CO-203

COGNITIVE MAPS IN THE GENERATION OF SPATIAL DATABASES

CORREIA A.C., SÁ L.
UNIVERSITY FEDERAL OF PERNAMBUCO, RECIFE, BRAZIL

ABSTRACT

The knowledge and a reality representation are essential to the development of cartographic documents that are composed by Spatial Database. This research became real because of the need of abstracting information of actual world in an organized and structured way to use in cartographic documents. The construction of this knowledge was developed by using some techniques of mapping information. The purpose of this research was an investigation of the use of cognitive maps, with identification of the needs of users and a discussion of the value of a generation of spatial database, in addition to this the presentation of procedures to the construction.

Keywords: Cognitive Maps, Knowledge Construction, Spatial Database.

1 INTRODUCTION

In mapping, spatial knowledge of the place you want to map is paramount. The perception of the Real World is different for each individual, because each one perceives phenomena or situations according to their own characteristics and experiences, and he also observes the aspects that are most relevant to himself. Thus, individuals create a mental model of how the world works and these changes as new information is acquired.

When faced with problem where there are many related information, the individual feels the need for resources to assist in the information organization.

The understanding and representation of reality are essential for the development of cartographic documents that are formed from Spatial Databases. The development of a cartographic document for a particular application requires the selection of spatial data, the simplification and expansion of features, cartographic generalization, the choice of symbols, among other factors that make the technical specifications of a project mapping.

Knowledge of the application is acquired in step Abstraction of Real World, which are defined in the spatial data that will compose the application, as well as their relationships.

Spatial Data Modeling is a procedure that has been used in the construction of Spatial Databases and consists of three basic steps: Abstraction of the Real World, and the Development and Implementation of the Conceptual Model of the Physical Model. The first step, Real-World Abstraction, is crucial to understand the application. TAKAHASHI and LIESENBERG (1990) refer to mental operations that individuals perform to observe an application and capture its structure in a conceptual model. It is through this stage that the reality is observed, and abstracted entities, their relationships and actions considered essential for an application, and excluding all aspects deemed irrelevant.

This research developed a methodology for studying the development of cognitive maps as a way of understanding the application, identify the user needs, and provide subsidies for the construction of Spatial Databases.

The term cognitive map refers to the mental representations that individuals make in relation to the surrounding environment. This representation is given from their interactions and learning in a specific field of the environment, Real World, with the function of giving meaning to reality, allowing us to deal with the problems and challenges it presents.

Cognitive maps allow the organization, structuring and visualization of data that create the implementation, monitoring and updating of a systematic and dynamic knowledge. Several individuals from different areas can interfere, modify and expand the cognitive map constructed by formulating or complementing Spatial Database created for representation and development of cartographic documents.

The overall objective in this research was to study the cognitive mapping in relation to the methodologies of cognitive maps in order to determine the Abstraction of Real World for the construction of knowledge and generation of the Spatial Databases. The specific objectives can be highlighted as follows:

- Investigate the use of Cognitive Maps for building networks of the information and knowledge;
- Provide the procedures for building a cognitive map;
- Discuss the importance and usefulness of cognitive maps in knowledge construction for generation of Spatial Databases.

2 COGNITIVE CARTOGRAPHY

According to SERPA (2005), cognitive cartography can be considered as integral and inseparable part of spatial practices; it facilitates the resolution of everyday spatial problems and guides the strategies of space appropriation.

A Cognitive Mapping facilitates decision-making as it provides tools for mapping and graphical representation of information, enhancing the processes of selection, linkage and association of ideas, besides it also allows a critical reflection.

The concepts of perception and cognition, as GOLLEDGE and STIMSON (1997) describe appear in different and varied contexts by psychologists and other scientists, often in a confused manner. The conceptualization and the distinction of these terms are important factors to be considered, since they help to improve understanding on issues related to user involvement with the geographic space and facilitate the acquisition of knowledge to development of cartographic documents.

2.1 Perception

According to GOLLEDGE and STIMSON (1997), perception can be considered as the immediate apprehension of environmental information for one or more of the physical senses (sight, hearing, smell, touch and taste). It occurs in the presence of perceived objects. The term perception tends also to be associated with visual perception, according to the vision which is the dominant sense in humans.

The way that the individual perceives and assesses Earth's surface is varied. In general, humans share insights because they have similar meanings. Individuals with different world's views are different assessments of the environment. Each set of individuals has its own knowledge; it is fact that due to their experiences and how to observe the environmental elements (TUAN, 1980).

2.2 Cognition

Cognition is the process of constructing knowledge in mind, which is formed through everyday experience; it is complementary to perception. Besides, it is through the cognition that the sensations acquire values and meanings, forming image on the universe of the individual knowledge. Necessarily it involves recognition, memory and thinking and creates expectations about the environment as manifested in attitudes and behaviors (REIS and LAY, 2006).

To GOLLEDGE and STIMSON (1997), cognition refers to the way of information is received when it is encoded, stored and organized in the brain, so that fits with the accumulated knowledge of the individual and their values. The authors also say that psychologists differentiate perception cognition; the perception is related to the immediacy and depends on the stimulus, while cognitive behavior does not require immediate needs and not be directly related to the events of the environment next. Cognition includes feeling, perception, mental image formation, retention of information, reasoning, solutions, formation of judgments and values, which are decisions and choices.

SLOCUM (1999) discusses the concept of cognition to cartography related to memory. He says that there are three types of memory: Iconic memory, visual short-term memory and long-term visual memory, as illustrated in Figure 1.

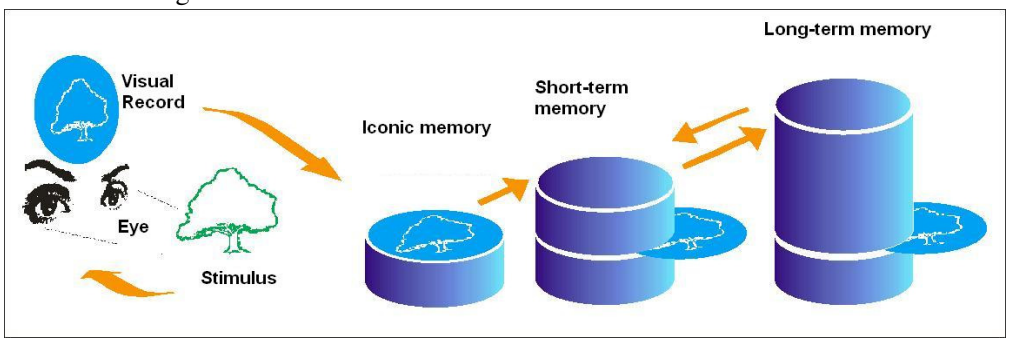

Figure 1 - Memory used at Cartography.

The iconic memory is the initial perception of an object by the eye, where individuals have no control. This memory has unlimited capacity and the information is captured in a split second, which is enough to start the object recognition. After the information is recorded in iconic memory, the image of the object moves to the short-term memory in the brain, where information is selected and transmitted to the next stage. When some object or information is initially stored for later use, then the long-term memory starts. In the information retrieval the reverse process is used, i.e., the object moves from long-term memory to short-term (Figure 1). The long-term memory represents a permanent storage where nothing is lost (SLOCUM, 1999).

Although the processes of perception and cognition are part of the same event, the perception process occurs before the start of cognition. Thus, it can be argued that the end product of perception and cognition is the mental representation of the environment.

2.3 Cognitive Mapping and Spatial Databases

The cognitive mapping is considered as a part of the process of spatial cognition. It can be defined as knowledge of the cognitive representation of the entities' structure and relationships of the space, in other words, it is the internal reflection and reconstruction of thought and space (GOLLEDGE and STIMSON, 1997). The final product of the process of cognitive mapping is known as cognitive map, a device that helps simplify and organize the complexities of human-environment interactions and model essentially individual in the world in which we live (GOLLEDGE and STIMSON, 1997).

The knowledge of how the individual of a particular group or a particular geographic region view the space in which it is inserted. It also helps to clarify some variables of spatial perception and cognition, and therefore makes it possible to model the spatial thinking in general terms. From the cognitive mapping perception, it is possible to generate cartographic representations that would be accepted and used as the default (ISSMAEL and MENEZES, 2004).

In addition, geographical and cartographic documents are used to represent connections between different elements of any field of knowledge. The development of cartographic documents is a process of creation, knowledge building, revealing that decisions can be made about what they include or exclude, how to represent and how to communicate (OKADA, 2004).

The BDE is used in the preparation of cartographic documents, beyond forming the charge of GIS. According to GOLLEDGE and BELL (1995), cognitive maps can facilitate the process of developing a GIS application system, since the definition of variables and their relationships can be found in cognitive maps. Therefore, the established procedures help to solve tasks and make spatial analysis.

To ISSMAEL and MENEZES (2004), who study the geographic space representation, it is also a relevant factor for spatial perception and cognition. For example, individuals who live in the countryside and have never seen the ocean or large groups of buildings of the cities will probably have only a picture of how these may be. The images may have been created on the basis of journals, photographs, television or reports from others. Thus, it is easy to see that the spatial abilities of each individual are closely linked to the experience and spatial learning and, somehow, to creativity and intelligence.

The conclusion is that for the cartographer, it is essential that you have a clear and defined purpose and you know the target audience of the cartographic document; as well as it is important to have an overview of the content to be mapped and the context in which it is used.

3 TECHNICAL INFORMATION MAPPING

Attempts to visual representation, usually presented in the mapping information are one of the most important tools in the study of knowledge (CARVALHO, 2001). The visual representation aims at a reproduction of the individual to understand, organize or structure the environment around them. The mapping information can be useful tools to summarize, analyze and communicate the individual's knowledge.

3.1 Concept maps

The concept maps were developed by Joseph Novak in 1960 at Cornell University, USA, and its construction is based on Constructivist Theory and the Theory of Meaningful Learning of David Ausubel, i.e., Novak created the concept maps as a formula to practice the ideas of Ausubel's Meaningful Learning (ARRUDA, 2003 and MOREIRA, 2008). According to OKADA (2004), at the Constructivist Theory, individuals construct their knowledge from the relationships between various elements. This relationships help in the systematization of new concepts in meaningful content to the learner.

RODRIGUEZ et al. (2008) refer to the conceptual map as a graphical representation of relationships between concepts. It is a cognitive tool that allows to represent knowledge (ideas and associations) and a graphical summary, efficient learning-oriented and meaningful. The knowledge is organized and represented at all levels of abstraction, placing the more general concepts at the top and more specific at the bottom.

Concept maps consist of nodes, which correspond to the concepts and are generally represented by ellipses, circles or rectangles. Related concepts are joined by lines forming simple propositions and direction of the relationship is formed with keywords, which are written with small letters along the lines (ANDERSON, 2003 and ONTORIA et al., 2004).

The organization of the concepts will depend on the researcher's thinking, i.e., how to structure their ideas from their interaction with the elements of study and their experiences with the environment that surrounds it (OKADA and SANTOS, 2005).

According to SMITH (2008) there are no fixed rules for the general layout of concept maps. The important thing is that the map is a tool to highlight meanings attributed to concepts and their relationships. Therefore, it is enough to consider using one or two key words written on the line linking the two concepts. However, this feature makes the self-explanatory concept map. The map should be described by its maker, to explain it because the guy outside their meanings.

The concept map contains three key elements; it is described by NOVAK (1982) in ONTORIA (2004):

• Concepts - which refer to events and objects (are there any thing and can be seen). According to Ausubel et al. (1980) it represents the objects, events, situations or properties that have common core attributes that are designated by a word or any symbol.

• Proposition - represent two or more conceptually united by keywords to form a semantic unit, expressing meanings attributed to conceptual relations.

• Keywords - the words that serve to unite the concepts and present the kind of relationship between them.

The characteristics of concept maps that differentiate them from other graphics and other cognitive strategies or techniques are according to ONTORIA et al. (2004): ranking, selection and visual impact.

The ranking technique is established on the conceptual maps when the concepts are arranged in order of importance or scope. The broader concepts (inclusive) occupy the top places of the graphic structure. The examples fall into last place. Each concept appears only once in a conceptual map and, on occasion, should determine the seams with an arrow to indicate the concept derived, when both are located at the same time or in case of cross-relations.

The selection technique consists of an overview or summary where maps contain what is more important or meaningful to a message, theme or text. First of all, to construct the map it must choose the terms that refer to the concepts and to draw attention to them. Furthermore, it is preferable to carry maps with different levels of generality, which presents an overview of a subject or theme while others focus on parts or sub-topics more concrete.

The visual impact technique is based on the selection. A good concept map is concise and shows the relationships between the main ideas in a simple way, taking advantage of the remarkable human capacity for visual representation (NOVAK, 1982 in ONTORIA, 2004).

According to ONTORIA et al. (2004) it is advisable not to give the first definitive map, to make it necessary to repeat all the steps to improve its presentation. To NOVAK and GOWIN (1988), the first conceptual map that is constructed, almost always contains a defect: it can be difficult to show the importance of the hierarchical relationships between concepts or concepts with closely related meanings. They are located at opposite positions on the map, so that they appear cross-connections that traverse the entire paper.

4 RESEARCH METHODOLOGY

4.1 Methodological Procedures

THEORETICAL FOUNDATION - It consisted of literature relevant to the issues of Construction Spatial Databases and Cognitive Mapping. This stage was very important because it was a research on theories that, taken together, indicated a way for the construction of knowledge in the field of cartography.

IDENTIFICATION AND ANALYSIS OF EXISTING METHODS AND THE PROGRAM – Since the theoretical methods has been studied and analyzed, a method for preparing cognitive maps and a computer program was available for their generation.

DISCUSSION OF METHODS - A discussion on the feasibility of using the methodology for the elaboration of cognitive maps was conducted. The methodology presented focuses on the construction of knowledge within the context of cartography, specifically for the stage of Abstraction in Real-World Modeling Spatial Data.

4.2 Computer Program

• CmapTools: used for preparation of the Concept Map.

5 CmapTools

CmapTools is a versatile program for construction of concept maps in networked environments, developed at the Institute of Human and Machine Cognition (IHMC), University of West Florida and distributed for free download at the electronic address http://cmap.ihmc.us (Figure 2), under the supervision of Dr. Alberto J. Cañas.

On the electronic page IHMC publications, documentation and program information can also be found, as well as tutorials and articles about its use. This program offers several features for organizing information, facilitating the reading of data and allowing the construction of knowledge models represented as concept maps.

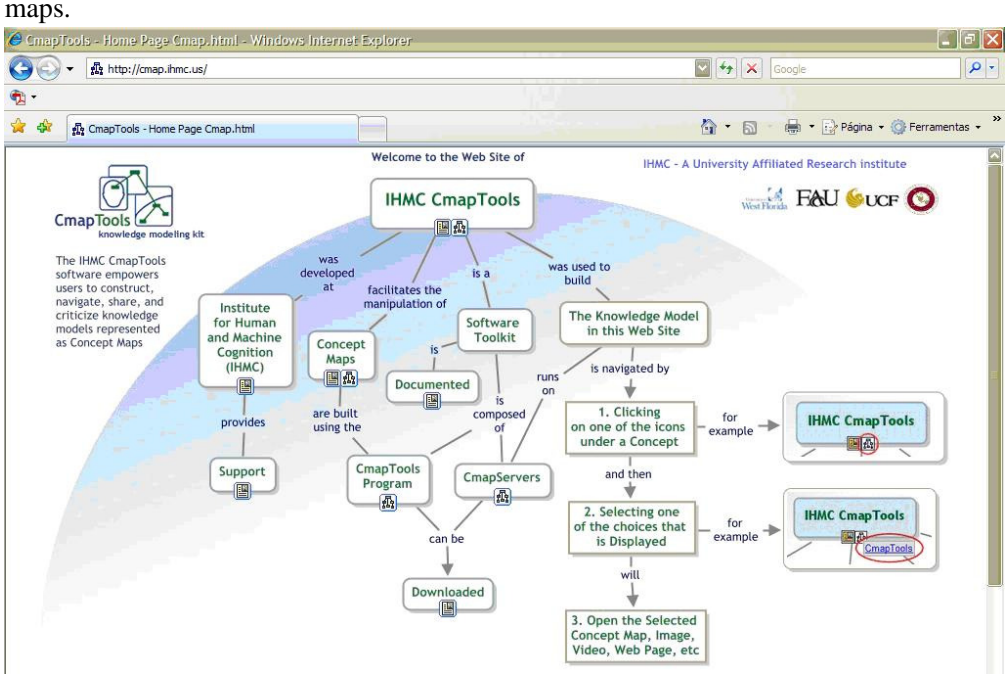

Figure 2 - Electronic Home of CmapTool. Source: http://cmap.ihmc.us

Due to the flexibility of its architecture, the program allows the user to install only the functionality needed by adding more modules according to your need or as new features are being developed. Also, it can run on multiple platforms, since its development was done using Java technology.

Using the program enhances and helps in the construction of concept maps because of the flexibility of digital technology itself, especially the Internet and World Wide Web (WWW). The program is for users of all ages, making it easier to construct and modify concept maps, because it works similarly to a word processor. The written text allows users to exchange information and act at a distance in constructing their maps. Concept maps can be published on the Internet so that anyone can access them. The option can be shared Cmaps on servers, turn its resources to new maps, explain its contents, and search the WWW information related to the map (NOVAK and CANAS, 2006). The organization of Cmaps and other resources used in the Models Knowledge is made through the initial screen of CmapTools (Figure 3).

Figure 3 - Initial Screen CmapTool.

CmapTools allows users to construct concept maps representing the understanding of a domain of knowledge. In the case of a large area or a detailed representation, a simple concept map can become unmanageable for the user to understand, manipulate and display. To facilitate the construction of large representations, the CmapTools allows users to divide them into collections of concept maps (Cmaps). To show the relationship between the set of Cmaps, the program facilitates the connection of Cmaps, allowing navigation of a CMap to another (Figure 4).

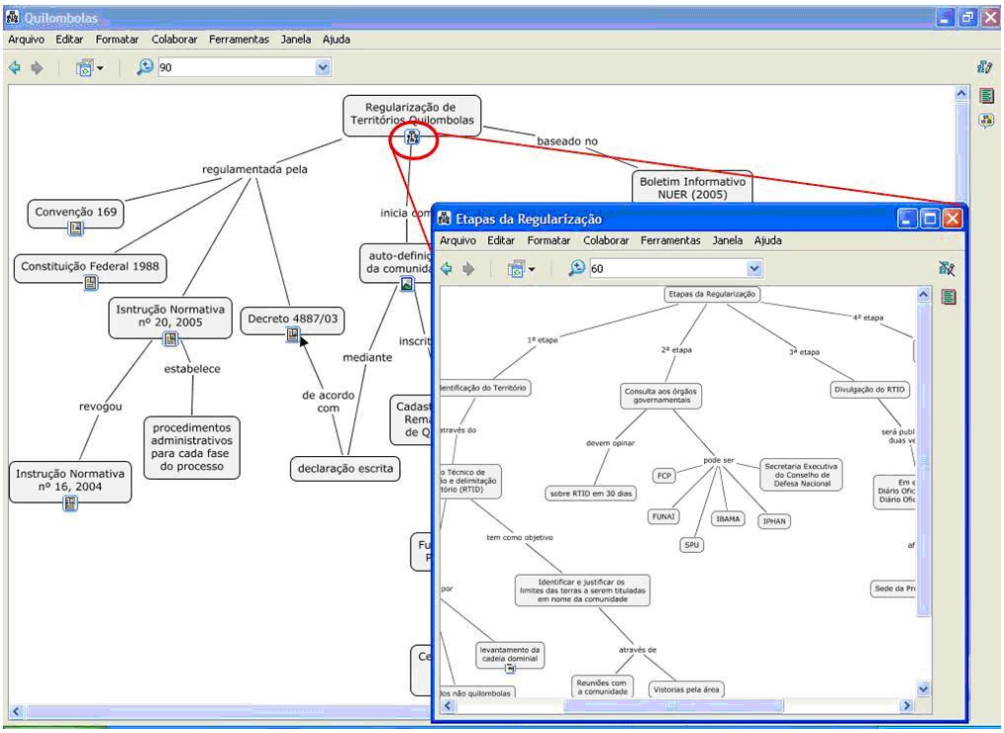

Figure 4 - Presentation of the link between Cmpas.

The option displays Cmaps on servers shared servers on the Internet that contain models of knowledge created and shared by users around the world (Figure 5).

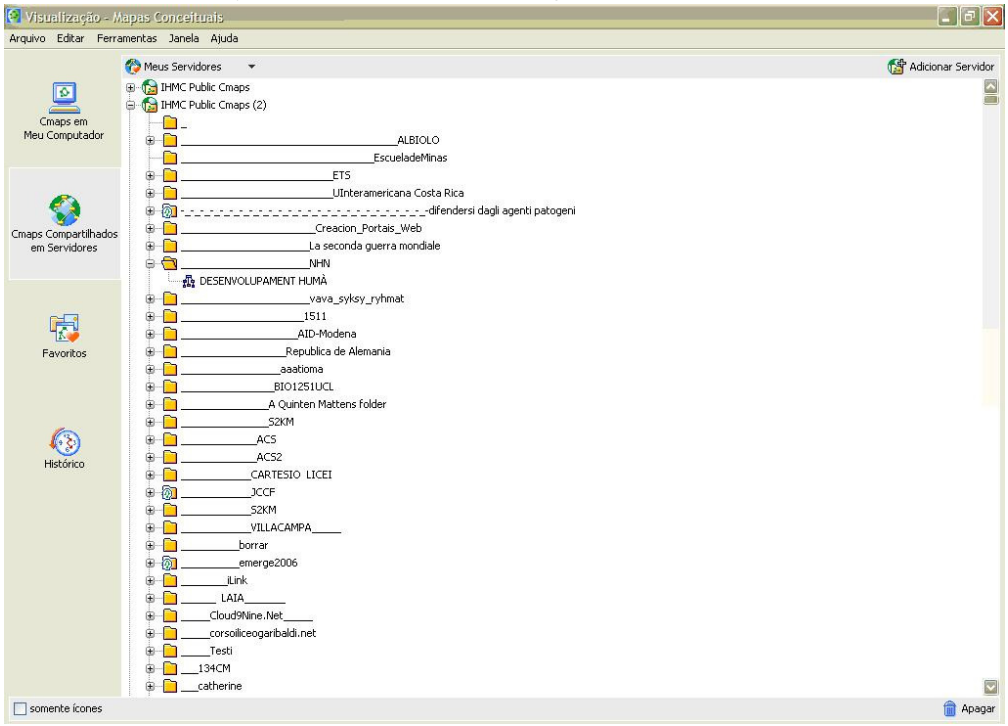

Figure 5 - Presentation server available on internet.

Figure 5 shows a collection of Cmaps, images, texts, videos, links to Web pages (URL - Uniform Resource Locator) and other resources that have been imported into the viewing screen, all stored on the hard disk.

The CmapTools program and presents a cognitive strategy for knowledge representation using conceptual maps, has features for formatting the reports, i.e., it allows users to add features such as photographs, images, graphics, videos, tables, texts, links and electronics (WWW) and even other conceptual maps located anywhere on the Internet or personal files to detail the concepts better. Electronic links (links) to these resources are listed as icons below the concepts, as shown in Figure 6.

Among other features can be cited: import and export as files, Web pages, XML, and so on, recording for playback of the steps in building a map and a presentation module in full screen.

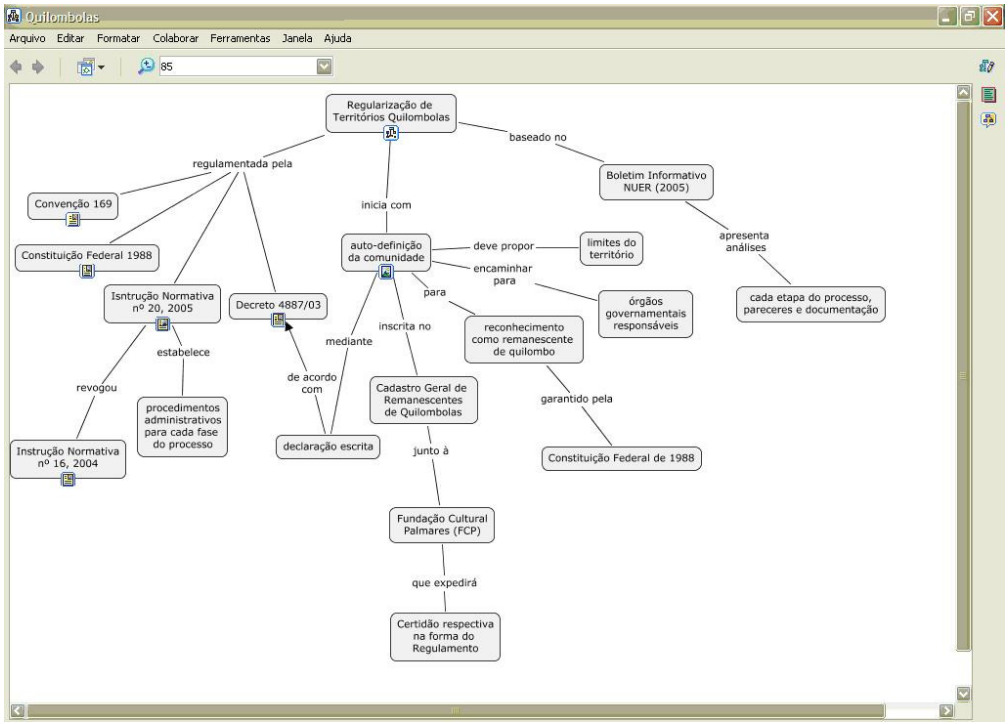

Figure 6 - Presentation of icons related to Concepts.

Clicking one of the icons will display a list of links from which the user can select to open the resource. With CmapTools you can use concept maps to access any material that can be presented digitally.

Thus, concept maps can serve as tools for navigation in complex areas of knowledge. By facilitating the connection between concept maps, users can construct knowledge models that are collections of maps with concepts related to resources on a particular topic, demonstrating that their understanding of a domain is not limited to a single concept map (NOVAK and CAÑAS, 2006).

CmapTools provides a rich collection of resources that allow users to easily build models of Knowledge, publish them and share them across servers or the Internet. The user can create links to other resources (e.g., images, videos, sounds, graphics and text) that help explain and supplement information in the map, as shown in Figure 7 (CAÑAS et al., 2008) .

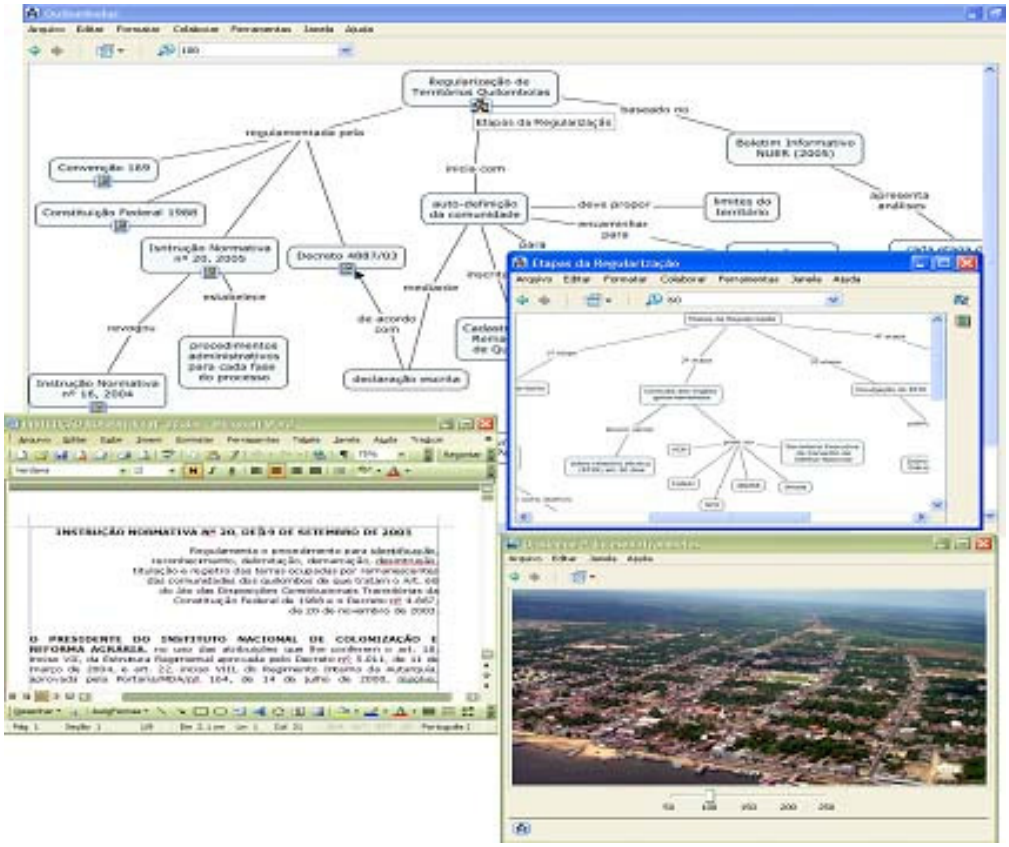

Figure 7 - Navigation between the icons and Resources Concept Map.

Figure 7 shows several windows open, the result of navigating through a model of knowledge. The Cmap and the entry point for this kind of knowledge. Some concepts have small icons below that indicate the existence of other resources, e.g. images, texts, videos, Web pages or other Cmaps, which contain additional information to explain a particular concept.

In the example shown in Figure 7, clicking the icon concept map, the user can select and open another Cmaps. The other images shown are opened by a similar navigation through the icons in Cmaps.

CmapTools provides extensive support for collaborative work during the construction of concept maps, which can be stored on servers (CmapServers) where anyone on the Internet can access them. Many CmapServers are public, allowing anyone to publish conceptual maps.

Thus, one can say that the CmapTools is used to acquire and develop concept maps, while the CmapServer is used to store and share maps and resources, which allows sharing concept maps through the internet to work collaboratively with other users.

6 FINAL CONSIDERATIONS

The concept maps were chosen for this study because of the versatility and simplicity of its preparation. The maps also show a structure more compatible with the process of acquiring spatial data, since they can be developed from existing documentation through the organization of concepts and keywords.

These maps can be used as powerful tools that help in building a structured thinking throughout the research process, especially in the stage of Abstraction of the Real World for generation of Spatial Databases. To supply the Spatial Data Base, it is necessary that knowledge of the application to go through a selection process where the most relevant spatial data will be used in cartographic documents, allowing a better use and future updates.

Cognitive maps facilitate the registration of various elements in unusual ways. It allows them to realize new ways and instruments to store, secure, display and retrieve information through the most important concepts. Thus, the cognitive maps help in understanding and assimilation of the basic ideas of a certain subject.

In relation to computer programs, the use of CmapTools leads to lower costs, since the cognitive maps are dynamic and can change at any time. It also facilitates the handling and displaying the map as a whole, which is not always possible on a single sheet of paper. The main features of CmapTools observed are:

• It is a program that can be obtained from the Internet at no cost and can be built and shared collectively in order online, by several individuals;

• Lets you create links to other files or maps;

• The main potential of CmapTools is its use as a tool to share concepts, using it from a different server where the involved parties can access and share insights through CmapServer;

• How is based on the CmapTools concept mapping, the words are inscribed in rectangles connected by lines that can be directional or bidirectional, depending on the relationship established. In addition to the arrows, the link between the rectangles is done by a linking word.

This research presented a methodology for development of cognitive maps and showed how can its use in modeling. It has made clear the importance and usefulness of mapping techniques in the construction of knowledge to development of a Spatial Data Base structured, organized and detail of the subject, allowing the generation of new ideas and development of cartographic documents.

7 REFERENCES

ANDERSON, D. M. Mental Models. Technical note. National Institute of Technology - Division of Production Management - DGEP. 2003.

AUSUBEL, D. P., NOVAK, J. D.; HANESIAN, H. Educational psychology: A cognitive view (2nd ed.). New York: Holt, Rinehart and Winston, 1978.

CAÑAS, A. J. and HILL, G., Lott, J. Support for Constructing Knowledge Models in CmapTools. Technical Report IHMC CmapTools 93-02. Available in <http://cmap.ihmc.us/Documentation/WhitePapers.php> Accessed: 31 March 2008.

CARVALHO, J. P. B. of. Cognitive Maps Based on Fuzzy Rules: Modeling and Simulation of Dynamic Qualitative Systems. Doctoral Thesis. Technical University of Lisbon, 2001.

GOLLEDGE, R. G. and BELL, S. M. Reasoning and inference in spatial knowledge acquisition: The cognitive map and an internalized geographic information system. Unpublished manuscript, Department of Geography, University of California - Santa Barbara, Santa Barbara, CA, 1995.

GOLLEDGE, R. G. and STIMSON, R. J. Spatial Behavior: A Geographic Perspective. Publisher The Guilford Press, 1997.

ISSMAEL, L. S. and MENEZES, P. M. L. of. Cartography, spatial perception and cognition: mental mapping of geographical space., In Proceedings of the Symposium on Geodetic Sciences and Technologies of Geoinformation, 2004, Vol I, Recife - PE, Brazil.

MOREIRA, M. A. Distance Education and Meaningful Learning. Available: http://br.geocities.com/impactos_usp/mapas_conceituais_OFICINA_texto_apoio.pdf

Accessed: January 21, 2008.

NOVAK, J. D. and GOWIN, D. B. Aprendiendo to learn. Martínez Roca. Barcelona, 1988.

NOVAK, J. D. and CAÑAS, A. J. The Theory Underlying Concept Maps and How to Construct Them. Technical Report IHMC CmapTools 2006-01, Florida Institute for Human and Machine Cognition (IHMC), Pensacola, 2006.

OKADA, A. Cognitive mapping: new challenges and possibilities. 2004. Available in <http://www.projeto.org.br/cartografia/texto2.htm>. Accessed: 03 Mar. 2008.

OKADA, A. L. P. and SANTOS, E. O. of. Mapping information networks with the use of software: an experience of research and teaching in distance learning online. Digital Journal of Educational Technology and Distance Education. Vol 2 - No 1. October, 2005. ISSN 1808-1061. Available at: <http://www.pucsp.br/tead/n2/pdf/artigo2.pdf>. Accessed: 25 Feb. 2008.

ONTORIA, A. et al. Concept Maps: A technique to learn. Narcea, SA of Ediciones, 2004. 12 ª Edición. Madrid, Spain.

REIS, A. T. L. and LAY, M. C. D. Quality evaluation of projects - a perceptual and cognitive approach. Built Environment, Porto Alegre, v. 6, No 3, p. 21-34, 2006. Available in <http://www.antac.org.br/ambienteconstruido/pdf/revista/artigos/Doc125160.pdf>. Accessed: 19 Feb 2008.

SANTILI, F. L. P. Development of a prototype Electronic Atlas of Conservation for environmental education. Dissertation. Postgraduate Diploma in Cartography. Universidade Estadual Paulista - Unesp. Presidente Prudente, 2001.

SANTOS, E. C. of. Geoinformation technologies as a tool in risk analysis of landslides. Dissertation. Graduate Program in Geodetic Sciences and Technologies of the Geoinformation. Federal University of Pernambuco. Pernambuco, 2006.

SERPA, A. For a geography of social representations. OLAM magazine - Science & Technology. Vol 5, No 1, p. 220-232. Rio Claro-SP, 2005. Available in <http://www.esplivre.ufba.br/artigos/AngeloSerpa_Olam5_2005.pdf>. Accessed: 03 Mar. 2008.

SILVA, J. X. GIS for Environmental Analysis. 228p. Rio de Janeiro, 2001.

SLOCUM, T. A. Thematic Cartography and Visualization. Prentice Hall, New Jersey, 1999, 293p.

TAKAHASHI, T. and LIESENBERG, H. K. E. Object Oriented Programming. VII School of Computing. São Paulo, 1990. 335p.

TUAN, Yi-Fu. Topophilia: a study of perceptions, attitudes and values of the environment. Translation: Livia de Oliveira. São Paulo: Difel, 1980.