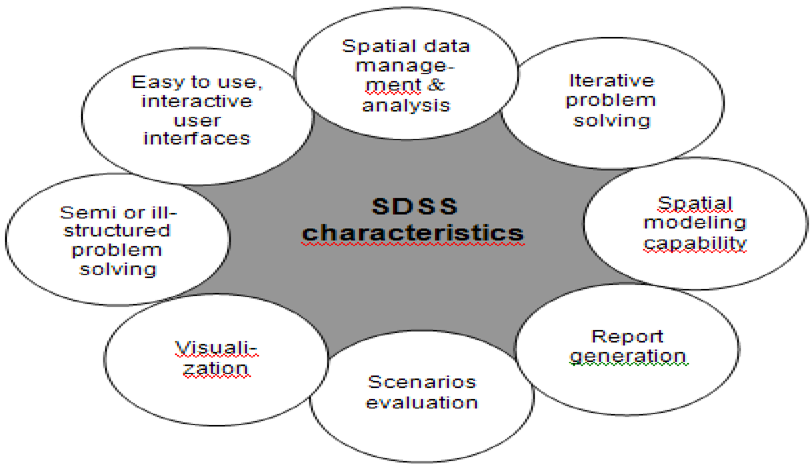
– Decisions: Results generated by the DSS based on user criteria (Amstrong, Densham, 1990).

Another taxonomy for DSSs has been created by Daniel Power. Using the mode of assistance as the criterion, Power differentiates communication-driven DSSs, data-driven DSSs, document-driven DSSs, knowledge-driven DSSs and model-driven DSSs (Power, 2002, 2003). Amstrong and Densham (1990) define the following structure of the DSS:



Source: (Amstrong, Densham, 1990)

Figure 1: General structure of the decision support system.



Source: (Sugumaran, Degroote, 2010.

Figure 2: SDSS characteristics.

Special categories of DSSs are called Spatial Decision Support Systems (SDSS). SDSSs are an interactive, computer-based systems designed to support a user or group of users in achieving a highest effectiveness of decision making while solving a semi-structured spatial decision problems (Sugumaran, Degroote, 2010).

The main characteristics of spatial decision problems include:

- a large number of decision alternatives,
- the consequences of the decision alternatives are spatially variable,
- each alternative is evaluated on the basis of multiple criteria,
- some of the criteria may be qualitative while others may be quantitative,
- there are typically more than one decision maker (or interest group) involved in the decision-making process,
- the decision makers have different preferences with respect to the relative importance of the evaluation criteria and decision consequences,
- the decisions are often surrounded by uncertainity (Malczewski, 1999).

Typical SDSS provides a framework for integrating:

1. analytical modelling capabilities,
2. Database management systems,
3. graphical display capabilities,
4. tabular reporting capabilities,
5. the decision-maker's expert knowledge (Binda, Sharma, 2008, p.198).

Many spatial problems are complex and require detailed analysis. The such problems are very frequently semi-structured or ill-defined because all of their aspects cannot be measured or modelled. Decision support in solving spatial decision problems can be the great opportunity for the geoinformation technology. This information technology in data processing and spatial analysis, together with modern decision analysis techniques promote new styles of knowledge communication and utilization. This technology is closely linked with GIS technology. The corresponding Geographic Information Systems (GIS) can play the significant role in SDSS. The capabilities of these devices in similar matters sets out a number of authors (Johnson, 2005, Pandey, Harbor, Engel 2001, Wilson, Mitasova, Wright 2000, Xu, Ito, Schultz, Li, 2001). Some authors, however, in this context, conclude that GISs normally provide the above paragraph 1, 2,3 and 4, but not the 5 (eg. the decision-maker's expert knowledge) (eg Kurland, 2009), just this role of knowledge in solving spatial problems is crucial. However, this view can be debatable. Therefore, in next will demonstrated that the matter of point 5 is the means of GIS.

Results and discussion

The above stated implies that the fundamental feature of such applications will be possible to make use of corresponding knowledge in decision-making processes. The crucial role of knowledge in decision making and sensemaking is highlighted (Burstein, Holsapple, 2008, p. Preface XV.). The problems of storing and making use of knowledge in GISs involves the following matters.

Tabular representation of the knowledge may be an option for these purposes. This representation was already in the past by a number of authors published and verified (Vanthienen, 1995, Wets 1998, Ziarko, 2005, Vostrovský, 2008). Such a mode of representation of knowledge (ie. the relevant knowledge rules) is acceptable GISs themselves as being in accordance with its database component (for example. in ArcView GIS ESRI, the so-called QUERY BUILDER). In the framework of this component GISs offer for this purposes the SQL tool. Its commands as SELECT a CREATE TABLE provide enough options for in these matters. The syntax of these commands is as follows:

SELECT [DISTINCT] {* |< list column > FROM < name of the table > [, < name of the table >] ...[WHERE < selection condition >] [GROUP BY < list column > [HAVING < selection condition >]] [ORDER BY < column name > [ASC | DESC] [,< column name > [ASC | DESC]]]

CREATE TABLE < name of the table > (<column name > < datatype > [NOT NULL] [,< column name > < datatype > [NOT NULL]]...]

In the context of these commands, is then possible to create the corresponding knowledge databases

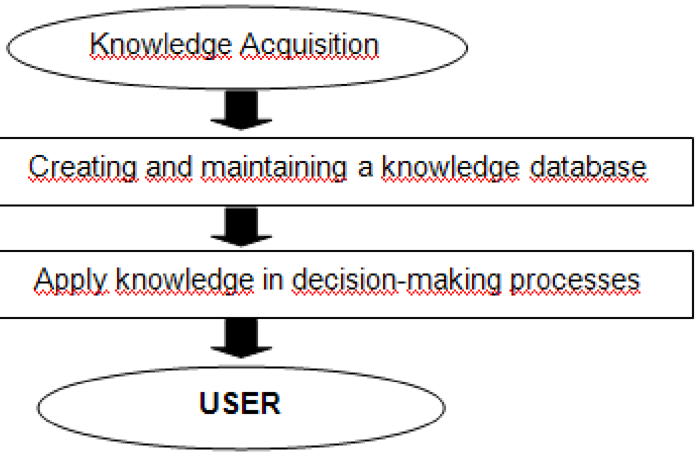


Figure 3: Typical system architecture of the knowledge-driven DSSs.

PROPOSITIONS

PropositionNo	PropositionText
1	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
2	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
3	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
4	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
5	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
Etc.	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Rules

RulesNo	PropositionNo	Value
1	1	Y
1	2	Y
1	6	xxxx
2	3	Y
2	5	N
2	7	Y
2	9	yyyy
3	3	N
3	4	Y
3	5	N
3	8	zzzz
Etc.	Etc.	Etc.

Figure 4: Possible logical data scheme of the acceptable knowledge database.

and thus retained the knowledge, if necessary, recall, and apply them in solving problems. Such an approach allows the recording knowledge required in the form of rules of type of type IF A THEN H. IF (features, conditions) THEN (consequential identification, methods, techniques)] with the analysis of type WHAT IF, accounting all advantages of spatial data analysis. The final outcome of these applications is usually a map depicting areas simultaneously fulfilling all requested conditions and evaluated in context of related information layers.

In this scheme can be derived knowledge (knowledge rules) of the following structures:

RULE1: IF proposition1= YES AND proposition2 = YES THEN proposition6 (conclusion6) = xxxx

RULE2: IF proposition2= YES AND proposition5 = NO AND proposition7= YES THEN proposition9 (conclusion9) = yyyy

RULE3: IF proposition3= NO AND proposition4= YES AND proposition5=NO AND

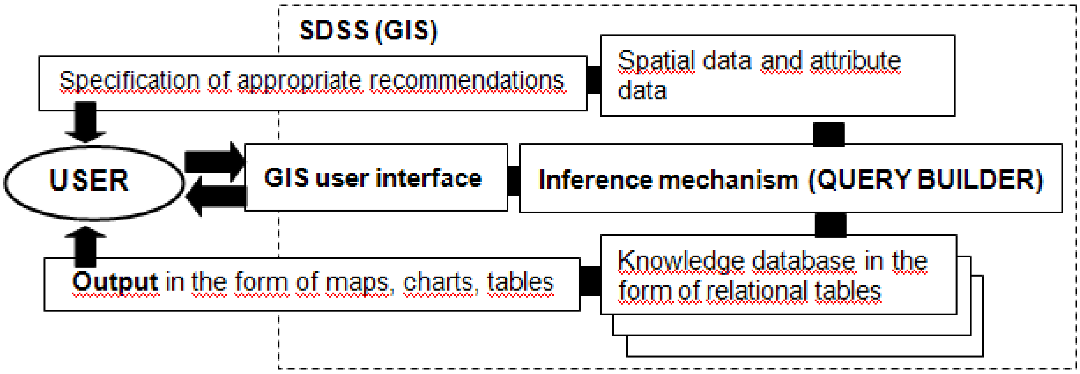


Figure 5: General structure of the proposed solution.

proposition8=YES THEN proposition9 (conclusion9) = zzzz etc .:

The resulting proposed application of GIS tools, as the SDSS will have the following form Own use of GISs in supporting solutions to semi-structured spatial problems should implement the following procedure:

1. identification and localization of the solved spatial problem,
2. specification of its attributes,
3. analysis of the current state by means of the layers,
4. output in the form of maps, charts and graphs,
5. prognosis of future state,
6. specification of the appropriate recommendations.

Conclusions

This article discussed the issue of utilization of GISs as a means to support decision making in solving spatial problems. The above stated implies that the fundamental feature of such applications will be possible to make use of corresponding knowledge in decision-making processes. From the above, it is possible for GIS to store not only knowledge but also in decision-making processes apply. If this knowledge to solve the semi-structured spatial decision problems so utilized, can reasonably expect that the final decision will be of higher quality. The rapid development of information technology, image processing techniques and database knowledge is conceived of such a guarantee of much wider use of GISs as a means to support decision making in solving spatial problems. Our decisions are increasingly dependent on understanding the complex relationships and events surrounding the world of GIS technology is able to include the new requirements.

Acknowledgements

The Project Information and knowledge support of strategic control - MSM 6046070904 supports this work.

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