GIS AND UNCERTAINTY MANAGEMENT

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ABSTRACT:

The contribution deals with issues that are very closely connected: Web services model, Dynamic GIS and the problem of uncertainty of spatial data and discusses the possibilities of the context use as a reflection of the system of understanding. The problem of the relation to the decision support system is addressed and GIS as a tool dealing with all phases of knowledge structure. GIS Web services architecture makes GIS more open and interoperable in using and offers wide range of context information. Web has a unique ability to integrate diverse data through shared location and GIS Web services offer real potential for meeting the demands of users. On one hand the use of very heterogeneous data available on Web – multi-sensor, multi-band and others in the combination with multi-criteria conditions evaluation causes increasing of uncertainty we meet in the processes and consequently in results. The paper discuss the problem of wide context (temporal, spatial, local, objective, attribute oriented, relation oriented) as a tool to compensate and to decrease the uncertainty of data, classification and analytical process at all process to increase the information value of decision support.

1. INTRODUCTION

In comparing with initial ideas and visions the ways of managing and distributing data and particularly the resolution of data sources has rapidly changed. Spatial data are collected and processed and during the last couple of years the data flows in and between organizations have extremely increased. In the connection with these facts also the data management tools and techniques are continually changed (O'Leary, 1998). It includes the automated knowledge acquiring, proper handling of large volumes of data, new accesses to data interpretation and effective exchange of information between and among various institutions.

1.1 Access to Data

Thanks to the Internet and Mobile Internet GIS, Mobile Web Map Services and Mobile Web Analytical Services that facilitate the acquiring of data it is much easier to monitor and map temporal states of the objects and phenomena.

Mobile Internet GIS and Mobile Web Map Services, it is a new solution that offers mobile Internet access to the data including theirs updated versions, provides the transmission of maps that are composed under the demands and the transfer of map attributes and provides the access to the raster data, orthophotomaps and vector data (Fensel, 1998).

The progress in new sensor technology for Earth observational remote sensing continues and increasingly high spectral resolution multispectral imaging sensors are developed and these sensors give more detailed and complex data for each picture element. The increasing resolution of the data sources results in the increasing number of imaged objects (classes). The dimensionality of data and the complexity of objects structure hierarchy are rapidly growing too and consequently with these aspects increases the uncertainty entering into the processing.

Data uncertainty plays a special role in this environment (Bernbom, 2001, Fuller, 2000). It is quite another situation than in case of the closed system, where the user has full control over all steps of processing from data input to presentation of results. In frame of open interoperable system with access to web sources with a great number of existing databases the user control gets completely lost.

A great number of existing databases offer a variety of data sets covering different thematic aspects like topographic information, cadastral data, statistical data, digital maps, aerial and satellite images including temporal data. Data collection is changing from digitizing own data to retrieving and transferring from existing databases coming from task processing and result presentation.

To deal with such data sets, the user requires an uncertainty description that has to be added by the producer. User needs an appropriate uncertainty model for this purpose, integrated in GIS (Bolloju ,1996, Cornelis, 2002).

The changing society needs changing approaches to real world observation, modelling, analysis and evaluation. The concept of the time plays the significant role in our life and all our thoughts about the history, present time as well as about the future is not relevant enough without accounting the temporal axe, without state transition modelling.

1.2 Dynamics Modelling

That is why the geo-society calls for temporal data, temporal oriented spatial databases. This need comes from natural necessity of registration of changes appearing around us on one hand and the need of monitoring of long-term processes and trends and theirs interrelations on the other one (Cornelis,2002).

Data are not perfect from many reasons:

- Incomplete data
- Precision of measurements
- Discreet description of connective phenomena
- Inherent part reflecting our understanding of things (Deng, 2002).

On the other hand the current top level of GIS usage, it is control GIS, where the large ability is aided to implement knowledge models from different branches of scientific investigation, wide context implementation including less evident connections, models of trends, objects and expected or predicted relations.

The integral part of control GIS (Klimešová, 2006) is the modelling where the information layers from real, artificial and virtual world are composed together to select optimal scenario or verify given hypothesis or assumptions. The contextual design of spatial data and further development of geo-information technologies, image processing techniques and the possibilities of object history modelling together with the geographical networks environment will provide quite new and considerably wider possibilities of using GIS.

GIS architecture is open to incorporate new requirements of knowledge-based analysis and modelling, namely in connection with web designed spatial databases and temporal oriented approaches. This type of geo-information processing it is the resource, tool and means. It is modelling in most common sense.

If the standard geographical database is understand as a digital model of the real world than control GIS handles the DB, which is the result of temporal interface of standard DB with virtual and artificial models of real world.

2. UNCERTAINTY

From the philosophical point of view the uncertainty is quite natural part of our life and the surrounding world. Uncertainty might not be a bad thing if you can make better use of it then others, in the sense of competition. We can understand this concept in the frame of description - ordered and chaotic. Usually we meet uncertainty in the sense of valuation. Uncertainty is a real and universal phenomenon in valuation and the sources of uncertainty are rational and can be identified. Valuation is the process of estimating the value and estimation will be affected by uncertainties. The input uncertainties will translate into an uncertainty of the valuation.

Actually – the uncertainty arises from imperfect understanding of the events and processes in the world around. From another point of view the fact of uncertainty is very stimulating for the research on the field of *defining*, *measuring*, *modelling* and *visualizing* uncertainty and data quality analysis. The uncertainty opens the space for further questions like: *where, why and when* and the answers to this question can help us to do better decisions (Fuller, 2000).

To gain the answer it is necessary incorporate the various contexts into the analysis of objects, phenomena, events and processes and connect up uncertainty into the knowledge-construction and decision-making process through context cognition.

Web provides universal and rapid access to information at a scale that has never been seen before and GIS technology has become easier to use and more accessible and make possible to think about large context of processed data.

The wide context (temporal, spatial, local, objective, attribute oriented, relation oriented) influents in the sense of decreasing the uncertainty of data, classification process, analytical results and consequently increases the information value of decision support (Benedikt,2002).

Uncertainty in GIS caused by

- Data uncertainties
- Attribute accuracy
- Logical inconsistency
- Use of many data types, different resolution, integration of data types
- Incorrect interpretation of results
- Unsuitable sequence of operations
- Insufficient information about source of data, data production, quality
- Different data models

The model is only an approximation of reality and the modelling process is dependent on the subjective interpretation of the knowledge. It means that new observations may lead to a further refinement, modification, or completion of the already constructed model. And the model may guide further acquisition of knowledge and the knowledge is the base for decision support. Moreover, besides knowledge modelling also knowledge representation is very important field of research.

2.1 Uncertainty Management

To reduce uncertainty of data it is mainly the question of the proof of recognized quality assurance. Some users often take the pragmatic approach to the cost versus accuracy. Sometimes, without the relevance testing, the resolution of data is used for the whole set of different task. Then the problem of over-defined and under-defined objects brings the difficulties (Klimešová, 2004).

It is necessary to mention that important role in uncertainty management needs the new methods, namely intelligent methods with knowledge based approaches and multicriterial oriented environment where the level of the risk can be defined and kept.

For this purpose we distinguish two main types of uncertainty:

- Uncertainty of objects
- Uncertainty of relations

Uncertainty of objects (points, lines, polygons) is implied by the differences among objects inside human cognition and system. Uncertainty of relations arises from the differences among cognitive, computational and GIS objects. Uncertainty of a geographic object can be modelled through uncertainty of its geospatial, temporal and thematic attributes. Uncertainty of relations takes into consideration spatial, temporal and spatio-temporal relations.

To add suitable attribute or to spread the net of relations reduce the uncertainty of the object. The special case is to model objects uncertainty using spatial-temporal approach to the objects and incorporate spatial-temporal relationships. The dynamics of object is very powerful tool to obtain exact results about the object and phenomenon behaviour to support further decision (Zhang, 2002).

The decision making process is always associated with some level of uncertainty which can rise from:

- Definition of the problem
- Spatial data used
- Sequence of operations used to obtain result
- Understanding of result

GIS is shifting very fast from desktop GIS to network GIS. Great advantage of network GIS is ability to provide GIS services in a networked environment, typically through the Internet.

With this technology, all GIS components, data components and functional objects, can be distributed across the network. In this component-oriented framework the user has no problem with the increasing complexity of information structures and quality demands and is able understand objects and phenomena and theirs expressions in various context and provide richer analysis with different aspects of modelling.

2.2 Context Understanding

The contextual modelling, as mentioned over, deals with different types of context information. It is possible consider context as follows.

Context as the reflection of object or phenomena using different interpretation through the system of cognition:

- Perception
- Conception
- Interpretation

Context as the reflection of selected facts is concerned with validity of statements and the system of argumentation:

- Identification
- Analysis- coordination
- Synthesis – decision

Context as the reflection when hypothesis stays instead of experience in the system of abduction – instinct based context:

- Recognition of patterns
- Coordination by intuition
- Judgement due to synthetic inference

Context as the reflection concerning validity of statement using knowledge generating system – knowledge based context:

- Abduction – iconic analogy to experience
- Deduction – model of ideal world
- Induction

Context as the reflection of internal/external learning processes through the system of quality – learning based context:

- Abduction
- Deduction
- Induction

Using context it is possible to derive new quality of information that can be used to support decision.

2.3 Spatial-temporal Data Modelling

Temporal or dynamical analysis of spatial data is needed in various fields such as mainly known environmental systems analysis. Dealing with this approach we are facing the difficulties in generating spatial-temporal space of quality data for analysis, the necessity of interpolation or integration of observational data (Parent, 2000).

The great advantage is to mix spatial topological relations with temporal topological relations and generate and extract new spatial-temporal relationships from the spatial-temporal objects. The uncertainty of objects is projected to the uncertainty of relationships between objects.

Context sensitive object recognition is a successful strategy to reduce uncertainty geographical objects through multi-aspect geographical relations that can help us to select enough discriminative sources of information.

3. CONCLUSIONS

The contribution deals with more abstract level for reflection and understanding of the various modelling processes in geo-information processing. Due to this fact the modelling tool has been introduced as a formal framework reflecting the context in various representational levels. Due to this argumentation the understanding of the model as related to an actual context represents perfectly this idea. In this article this general view on the way of building models is presented as a formalized modelling tool and the capacity is illustrated due to the aspects of argumentation and learning.

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