

# Study on Uncertainty and Contextual Modelling

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**Abstract** — The contribution deals with issues that are very closely connected: Dynamic GIS, the problem of uncertainty of spatial data and 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. 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 discusses the problem of wide context 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.

**Keywords** — Knowledge, uncertainty, knowledge management, contextual modelling, temporal modelling.

## I. 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 [10]. 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.

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.

Manuscript received: October 9, 2006.

Revised Manuscript received: March 7, 2007.

This work was supported by the project Information and knowledge support of strategic control - MSM 6046070904 and by project VEGA 1/0386/08.

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Mobile Internet GIS and Mobile Web Map Services, it is a new solution that offers mobile Internet access to the data including their 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 [6].

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 [3], [7]. 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 [4], [5].

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.

That is why the geo-society calls for temporal data and 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 their interrelations on the other one.

## II. CONTROL GIS

The unique integration capabilities of a GIS allow disparate data sets to be brought together to create a complete picture of a situation. GIS technology illustrates relationships, connections, and patterns that are not necessarily obvious in any one data set, enabling organizations to make better decisions based on all relevant factors. Forward thinking government agencies have found GIS essential to manage the business of government. GIS is demonstrating real business value.

GIS plays a significant part in the day-to-day functions of information gathering agencies; the way this information is distributed to other agencies and organizations. By integrating GIS with government processes it is possible to create an information base that shares information resources, to reduce data redundancy, and increases data accuracy, to perform joint project analysis, to provide decision support and to increase efficiency, automate tasks, and save time and money.

GIS gives the tools to be able to make informed decisions and to share knowledge with others.

### A. GIS Architecture

The current top level of GIS usage, it is control GIS [8], 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 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.

The area of Computer Science that is most influenced by the concept of knowledge is Artificial Intelligence (AI) and Knowledge Based Systems (KBS) [6].

In the early 1980s the development of a KBS was seen as a process of transferring human knowledge to an implemented knowledge base. This transfer was based on the assumption that the knowledge, which is required by the KBS, already exists and only has to be collected and implemented [5].

Since the knowledge is specified independently from the application domain, reuse of the knowledge is enabled for different domains and applications.

Some observations can be made about modelling view of the building process of a KBS.

The model is only an approximation of reality. The modelling process is a cyclic process. New observations may lead to a refinement, modification, or completion of the already constructed model. On the other hand, the model may guide further acquisition of knowledge – contextual understanding.

## II. 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 than others. 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.

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 [7].

To gain a new quality of information it is necessary to 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.

The dimensionality of data and the complexity of objects structure hierarchy are rapidly growing and consequently with these aspects increase the uncertainty entering into the processing and play significant role in the environment of Internet and Web Services [3]. 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. Data collection is changing from digitising 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 [4].

### A. Uncertainty Management

Data are not perfect from many reasons: *incomplete data, the precision of measurements, discreet description of connective phenomena, inherent part reflecting our understanding of things* [11].

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.

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 [8].

Especially 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 [16].

The decision making process is always associated with some level of uncertainty which can rise from: *the definition of the problem, used data, sequence of operations used to obtain result and the measure of 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 their expressions in various context and provide richer analysis with different aspects of modelling.

### B. Context Understanding

The contextual modelling 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, and interpretation.*

Context as the reflection of selected facts is concerned with validity of statements and the system of argumentation: *identification, analysis-coordination, and 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 and judgement due to synthetic inference.*

Context as the reflection concerning validity of statement using knowledge generating system – knowledge based context. Using context it is possible to derive new quality of information that can be used to support decision.

### III. TEMPORAL DATA MODELLING

The integral part of control GIS [9] 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.

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 [11].

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 and primarily it holds in temporal context application.

The time is considered to be continual valuable,  $T$  is the set of measured times that corresponds to the set of real numbers and  $I$  is the set of temporal intervals.

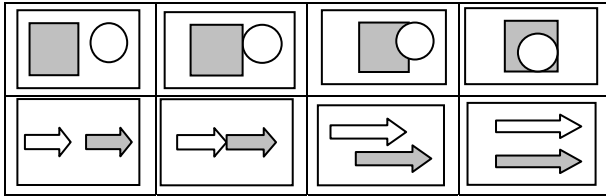
Let  $i$  is the temporal interval from  $I$ ,

$$i = [t_1, t_2], \text{ where}$$

$$t_1, t_2 \in T \text{ a } t_1 < t_2. \quad (1)$$

The selected relations between the temporal intervals of type: *before, meets, overlaps, equal* are considered and in the similar way it is possible to introduce the spatial relations in two-dimensional space like: disjoint, touch, inside, overlap, covered between two objects  $p_1$ ,  $p_2$ .

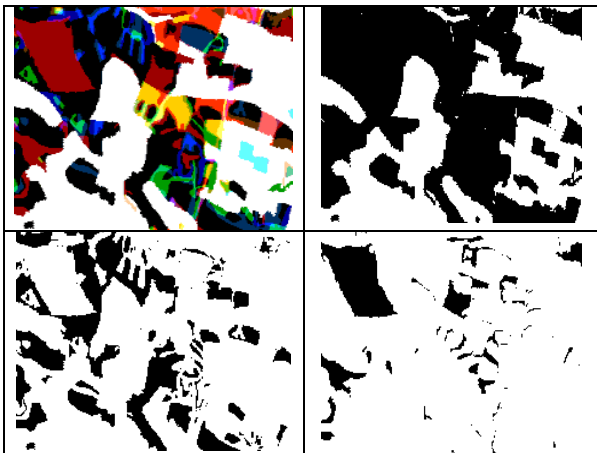
TABLE 1.  
SELECTED SPATIAL AND TEMPORAL RELATIONS.



Then it will be useful to define the interior and the border of the object (phenomenon)  $p$  and the concept of temporal and complex object as a reflection of combination and temporal decomposition of the object.

On the base of these considerations it is possible to create temporal space, to define objects type and propose the concept of interior and border of the interval. Then the algebra can be built. It is of course far from our exciting imagination to build real temporal database.

TABLE 2.  
COMPLEX AND TEMPORAL OBJECTS.



#### IV. CONCLUSION

The contribution deals with more abstract level for reflection and understanding of the various modelling processes. In this paper, the problem of wide spatial and temporal context is discussed. Our decisions are becoming increasingly dependent on understanding of complex relations and phenomena in the world around and context modelling is able to incorporate new requirements and produce more valuable results. The main goal has been to show selected aspects of this process and compare the increasing possibilities of the sources with the difficulties of data contextual structuring and the object dynamics implementation.

#### ACKNOWLEDGEMENTS

The Project Information and knowledge support of strategic control - MSM 6046070904 and VEGA 1/2185/05 support this work.

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