Dynamic Knowledge Management Toolkit

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Abstract: An important aspect of knowledge management is the implementation of methods to share the unstructured knowledge of expert practitioners within an organization. The existence of unstructured and dynamic knowledge represents a challenge to experts due to the dynamic and non-sequential nature of such knowledge. In order to make such knowledge sharable, it is necessary to have both an effective elicitation method and a useful representation toolkit. In this paper we describe a Dynamic Knowledge Toolkit (DKT) that is used in knowledge elicitation and representation based upon Knowledge maps. Knowledge Maps content is different from the more general information in typical reference material and that is organized quite differently than standard textbook knowledge or mainstream hypermedia learning systems. These knowledge models tend to be large and complex with interwoven themes and rich interconnections of the concepts based on the expert's highly articulated mental model of the domain. Knowledge Maps have been used in all facets of education, training and business. With the fundamental goal of fostering learning and knowledge sharing they have been shown to be an effective tool for displaying prior knowledge, summarizing, planning, scaffolding for understanding, consolidating experiences, improving affective conditions for critical thinking, decision making, supporting cooperation and collaboration, and organizing unstructured knowledge content. We describe the use of the toolkit in a case study on the capture and representation of local weather forecasting knowledge. We also show how Knowledge maps can be used to support activities such as the preservation of institutional memory, the "recovery" of expertise that might reside in less accessible forms such as archived documents, for performance support, and for other knowledge-intensive pursuits such as weather forecasting or crisis management.

Keywords: knowledge elicitation, knowledge modeling, knowledge sharing, knowledge maps

1. Introduction

The knowledge elicitation, representation, construction, retrieval and demonstration have been conceived as a sequential process with a pre-defined goal. The existence of unstructured and dynamic knowledge represents a challenge to experts due to the dynamic and non-sequential nature of such knowledge.

In order to make such knowledge portable and sharable, it is necessary to have an effective elicitation method, a useful representation scheme, and a Knowledge Management System to demonstrate and share such knowledge.

Knowledge Maps have been used in all facets of education, training and business (Novak 1984). With the fundamental goal of fostering learning and knowledge sharing they have been shown to be an effective tool for displaying prior knowledge, summarizing, planning, projects management, scaffolding for understanding, consolidating experiences, improving affective conditions for critical thinking, decision making, supporting cooperation and collaboration, and organizing unstructured knowledge content.

The representation scheme described here is less formal and different from other ones such as PreSERVe method of knowledge modeling, concept maps (Michelini 2006; Gordon. 2000), and the like, in that it conveys rich knowledge content and also provides an organizing factor for other resources and media that are added to the organization of knowledge.

Also, knowledge Maps affords a more intuitive way to capture tacit knowledge than is required by formal schemes such as conceptual graphs (Sowa 1992), KADS (Moreno 2001) and Ontolingua (Gruber 1993) models. The next sections of this paper elaborate the Knowledge Maps method, the knowledge representation approach, and a case study from the domain of weather forecasting.

2. Knowledge organization using ontology and cognitive maps

Knowledge can come in a variety of forms structured, semi-structured or unstructured. In order to capture, represent, and organize this knowledge, we need to find away to group, index, or categorize it in some way. We could present schema conceptualizing a vocabulary of terms and relationships to present the knowledge. This is called 'Knowledge Maps' or 'ontology' (Jashapara 2004).

Current cognitive models of learning and thinking support the idea that individuals learn not by passively absorbing information but by actively trying to make sense of new information (Borich 1997). Each of us has a framework to explain how the world operates, and within that framework we relate new information to old. One example of active learning is cognitive mapping, a graphic technique that describes a large amount of information in a one-page "snapshot" representation. Used as a teaching strategy to enhance meaningful learning, a cognitive map graphically describes key ideas and helps the user view relations among concepts (Havens 1997). As an evaluation strategy, experts draw their own maps, identify concepts, and discuss their relation.

2.1 Knowledge map

One variation of knowledge map or ontology useful to integrating old and new knowledge is Mind Map, a graphics technique created by Tony Buzan (Buzan 2007). Used to assess higher order learning, Mind Map de-emphasizes memorization and focuses, instead, on the understanding and relation of ideas, thus promoting critical thinking skills (McCabe 1995; Oermann 1994; Oermann 1998).

Mind (Knowledge) Maps are graphs that are comprised of central Image that represents the core concept of knowledge, similar to the concept maps defined by Novak (Novak 1997). and the relationships among the sub-concepts on the branches. Concept Maps are used to form knowledge models by placing them in a radial organization and appending elaborating media onto the branches within each map. The resultant model of expert knowledge contains numerous unstructured sub-domain concepts, principles, and relations (Ausubel 1968).

2.2 The knowledge elicitation method

The actual elicitation of knowledge can take many forms that can be categorized broadly into those that are direct (in collaboration with the expert) and indirect (through study or inclusion of relevant information sources identified by the expert or knowledge engineer) (Waterman. 1986). Direct methods of knowledge elicitation are chosen from a variety of techniques based upon interviews, analysis of familiar tasks, and so-called contrived (or experiment-like) techniques (Hoffman 1995). The knowledge elicitation process leads to the creation of artifacts (knowledge maps, interview transcriptions, edited videos of the expert discussing a topic or making a point, etc.) that will be included in one knowledge Map.

2.3 The structure of a knowledge map

Knowledge maps provide an explicit, concise representation of what the expert knows about a non-structured knowledge domain. The mind map continues to be used in various forms, and for various applications including planning and in engineering diagramming.

When compared with the earlier original concept map (which was developed by learning experts in the 1960s) the structure of a mind map is a similar, but simplified, radial by having one central key word.

A mind map is similar to a semantic network or cognitive map but there are no formal restrictions on the kinds of links used.

The elements are arranged intuitively according to the importance of the concepts and they are organized into groupings, branches, or areas. The uniform graphic formulation of the semantic structure of information on the method of gathering knowledge, may aid recall of existing memories.

Figure 1 is a depiction of part of a knowledge map to weather forecasting station. As can be seen in Figure 1, the branches within the map are populated with icons that indicate sources of information

related to a given concept. An icon is provided for each of the various information sources such as text, graphs, photos, digital audio or video, links to Web pages, or other knowledge map. The icons appear at the branch in varying combinations to indicate the media containing information regarding the concept. When the user clicks the icon that represents one of these sources of information, a pop-up menu appears that presents links to the media of the selected type.

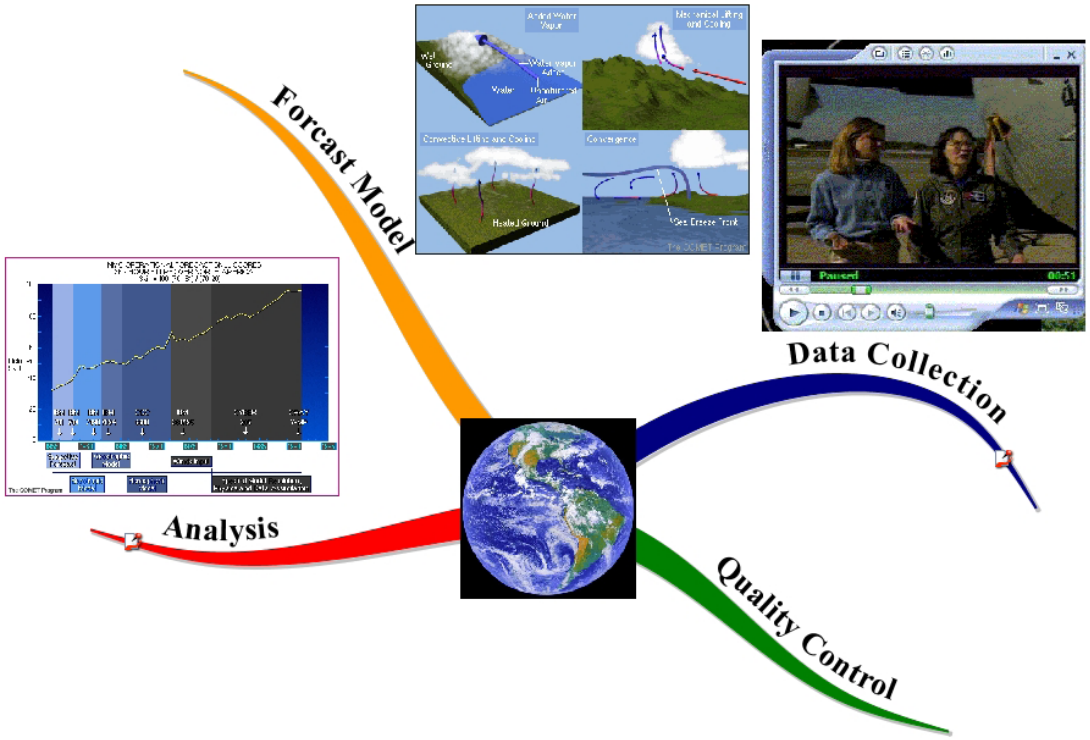

Figure 1: A depiction of a knowledge model from the domain of weather forecasting

A special icon representing other knowledge maps is used to indicate links within the model. The overall navigational scheme allows the user to start in a new knowledge map at a given location. The user can also examine the other concepts and links in the current map as they relate to the concept under consideration. Since these facilities all occur in the context of a Knowledge Map set, the user has great navigational flexibility throughout the knowledge Map.

Knowledge Maps contain content that is different from the more general information in typical reference material and that is organized quite differently than standard (sequential) textbook knowledge or mainstream hypermedia learning systems. These knowledge models tend to be large and complex (reflecting the complexity of real domains of knowledge) with interwoven themes and rich interconnections of the concepts based on the expert's highly articulated mental model of the domain. As such, these knowledge models contain highly contextualized, domain-specific knowledge that is more directly applicable to specific problem situations than much of the more generic knowledge that typically comprises instructional materials or references.

3. Case study on weather mapping and forecasting system

A weather mapping system is required to generate weather maps on a regular basis using data collected from remote, unattended weather stations and other data sources such as weather observers, balloons and satellites. Weather stations transmit their data to the area computer in response to a request from that machine.

The area computer system validates the collected data and integrates it with the data from different sources (Boose 1986). The integrated data is archived and, using data from this archive and a digitised map database a set of local weather maps is created. Maps may be printed for distribution on a special-purpose map printer or may be displayed in a number of different formats.

The meteorology community has a number of interesting knowledge management problems. Theirs is a domain that is characterized by an enormous number of data types and information sources, with

new ones continually becoming available. Forecasters work under conditions of significant uncertainty with very high stakes. Weather impacts on navigation, fishing and military operational missions are one of the most problematic areas the meteorology community faces. Furthermore, effects of local conditions can have significant impact on the weather. Knowledge of such local effects is gained by forecasters who have had extensive experience in a particular locale. However, the meteorologists' careers typically unfold as a succession of land-based duty weather forecasting stations and assigned to certain geographical area, with an ongoing need to understand local effects on weather.

A knowledge modeling effort to demonstrate the feasibility of eliciting and representing local meteorological expertise was undertaken at the Training Meteorology and Oceanography Facility (TMOF) in Egypt (Hoffman 2001). Figure 1 depicts a small but typical part of the knowledge model that was created. The Knowledge Map labeled "Regional Weather Forecasting" is the top-level map for the model. In front of the top-level map is a more detailed one on the topic of thunderstorms in the Coastal region. Also appearing are other resources that have been accessed, including the text labeled "Thunderstorms," graphics (Annual Frequency of Thunderstorms), satellite imagery, and a digital video of an expert discussing local seasonal variations in thunderstorms.

Knowledge elicitation for the creation of this model primarily utilized knowledge mapping as a scaffold for structured interviews (Coffey 1999). Several Knowledge Maps could be created on topics such as the local climate, the effects of the Red and Mediterranean seas on the weather, the various seasonal regimes, fog, thunderstorms, hurricanes, frontal passage, and the local authority's tools and products were created from several iterations of interviews with meteorologists. The knowledge Toolkit was developed iteratively with review of the Knowledge Maps after each wave of elicitation, and the assessment of potential resources that could be included in the representation.

Many pre-existing resources such as graphics from the personal collections of the forecasters, links to useful Web sites, etc., were identified and incorporated into the model. Additionally, all the materials from the "Local Forecaster's Handbook" were included. Other information such as the Standard Operating Procedures of the installation was attached at appropriate places in the model. A substantial amount of digital video was created from experts' discussions of topics of interest (thunderstorms, hurricanes, fog, etc.) and included

As the project proceeded, verification was performed in two ways. First, the emerging knowledge model was reviewed with the experts to monitor how the model was structured by the Knowledge Maps. Second, independent verification of the Knowledge Maps was performed. An independent expert worked through all the elicited Knowledge Maps, looking for poorly described phenomena and errors. A study of this part of the process showed that experts could evaluate the propositional content in Knowledge Maps at the rate of approximately 7 propositions per minute. The typical map size was approximately 47 propositions. Approximately 10% of the concepts and linking phrases were changed.

Resource-appended Knowledge Maps make useful, highly accessible learning resources. Subsequent to the creation of the meteorology model described here, several new meteorologists at the installation of new weather forecasting station used the system as part of their Sub-regional Forecaster Training Course.

4. Summary and conclusions

This paper contains a report on a Dynamic Knowledge Toolkit for Knowledge elicitation, construction and verification. The paper also discusses the use of the toolkit to create a Knowledge Maps that captured expert knowledge pertaining to local effects on weather forecasting station.

A software Toolkit entitled Dynamic Knowledge Toolkit (DKT) has been developed to provide the capability to capture, model, and view unstructured knowledge. The client software allows the Knowledge Maps themselves to be created and populated with other resources such as text, graphics, video, Web pages, etc. The DKT server allows all these resources to reside across multiple machines and to be edited or browsed from any machine that is running the DKT client program.

With DKT, knowledge models may be shared throughout an organization and may be accessed anytime and anywhere that permits a connection to the server where the knowledge maps reside. Knowledge Maps can be evolved dynamically and shared across the organization.

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