Knowledge Management Improvement Using GIS

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Abstract: In this paper, the problem of knowledge management is addressed and the different ways of knowledge integration are discussed. The contribution deals with the possibility to support our decisions using GIS with knowledge based DB in combination with raster oriented advanced methods to acquire, analyze and evaluate data. Accessible satellite data can bring new aspects into landscape evaluation including temporal point of view and understanding various contexts on the background of the process understanding. The paper discusses the contribution of image processing techniques to improve cognitive processes.

Key-Words: Knowledge management, data classification, temporal analysis, decision making, composed classifiers, boosting

1 Introduction

1.1 Geographical Objects
A single piece of data has no meaning unless the context is considered. The quality of decision-making is always dependent on the quality and quantity of information about issues and on the suitable classification methods enabling to select the best alternative from the set of all available solutions [2], [4].

A sufficient amount of the quality information about the issues to be decided is needed and the quality decision can be made. For this reason certain properties of objects are observed, which are important from the decision-making process aspect, it means, they are being evaluated according to certain evaluation criteria.

Information about the significance of evaluation criteria has, in many multicriteria decision making methods and approaches, significant importance. Our decisions are becoming increasingly dependent on understanding of complex relations, deep context and dynamics of phenomena in the world around [5], [7].

1.2 Geographical Information System
GIS technology provides essential marketing and customer intelligence solutions that lead to better business decisions. Geography is a framework for organizing our global knowledge and GIS is the technology for being able to create, manage,
publish and disseminate this knowledge for whole society.

GIS help our business saving time and money, while improving access to information and realizing a tangible return on our GIS investment. Information must be structured and knowledge must be represented so that answers can be found among the information in the system or derived from the information in the system.

GIS can be easily considered as knowledge management platform. The evolution of the Internet and Intranet applications intensely contributes to effective information and knowledge acquisition, incorporation and significantly shapes the role of the technological infrastructure [3], [10].

We need the system that is able to ask for more information if it is needed to derive a good answer and to answer in easily understood format. The system assists in knowledge acquisition, is able to learn and accept different information structures and to have in disposal a wide range of information processing techniques and methods, and appropriate knowledge presentation tools [12].

The geography plays a very important role in many situations. Spatial decision making, targeting market segments, planning distribution networks, responding to emergencies, and many others - all of these problems involve questions of geography.

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. GIS technology is also being used via the Internet and Web services.

1.3 Remote sensing

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. The higher resolution of multispectral data makes possible not only improves the recognition of geo-objects, it makes possible to deduce selected attributes of geo-objects.

GIS and its constructions are based on the models. These models are an approximation of reality and are dependent on the subjective interpretation of the knowledge. It means that new observations may lead to a refinement, modification, or completion of the already constructed model.

On the other hand, the models may guide further acquisition of knowledge and the knowledge is the base for decision support.

The integral part of control GIS [6], [7] 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.

1.4 Knowledge Management

Knowledge is an important resource for successful decision-making process in the whole society. The special procedures of control and management of knowledge therefore have to be used. In the area of knowledge management and knowledge engineering basic terms of these disciplines are data, information, knowledge and knowledge transformation [8], [13].

Knowledge is a product of successful decision-making process and knowledge modelling and knowledge representation is an important field of research also in Computer Science and Artificial Intelligence. The development of knowledge-based systems was seen as a process of transferring human knowledge to an implemented knowledge base.

Geographical Information Systems (GIS) support decision-making process, therefore they also produce a new knowledge. They are an interactive computer-based systems helping decision makers complete decision process. Geographic Information Systems provide essential marketing and customer intelligence solutions that lead to better business decisions.

Knowledge is a multifaceted concept with multi-layered meaning. Further more, new customer-oriented management [11], [16], quality principles and new information technologies promote new styles of communication and decision-making in company departments.

Knowledge can not be defined without its context, experience, interpretation, and reflection. Knowledge has the following aspects (Gottschalk-Mazouz 2008):

♦ represents solution of problem
2 Problem formulation

Many GIS users face the problem of acquiring accurate and timely suitable data at a cost effective price. Finding features in remotely sensed imagery can be a time-saving way to define and update geographical layers.

Space technology has been gaining more and more ground in our life. Earth observation images sometimes turn into an irreplaceable source of independent and up-to-date information about the condition of an area. Satellite data as well as aerial data is used to monitor fire situation, seasonal and flash floods, construction activities, forest management, environmental and navigation situation, etc. [19].

- Satellite imagery are the tool of an efficient modernization of economy (application in large industrial projects, investment, communication)
- Operational services for emergencies monitoring, control and response (strategy planning, fire situation, seasonal floods and flash floods, water areas)
- Application of satellite data for solution of nature protection tasks
- Integration of satellite data, GIS and Web technologies

When raster images with spectral information are available, so called multispectral images (usually satellite data with multiple wavelength channels), we can use a lot of methods for classification pixel by pixel into specific classes. Raster data classified in this way can then be converted to vector layers, and output to a variety of vector formats.

This process is usually much faster and easier than manually digitizing from the raster image. It is a cost effective way to update our GIS with accurate and timely layers and add new vector layers to geo-database.

Frequently used raster classifiers in image processing include standard approaches such as Bayesian classification, maximum likelihood and minimum distance classifiers as well as more sophisticated.

For example ESRI together with ENVI has in disposal the package focused on less and more sophisticated classification methods, including neural network and decision tree classifiers.

3 Classification

3.1 Statistical Pattern Recognition

Recognition (classification) it is assigning a pattern/object to one of pre-defined classes. Two basic approaches:

- Supervised classification when training set is available for each class
- Unsupervised classification (clustering) when training set is not available.

Desirable properties of the training set:

- It should contain typical representatives of each class including intra-class variations
- Reliable and large enough
- Should be selected by domain experts

Than it is necessary to setup the classification rule it means the way of the feature space partitioning.

Each class is characterized by its discriminate function \( g(x) \) and classification, it means maximization of \( g(x) \), where feature \( x \) is a point in \( n \)-dimensional metric space (usually Euclidean space) that describes the object. We assign \( x \) to class \( i \) if

\[
g_i(x) > g_j(x)
\]

Discriminate functions define decision boundaries in the feature space, see fig. 1.

Having no training set in disposal the unsupervised classification (clustering) is used. We can say that clusters are:

- Compact, well-separated subsets or
- Any partition of the data into disjoint subsets, see fig. 2.
Clustering techniques:

♦ Iterative methods, when the number of classes is given
♦ Hierarchical methods - typically when number of classes is unknown (agglomerative and divisive clustering)
♦ Other methods - sequential, fuzzy or genetic focused, etc.

3.2 Composed Classifiers

Great amount of tasks is focused on special factors monitoring, analysis and evaluation and new requirements result in new methods development. Precision of classification can be increased by the best properties of few classifiers united to one component classifier.

The advantage of the component classifier is: union of different approaches, for example statistical approaches, neuron network or decision trees. Composed classifier is a composition of component classifiers, which predictions are connecting by combining classifier [14], [17].

Main architectures for combination of classifiers:

♦ Bagging - creates individuals for its ensemble by training each classifier on a random redistribution of the training set [4]
♦ Boosting - tries to increase the precision of classifier by creating a complementary component classifier [6], [17] by filtration of a training set
♦ Stacked Generalization - classifiers on a higher level combine prediction of classifiers immediate on the lower

Composite Classifier Design Criteria

♦ Accuracy of the component classifiers (independently accurate).
♦ Diversity of the component classifiers - combining the predictions of a set of classifiers that all make the same errors cannot lead to any improvement in the accuracy of the composite prediction.
♦ Efficiency of the entire composite classifier – general requirement that a classifier should use only reasonable amounts of time and memory for training and application.

3.3 Post Classification

After pixels in a raster dataset have been assigned to classes, post-classification methods can clean up the resulting raster image in preparation for conversion to vector data. Raster classification often contains scattered individual pixels of one class surrounded by a larger area of another class.

Post classification improves raster analysis. The raster image with the classes is than converted to vector layers. Classifying images can be used as outputs in reports or analyses and more this approach help us:

♦ to replace or accelerate manual digitization processes
♦ manage multiple types of geographic data
♦ improve workflow processes, from data gathering and analysis to publication and distribution of findings
In the last years, also fuzzy logic is often implemented successfully in various GIS processes. Important implementations were made in the fields of classification, analysis, data collection and in remote sensing. The GIS practice deals with many activities with fuzzy behaviour and this is the reason why fuzzy knowledge should be modelled appropriately.

Most of the decision problems are multicriteria. The problem of the selection or the ranking of alternatives submitted to a multicriteria evaluation is not easy problem. Since every decision-making affects the course of further events, it is necessary to pay attention with an appropriate respect to the decision-making process.

Than will pay that GIS:

♦ shows data, information and knowledge and their relationships, patterns and trends in the form of maps, scenarios, reports and charts
♦ helps to solve problems using data which are quickly looked up, easily shared and internally and externally networked
♦ information layers can follow the local, temporal, thematic, spatial, and other types of context

Since the knowledge is specified independently from the application domain, it means that reuse of the knowledge is enabled for different domains and applications. The knowledge modelling connected with knowledge based systems is influenced everyday by new research results.

4 Conclusion

In this paper, the problem of multi-criteria evaluation is addressed and the different ways of knowledge integration are discussed. The great possibilities of satellite and aerial data to be incorporated not only as layer that visualize the scene but as a valuable source of irreplaceable information that can be transformed into knowledge. Our decisions are becoming increasingly dependent on understanding of complex relations, deep context and dynamics of phenomena in the world around and geographic information technology is able to incorporate these new requirements and produce more valuable results. The main goal has been to show selected aspects of this process.

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