Brus., J., Dobešová, Z., Kaňok, J., Pechanec, V.(2010): Design of intelligent system in cartography. Brad, R. (ed). : Proceedings. 9 RoEduNet IEEE International Conference. Sibiu, University of Sibiu, 112-117p. ISSN 2068-1038. ISBN 978-1-4244-7335-9.

Design of Intelligent System in Cartography

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Abstract — **There is an intensive using of information technologies in many branches of human activity nowadays. Software designers and developers are stimulated by positive results and success information technologies. Many new functions are arising in most software products used in geographical information systems and digital cartography too. For many users of this software it is very important possibility to design graphic outputs and map design. There are two ways how to eliminate problem of the insufficient knowledge of cartographic rules. The first way is education in cartography, but this is time-consuming. Second way is making application, which allows design correct maps and allows spreading of knowledge. This application can create map either automatically or with interactive activities of user. Automatically generated maps cannot fully substitute professional maps, but expert system for cartography is useful for students and other users in the process of map making. The expert system both leads in correct creation of map both explains rules of cartography. Design of intelligent web based application for cartography is described in this article.**

Keywords — Cartography, education, expert system, computer map creation, knowledge base, ontology.

I. INTRODUCTION

Spatial information is very easily accessible via the internet nowadays. Various groups of users use this potential and express their results by the digital maps. These users work in the area of spatial planning, nature protection, tourism, advertising and in many other professions. Students and teachers also make up a big part of people which deal with visualization of spatial information. Not only internet also spreading of computer technology brings opportunities of creation various maps. Production of map with using this adequate software is a simple process now, which can be used by non-cartographic users. These users haven't cartographical knowledge and very often make maps in own way. Geographic information systems (GIS) are very often used for this map creation. Despite the lack of success in the implementation of integrated digital cartographic systems into geographic information systems, the researchers still attempts to develop a framework for a complex automated map production. They examine alternative routes for accomplishing the goal of an integrated cartographic system. These routes involve mainly art technologies such as expert systems (ES) and software agents.

Map creation belongs to special discipline – cartography and map creation is a work for cartographers. Cartography has its specific origins in ancient period. Since this period experts – cartographers have created a system of laws, principles and recommendation. Maps evolve into unique communication tool. If the information in the map is represented correctly according to cartographic recommendations the transfer of information is correct and helps to the reader significantly. Correct map is also very important in decision making. Right visualized map exchanged via network is essential for right decision in crisis management. Misunderstanding of this information can have fatal consequences. Correct visualization of data is also important on the field of sensor network.

The possible way how to reach the correct map made by non-cartographer is to store cartographer's knowledge in knowledge base with using a computer intelligent system. Cartographic knowledge stored into intelligent systems can help users in creation digital maps according the cartographic rules. Intelligent systems can work as "computer teachers" or advisors in the process of map creation. In other hand these systems should replace role of cartographer in dynamic visualization of phenomena. Implementing similar system into web based server allows quick generating of correct maps.

Building such a system which can helps people to make maps according to the rules collide with extensiveness of whole cartography. Cartographic rules can be explicit only after a thought-out concept of hierarchy of rules and components. The first step in design similar system is based on ontology. Ontologies can significantly helps in whole process and be the base stone of building intelligent system.

II. USAGE OF ARTIFICIAL INTELLIGENCE

"Knowledge engineering" or expert systems started out as pure research, and were in fact developed and studied by artificial intelligence laboratories for more than a decade before knowledge engineering began to be offered commercially. Beginning in the mid 1960s, a new type of system, called an expert system, began to be developed to support management in the decision making process. The new type of system, which represents one of the first practical applications of artificial intelligence, is an exciting addition to the kinds of computer systems available. However, expert systems are designed to be users' assistants, not replacements. The most common definition of Knowledge-Based Systems (KBS) is human-centered. This highlights the fact that KBS have their roots in the field of artificial intelligence (AI) and that they are attempts to understand and initiate human knowledge in computer systems [1]. Expert systems are computer programs which are able to simulate actions of an expert in a particular field when solving complicated tasks. They are considered a sub-category

of knowledge-based systems. They are based on symbolic representation of knowledge and its implementation in an inference mechanism. Experts in the given field present the source of knowledge and procedures. These systems are able to justify solution procedures. They are used primarily for tasks difficult to structure and algorithmize, e.g. problems with recognition of situations, diagnosis of status, construction, planning, monitoring of status, corrections, management and decision-making. However, experience and intuition have to be part of the solution [2].

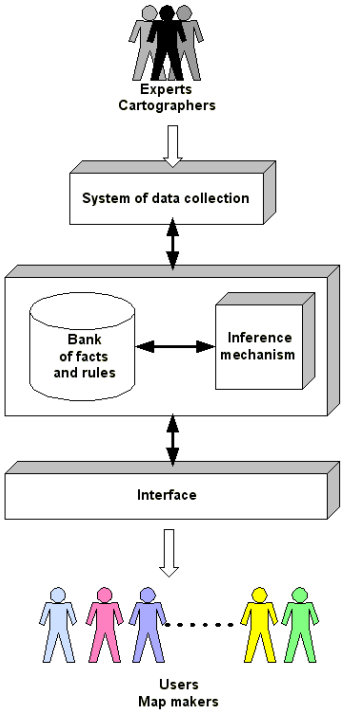

Figure 1. Parts of expert system

The KBS usually consists of four main components: a knowledge base, an inference engine, a knowledge engineering tool and a specific user interface [1]. On the other hand, the term KBS includes all the organizational information technology applications that may prove helpful to manage the knowledge assets of an organization, such as ES, rule-based systems, groupware and database management systems (DBMS) [3].

III. ONTOLOGIES

The term "ontology" has recently been adopted by the artificial intelligence community to refer to a set of concepts that can be used to describe some area of knowledge and also build a representation. Ontologies [4, 5] were developed in the framework of artificial intelligence (AI) to facilitate knowledge sharing and reuse. In process of building of an expert system in cartography is necessary to build a knowledge base which will include cartographical terms and rules. The difference between ontology and a knowledge base should be explained like this. Ontology provides the basic framework or skeleton, which can be used for building a knowledge base [6]. The reason of ontologies popularity is that they promise a sharing and common understanding of some domain that can be communicated between people and application systems. Ontologies are crucial for knowledge interoperation; sharing the same ontology is a precondition to data sharing and data integration. Ontologies are also central to the Semantic Web [7], because they allow applications to agree on the terms and consequently to communicate. The term of ontology became a trendy word but utilization of ontologies in complex application is more then necessary. Thanks to this situation ontologies are spreading into many kind of profession where some knowledge capture is requisite.

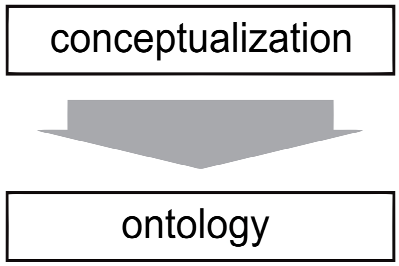

Figure 2. Relationship of concepts and ontology

The development of cartographic ontologies allows cartographers and computer programs to share a common cartographic knowledge to make cartographic rules explicit and reusable. In the same time it allows to separate domain knowledge (common vocabulary) of operational knowledge (cartographic rules) [6].

The problem of branch ontology is fundamental problem dealing with the use of artificial intelligence. This problem is solving in the research departments around whole world.

IV. DESIGN OF INTELIGENT SYSTEM

The technical and software level of modern information systems allows design of expert system with cartographic knowledge [8]. Spreading and accessing of the expert knowledge is easily to the end-users via internet nowadays. Effective implementation of intelligent system for interactive map design support requires a suitable technical solution. This task is solved in conjunction with the experts at computer science and especially at artificial intelligence. A suitable tool known as empty expert system was used for knowledge subsystem implementation. Solution based on products of free of charge under public domain license was preferred.

The keynote of this solution is an open access to cartographic knowledge base for every user. This access is related to using cartographic methods. Thanks to this access users will avoid big mistakes, due to their insufficient cartographic background. This support can be finally provided by the intelligent system designed for interactive map construction.

The aims of utilization of this intelligent system are two:

- creation impact – advises and explanation in practical map creating process,

- education impact - receiving of cartographic knowledge for future repetitive map creation.

The meaning of final intelligent system for interactive support of thematic map design can be achieved by fulfilment of the following goals:

- cartographic knowledge base for thematic map design,
- algorithm for assisted interactive support of thematic map design,
- technical solution for implementation of intelligent system and verification through pilot project.

A set of particular cartographic rules from knowledge base will be used for composition of the algorithm for assisted interactive support of thematic map design. The final algorithm will be general, formalized description of thematic map construction. The user interface of intelligent system will be user friendly with intuitive arrangement.

Cartographic knowledge base proposal, algorithm proposal and functionality of the intelligent system could be verified through a pilot project. Within the framework of the pilot project, the system will be implemented with functionality enabling to use the method of choropleth map and diagram (chart) map. Choropleth maps express relative data and diagram map express absolute data in map.

A. Knowledge acquisition

The first part of construction of knowledge cartographic intelligent system is transfer of expert knowledge from various sources to a computer form [9]. The sources in the area of cartography are mostly cartographers - experts, cartographic books, maps and atlases. Knowledge acquisition and ontology is a complex and time-consuming stage of expert system development which is indispensable without collaborating between cartographers and knowledge engineers. An effectively deployed intelligent system must do more than embody expertise. Its rule base must be complete, non-contradictory and reasonable. At this stage is necessary find out conceptual annotations on which can be based a domain model. Knowledge engineers employ a variety of techniques for eliciting information from the expert in order to construct a complete and consistent rule base [10].

The cooperation with cartographers – experts is considerable in some ways [11]:

- oriented interview - obtaining of facts,
- structural interview - obtaining of terms and models,
- free association - obtaining of relation between knowledge,
- monitoring - obtaining of global strategy,
- comment of steps - obtaining of derived strategy,
- dialogue of expert with users – results are interaction between knowledge and way of communication of user.

The knowledge engineer should be aware that expert knowledge is more than one kind and not all this knowledge can be acquired from one person. An interview with only one expert-cartographer can avoid some fail in expert system. Interview with group of cartographers is better. The suitable way of interview is brainstorming. There is necessary more punctually prepare interview and carefully lead interview with group of experts. There is also danger of conflicts between experts.

B. Technical background

Algorithm for assisted support of interactive map making was designed according to results of previously solved project „Orchestration of web services“ supported by Czech Science Foundation GA 205/07/0797. A prerequisite for using the proposed algorithm is an environment internet / intranet, in which we foresee the deployment and subsequent operation of an intelligent system for interactive support for the digital creation of thematic maps. Internet solution has number of advantages unlike to desktop applications. Most significant is the approach of intelligent system to a wide range of potential creators of thematic maps with lack of sufficient training and knowledge mapping. Another advantage is also the possibility of distributed processing of sub-steps in the creation of interactive thematic maps based on the usage of web services.

The creation of thematic data is very often made in geographic information systems (GIS) programs. Implementation of cartographic rules is possible directly into graphic software or outside the graphic or GIS software. Some software as ArcGIS® from ESRI company has some implementation of good cartographic function. The influence is only to users that use ArcGIS software. This software partly helps users to create a correct map but do not avoid them to create mistakes e.g. in choosing suitable colour ramp. The better way is creation of separate intelligent system with cartographic expert knowledge. Intelligent systems are independent on specific graphic or GIS software. This separate software solution is accessible to all mapmakers. Coupling of intelligent system and GIS software brings better utilization of GIS software.

Starting point for design intelligent system was another research at Palacký University in 2009. This research compared possibilities of creation thematic map in various GIS software. Research was carried out to search the conditions and the possibilities of map making process in GIS software. The special evaluation method named “CartoEvaluation” has been proposed for finding out the GIS software cartography potential [12]. Evaluation method is based on Goal-Question-Metric method. More than 13 GIS software of Czech and world production were evaluated under this method. The evaluation results are summarized into complex tables [12].

Different procedures of thematic map making in GIS programs can be compared with the design of our algorithms for assisted support of thematic maps. From the point of ontology we recognized mixture of GIS terminology in tested software. The terminology in software is very often consists from special term created by software producer. Several terms represent the same thing in different software. The terminology

used in software do not fully correspondent to cartographic terminology. Achieved knowledge will be implemented into a final domain model and significantly help in building intelligent system.

C. *Expert system*

Proposed intelligent model should be based on technology of shell expert system. Activities were mostly concentrated on the searching and assembling relevant information on available empty expert systems and the selection of suitable candidates that meet certain key requirements relevant to the final deployment of the pilot project.

Selection was done in two rounds. First choose was focus to find out the solution from broader programming tools (KADS, JESS, Drools, SweetRules Algernon, Jena, CLIPS), belonging to a group of empty expert systems. Assessment of key criteria (focusing mainly on interoperability and integration with other components) we decided to choose two final candidates that best met those criteria – JESS and Drools.

Detailed testing of mentioned expert systems follows this procedure. Individual instruments were individually tested with regard to the possibilities of a formalization of the rules applicable to an interactive guided of thematic maps creation, as well as with regard to the clarity of language of formalized rules for the inserting by a specialist, cartographer without deeper knowledge of programming. System Drools was chosen for implementing into final project based on the comparison of final test results.

System Drools [13] represents production rule system. Production rule system is a computer program used to provide some form of artificial intelligence, which consists of a set of rules about specific area, in this case - cartography. Rules are a basic representation finding useful in automated planning, expert systems and action selection. A production system provides the inference mechanism necessary to execute rules in order to achieve some goal for the intelligent system.

System Drools 5 is one from free accessible production rule management systems. Project Drools is community releases from JBoss.org that come with free download and utilization. Enterprise product from JBoss is JBoss BRMS (Business rules management system). Drools 5 introduces the business logic integration platform which provides an integrated platform for Rules, Workflow and Event Processing.

The Rete algorithm is implemented in Drools 5. Rete algorithm in expert system very quickly and efficiently checks the known facts against tree of rules in the knowledge base. Rete is a pattern-matching algorithm for implementing production rule systems.

Drools 5 is now split up into four main sub projects:

- Drools Guvnor (rules management system),
- Drools Expert (rule engine),
- Drools Flow (process/workflow),
- Drools Fusion (event processing/temporal reasoning).

Drools Guvnor is a centralized repository for cartographic knowledge base. The knowledge base is executable. Guvnor is the web and network related components for managing rules in a multi user environment with user-friendly interfaces. The definition of rules (Figure 3) consists of two parts: WHEN and THEN. Verifying of knowledge base is by scenarios.

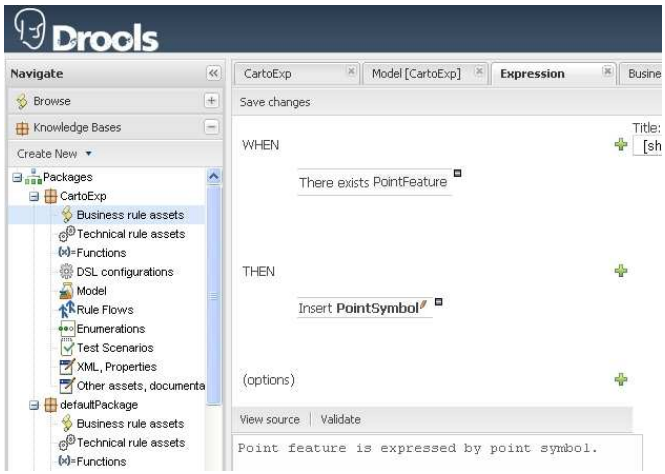

Figure 3. Creation of rules in Drools Guvnor

D. *Ontology design*

According of selection suitable empty expert system was also chosen appropriate editor for creating a knowledge base using ontologies. Branch ontologies are the fundamental means for defining the basic terminology, used in cartography. The reason for build this ontology is to prepare the basic concepts of thematic cartography and description of procedures used to create maps. Direct outlet should be the formalizing of the description of the map making and making maps describe the transformation of map making process from natural language into a formalized language for registration rules and algorithms.

An ontology design tool, Protégé System [14] was used. Editor is also chosen due to its interoperability easy to integrate with the tool DROOLS. Protégé is an integrated software tool used by system developers and domain experts to develop ontologies and knowledge-based systems. Protégé has been developed by the Stanford Medical Informatics (SMI) at Stanford University. It is an open source, standalone application with an extensible architecture. It holds a library of plug-ins that add more functionality to the environment [15]. The OWL Web Ontology Language is designed for use by applications that need to process the content of information instead of just presenting information to humans. OWL facilitates greater machine interpretability of Web content than that supported by XML, RDF and RDF Schema (RDF-S) by providing additional vocabulary along with a formal semantics. OWL has three increasingly expressive sublanguages: OWL Lite, OWL DL, and OWL Full (W3C consortium). Protégé OWL Plug-in now provides support for editing Semantic Web ontologies. There is also a list of the currently made ontologies on the Protégé Ontologies Library page [16]. It is a small but hopefully growing selection of existing OWL ontologies.

At the beginning of building first ontology for this project, OWL ontologies available via internet were explored. Some of them are suited for the expression of geographical information visualisation. They fulfil geographic information standards (ISO, OpenGIS Consortium - OGC, or standard by Federal Geographic Data Committee - FGDC) [17].

Our aim was to find out basic stones for building ontology on our specific domain and finally to develop a new ontology for specific cartographic application. After cataloging some semantic and structural relationships and after describing how these relationships have been exploited we tried to propose cartographical ontologies for one specific cartographic task with using adequate method (Figure 4). The classes represent the base cartography terms that was acquired from experts – cartographers.

Products that have been selected for deployment the project of intelligent system. These products will be implemented in JAVA language in web based application. This possible solution brings higher demands on hardware of developers and users of intelligent system.

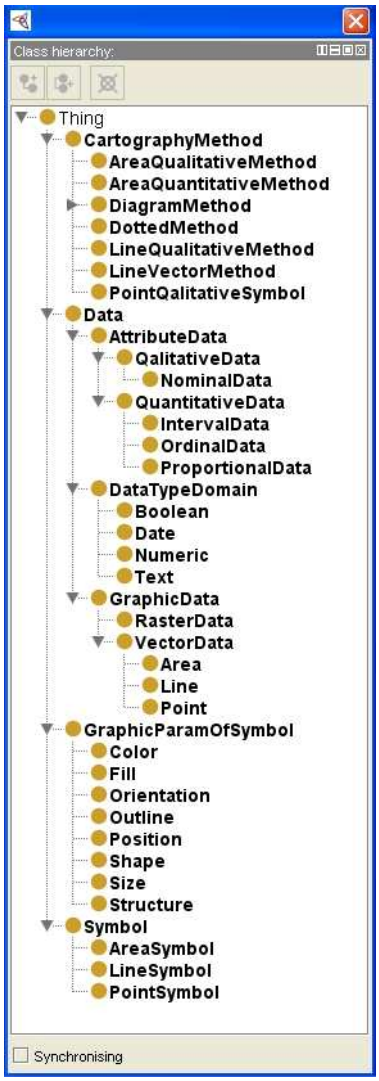

Figure 4. Proposed ontology design in Protégé System

V. CONCLUSION

Maps are unique means for communication of adequate amount of spatial information. Visualizing allows us to grasp and retain larger amount of information compared to the usage of words. Without the visual image, recalling the same information would require memorizing a long list of area descriptions [18]. Intelligent system is cartography is intended to wide group of non-cartographer and students. Intelligent system helps them to guide and create correct digital map output. This intelligent cartographic guide could be simply accessible through the internet. Realization of intelligent system is enabled thanks to progress in the area of artificial intelligence and technical development in computer science.

Design of intelligent system has several important steps. The background of intelligent system is expert system. Expert system consists of knowledge base with facts and cartography rules. Expert system processes these facts by efficient inference mechanism. Collection of cartographic knowledge is performed by discussion and interview with experts (cartographers). The knowledge engineers should not acquire the knowledge only from one expert. Collected information should be complex and comprehensive. For this reason group of experts is more suitable for whole process of knowledge acquisition. Acquired terms and facts from experts create the backbone of ontology. Creation of domain ontology is fundamental for definition relations and rules in expert system. The last task is design of interface (GUI) of application for end-users as a web application. Functions of intelligent system are tested under pilot project for creation choropleth maps and diagram maps. All this steps are necessary to carry out at organizational and technical level.

The design of intelligent system in cartography is partly based on long and extensive experiences with lecturing in the field of geoinformatics and cartography. The authors of article are university teachers, lectures and researchers. Our students are in the process of learning of cartography and GIS software. On other hand, cooperation with GIS users from practice is also frequent. All these users very often hesitate and create mistakes in digital map outputs. The assisted creation of thematic map increases the quality of map and quality of user's skills. Intelligent system will bring better utilization of map-making, mostly with GIS software. The internet solution will bring wider impact to user community.

ACKNOWLEDGMENT

This work was supported by the Czech Science Foundation grant GA205/09/1159. The intelligent system for interactive support of thematic map design.

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