KNOWLEDGE CONSTRUCTION TECHNOLOGY THROUGH HYPERMEDIA-BASED INTELLIGENT CONVERSATIONAL CHANNEL

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Abstract: There have been multifarious approaches in building expert knowledge in medical or engineering field through expert system, case-based reasoning, model-based reasoning and also a large-scale knowledge-based system. The intriguing factors with these approaches are mainly the choices of reasoning mechanism, ontology, knowledge representation, elicitation and modeling. In our study, we argue that the knowledge construction through hypermedia-based community channel is an effective approach in constructing expert's knowledge. We define that the knowledge can be represented as in the simplest form such as stories to the most complex ones such as on-the-job type of experiences. The current approaches of encoding experiences require expert's knowledge to be acquired and represented in rules, cases or causal model. We differentiate the two types of knowledge which are the content knowledge and socially-derivable knowledge. The latter is described as knowledge that is earned through social interaction. Intelligent Conversational Channel is the system that supports the building and sharing on this type of knowledge.

Keywords: Knowledge Building, Community Channel, Community Learning, Virtual Agents

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Introduction

There have been multifarious approaches in building expert knowledge in medical or engineering field through expert system, case-based reasoning, model-based reasoning and also a large-scale knowledge-based system. The intriguing factors with these approaches are mainly the choices of reasoning mechanism, ontology, knowledge representation, knowledge elicitation and knowledge modeling. In our study, we argue that the knowledge construction through hypermedia-based community channel is an effective approach in constructing expert's knowledge. We define that the knowledge can be represented as in the simplest form such as stories to the most complex ones such as on-the-job types of experiences. The current approaches of encoding experiences require expert's knowledge to be acquired and represented in rules, cases or causal model. The development time and cost upsurge with the amount of knowledge encoded in the system. Our approach emphasizes on collaborative knowledge construction where experts such as engineers can post their basic knowledge such as simple facts or a more complicated one in the form of stories in the interactive conversational channel. There are experiences that cannot be modeled, as they need to be visually observed in order to grasp the understanding. Our Intelligent Conversational Channel supports other hypermedia such as video, graphics, audio, video, animation, or images as part of knowledge entity in order to handle these types of knowledge. Each member of the community can build his/her own personal knowledge unit or ontology that will then be integrated as a larger form of expert knowledge, so-called expert community knowledge. We introduce an intelligent technique for knowledge integration such that this knowledge can be organized and retrieved by other community members for sharing purpose. We also introduce the knowledge sharing protocol that imposes certain restrictions for security and to prevent repudiation, spoofing of the knowledge being posted. Members are registered for identification but their personal information is not reflected to public as part of the knowledge content. This suppresses the chances of using personal status as a way to force one's understanding to the others. The personal knowledge unit can be protected by the owner at the same time it allows other members to patch their

knowledge to the existing knowledge unit. We believe our approach offers a low construction cost with minimal development time. The knowledge is more naturally encoded and represented and it is continuously maintained by the community for validity and update.

The paper is organized by firstly differentiating theoretically between the content knowledge and socially-derivable knowledge. This is essential as the system we developed; so-called Intelligent Conversational Channel (thereafter, ICC) emphasizes learning on socially-derivable knowledge. Secondly, we describe the process of knowledge construction technology through the Intelligent Conversational Channel. Thirdly, a demonstration of simulated scenario of ICC usage is given for illustration purpose. The paper concludes the discussion in the final section with the future work.

What is content knowledge and socially- derivable knowledge

If one asked a group of people to draw three symbols with different shapes such as rectangle, circle and triangle, the results for each of the participant will differ by the interpretation of the size, position on the paper of each symbol, relative position of each symbol to each other and also other additional imaginative features such as color or dimensions. In different example, a group of people witnessing a car accident is questioned by a police officer. Each witness contributes few pieces of the jigsaw puzzle that eventually shape up an overall understanding of the scene. In the above examples, there are two types of knowledge, which are the content knowledge and socially-derivable knowledge. Content knowledge is the fundamental theory about the knowledge that every learner has to know. Socially-derivable knowledge is about learning the knowledge produced by other learners in terms of its interpretation, analysis, ways of applying the concepts etc. In the former example, the three basic symbols (triangle, circle and triangle) are the content knowledge, which becomes the basic theory for everyone. The varieties of the construction and perhaps the explanation given by the individual who draws it are the socially-derivable knowledge. In the perspective of science and engineering, the formulas, physical laws, rules are examples of content knowledge, which everyone agrees and globally accepted. The approach and methods of applying the content knowledge differs among engineers especially how they interpret the problem, choose suitable techniques and analyze the solution.

Knowledge-shaping

In this paper knowledge-shaping is referred to how knowledge is formed using certain approach. There are many approaches to knowledge-shaping. Among them are knowledge acquisition, building expert system, building qualitative model and constructing case-based system. Knowledge acquisition tool is designed to acquire knowledge from a single expert. In some applications, multiple experts are used in encoding the knowledge into the knowledge base. However, the knowledge framework in the knowledge acquisition tool is rather rigid and designed by taking the perspective of few experts. An expert system is known to be a knowledge acquired from a single human expert. It contains the experience in the form of rules or frames of a single expert. Reasoner system, which is built on the qualitative model, describes the content knowledge that is modeled using qualitative terms and relationships. The qualitative model represents a single model for reasoning on multiple aspects of a problem. Case-based system contains a library of past case collections by an expert that is stored in the system and retrieved by the best-match method. We argue that these knowledge-shaping approaches are best applied in developing content knowledge. Expert system such as MYCIN or case-based learning tool can be used to train professional doctor or engineer into a more specialized skill based on the experience of an expert built on the system. However, the learner does not have the opportunity to learn skills from other experts, which are not encoded in the system he/she is using. Similarly, system that performs reasoning and explanation that is built on qualitative model, is mould to cater for a specific type of learning. The learning method, which is adopted from the current pedagogy theory, is tuned into the system. We claim that these technologies offer know-how knowledge in performing a specific task while in the real world, the process of acquiring knowledge and managing problems are rather ill-structured and difficult to be modeled.

The characteristics of socially-derivable knowledge towards knowledge-shaping are spelled out as follows:

- Multiplicity in learning objects – knowledge in the real world is delivered or obtained in different forms. The objects, which are used as part of the learning whether directly or indirectly is called learning, object as described by Community of Practice [Wenger, 1997]. Radio, television or LCD screen used for advertising are examples of broadcasting system that contribute to one's knowledge. Newspaper, magazines, leaflets or brochures are pieces of information, which transform into one's knowledge when he/she reads them. Other forms of learning objects are the working colleagues, animated or unanimated artifacts such as the copier machine, pets at home, video movies and neighbors whom one socialize with. In this respect, the expert knowledge does not come from a single source as well as the multiplicity in methodology for delivering the knowledge. Expert's talk in the open seminars or television is examples of learning objects.
- Open-world assumptions – assumption is needed when one designs a system to be used as problem-solver. The assumptions are perspective that draws the boundary of the intended world in order for the system to work successfully within the specified limit. In modeling the content-knowledge, close-world assumption is always used. Unlike the content knowledge, socially-derivable knowledge does not specify the assumption as the knowledge is not modeled but shared in its original form. The knowledge contains the description about the real world problems and solution rather than the hypothesized.
- Rapid knowledge-building – content knowledge requires a system builder to analyze and study, to model the solution, to build the system and test its performance. These processes are rather time-consuming and costly. On the other hand, the socially-derivable knowledge is built by the community in a progress manner and can be learned immediately without the need of highly mechanistic and sophisticated process. Knowledge is presented in a human-readable format rather than machine-readable format.

Unorganized, ubiquitous but retrievable – content knowledge built in an expert system is meant to be organized and frequently validated by the truth maintenance technology. The purpose is to avoid conflict of facts and retain consistencies in delivering solution. The retrieval of the solution depends on the reasoning technique employed in the system. Socially-derivable knowledge is rather unstructured and ubiquitous. The knowledge allows conflict solutions to a single problem as it can be treated as having choices of different perspectives. Learners are not confined to solution of a single expert in this case as knowledge is contributed by several experts or non-experts who is involved in the knowledge construction process. The socially-derivable knowledge is retrieved through social interactions and dialogues with the communities.

Knowledge construction technology through ICC

There are many related literature concerning learning through social interaction [Wenger, 1997;Thomas, 2004,Thomas, et al, 2001]. Knowledge building developers have realized the inclusion of community in the process of knowledge building is an essence to the social knowledge building [Stahl, 2000].

In this section we describe the three components of ICC that supports knowledge construction process. This is followed by the three fundamental knowledge construction process which are the knowledge-building process, the knowledge-sharing process and knowledge conversational process.

Components of ICC

We describe the community as the group of people participating in the knowledge-building process. In the actual application, the community could be a group of experts, engineers, scientists or layman such as managers or consumers. The three major components of ICC are the hypermedia-learning space, the discourse communicator, and the discourse analyzer in which all these are connected to the community channel as shown In Figure 1.

The community channel consists of several channels of knowledge units. Each channel is set up for a different set of community, which discusses separate issues. Each channel has a series of knowledge unit as shown in Figure 2.

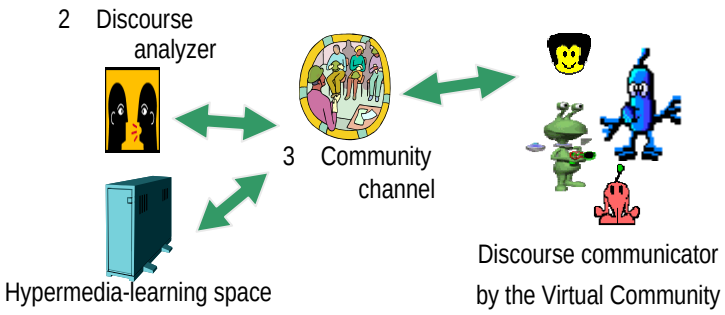


Figure 1- Components of Interactive Conversational Channel

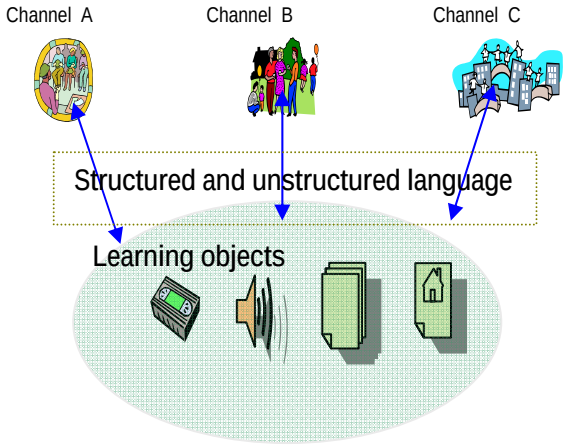


Figure 2- Community Channel

The three channels A, B and C are exclusive as they may be used by different organizations that do not demand the knowledge to be shared. Nevertheless, in some cases the channel can be made available with some sharable property such as viewing. Knowledge can be expressed in a simple natural language using structured and unstructured language. Structured language labels the written text so that the semantic meaning is identifiable by the system without the need to perform micro processing of the sentence. The unstructured language will be treated as a block of sentence in which the semantic is unknown. The learning objects are composed of any multimedia objects such as video clips, audio files, electronic documents or web pages. They are posted to the community channel together with the text describing or summarizing their contents. The hypermedia-learning space is a collection of learning objects that can be accessed by members in the community channel. Discourse communicators are collections of software agents that form the virtual community. They perform two tasks; firstly to simulate interactions and dialogues which have been transpired in the community channel on behalf of the community; secondly, to interact with individual member in the community when query is posted to the virtual community. The discourse analyzer functions as a social network analyzer that determines the density of participation in terms of the members a well as the popularity of the discussion topic posted by the members. In building expert community knowledge, we assume that the density of participation is not a critical factor as the community of experts is people of high skills and knowledge. The discourse analyzer is built to analyze if there exist spiral of silence of some individuals or unpopular topics, which are overlooked by the community.

Knowledge building process

The two main properties in knowledge building when the community manages it, is dynamism and multiplicity. Dynamism emphasizes on the speed of knowledge creation, knowledge update and knowledge maintenance. Knowledge can be created in a fast mode as it can be represented with a simple knowledge piece such as written text. For a more complex knowledge piece, such as a scene of oil drilling or injection molding process, the

knowledge can be presented using video clips or images. The knowledge in a lengthy document with a complex concept can be easily extracted and shared with a simple annotated text attached to it. A collection of several annotated texts (posted by different members) for a document helps a new reader to understand the content without the need to spend time reading its detail. In a collaborative learning strategy, different main points highlighted by different members form a uniform understanding about the document. Knowledge is updated communally such that not only by the knowledge creator but also other members. The members can update knowledge by issuing argumentative statements such as support, disagreement, suggestion or just a general remark. Knowledge is maintained by installing security feature such as password to the knowledge unit so that vital knowledge will not be deleted. The security feature can be set by the creator of the knowledge unit or otherwise will be set by other members if the creator did not set it initially.

Multiplicity describes the varieties of knowledge sources. Gordon Bell predicts that in year 2047, all physical objects such as buildings, cars, home appliances and also humans will be online [Bell, 2004]. Taking this speculative statement into account, the learning objects are not confined to the present application software or multimedia formatted files, which are accessible by computer system but also any objects surrounding a person's life that are directly connected. In the previous paper, social values can be part of learning objects which can be extracted the evidences in the community of practice [Syed Mustapha, 2004].

Knowledge sharing process

Surrogating strategy is used for knowledge sharing where each member may ride on someone's knowledge in order to develop his/her own understanding. In order to enable the knowledge sharing process, the learning objects have to be made sharable in a learning space. Few collections of learning objects, which are attached to the text object is called knowledge unit. Each knowledge unit may consist more than one representative term, which are contributed by other members in the channel. This idea is depicted in Figure 3.

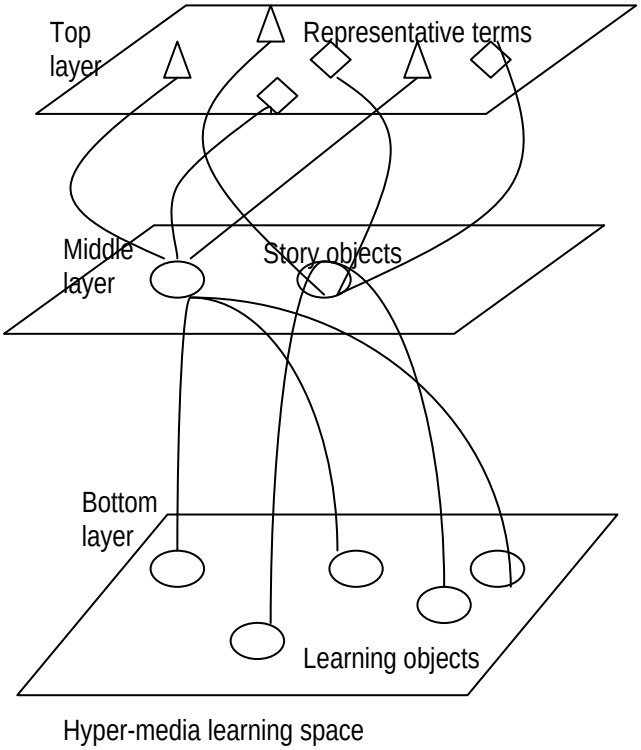


Figure 3 Schematic diagram of knowledge sharing process

The top layer consists of representative terms, which are submitted by the community members. The representative terms are the argumentative terms determined by the community such as “support”, “argue” or “suggest. They are structured language, which are machine-readable. In Figure 3, there are two examples of representative terms that are symbolized by the triangle and diamond shapes. Each representative term is associated to each story object as shown in the middle layer. Story objects have to be created before the representative terms can be linked to it. Story objects can be contributed by one or many members. In response to the submission, other members will create the representative terms (structured language) and tag it to a written text (unstructured language), this couple is called as argumentative bead that hangs to the story object. A series of the argumentative bead will continue to regenerate the knowledge cycle of a given concept in the story.

The bottom layer is the hyper-media learning space, which contains learning objects. At present, the community channel supports the multimedia objects such as video clips, audio, web documents, Microsoft office files that are commonly used by the community in sharing resources. Each story object can be associated to more than one the learning object. The learning objects are the artifacts, which act as the medium of knowledge sharing and knowledge exchange among the communities.

Knowledge conversational process

ICC creates the knowledge conversational environment through virtual community that represents the expert community. The virtual community consists of animated agents who speak on behalf of the expert community. They can be activated when query is entered into the system. The system will search for stories, which are relevant to the query and organize several agents to simulate the discussion. This session is called “interact with agent”. This approach is taken to enable knowledge to be converse in a more natural way i.e. through dialogue or question and answer. The knowledge unit in the community channel can grow very large that it is difficult to be read and searching certain entry is like searching needle in a haystack.

As the system is running on the web platform, the virtual agents that form the community and the type of discussion are personally tailored to the query being entered by the member. That means the conversational environment is different from user to user.

The conversational knowledge process is demonstrated in Figure 4. Each agent is assigned to response to a set of story objects. The sequence of the story object follows the entry order in the community channel. This replicates the actual dialogue order that is transpired in the previous session. Each agent will take turn in communicating the knowledge in the story object. The member can listen to the dialogue just like the actual conversation taken place by the real human. The conversation can be intercepted with other query and a new knowledge conversational environment will take place.

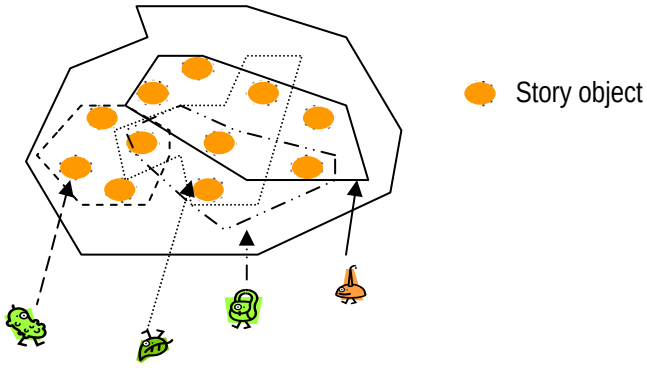


Figure 4. Virtual community in the conversational knowledge process

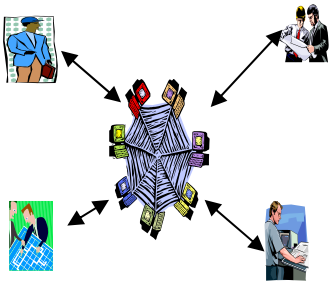
A simulated scenario of building expert knowledge community through ICC

Story-telling has been accepted as a form of knowledge exchange and sharing for scientist and engineers. Steve Denning [Denning, 2000] described an incident when Pakistan government wanted to new technology for to fix their widespread failure of pavement on the highway. The cost to maintain them is no longer affordable and new solution is needed. Since, the world bank team in Pakistan has no experience on that, they have to make a global contact with their partners. Colleagues in New Zealand reported that they had encountered similar problem in South Africa and they had developed a technology for that problem. At the same time, partners from Jordan shared their views after managed to solve the problem alike in Jordan with a promising result.

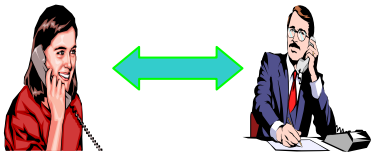
What can be learned from the above true story is that, the engineers do not share the content knowledge as all engineers are well-equipped with that knowledge through formal education and experience. Instead, they share the socially-derivable knowledge which are simply exhibited through simple discussion or video movie.

The scenario given above, the conversation can take place on the phone or video conferencing. However, the knowledge generated disappeared without being recorded. In our approach, the problems and solutions have to be stored for future retrieval. Similar to building expert system that is to retain human expert knowledge for reuse, the expert community knowledge is accumulative, retainable and referable.

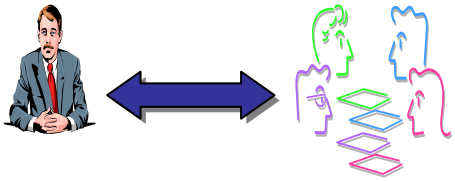
The example of how expert community knowledge can be built is given in the following three scenarios.



Scenario 1. Expert externalizing their experience, knowledge or ideas into the community channel



Scenario 2.An expert was contacted and consulted for an advice in solving a problem



Scenario 3.Expert consults the expert community knowledge through the virtual community

Scenario 1 shows the knowledge building process where experts encode their experience, knowledge or ideas into the community channel. Some may create story objects for new ideas or response to someone's idea using representative terms. Scenario 2 shows an expert was contacted by his colleague about a problem. Being a member to the ICC, he decided to consult the system. In Scenario 3, the expert acquires socially-derivable knowledge from the expert community knowledge which had been incorporated earlier.

Conclusion and Future Works

In this paper we emphasize the two different types of knowledge, which are content knowledge and socially-derivable knowledge. Many computer-based learning system such as intelligent tutoring system, computer aided learning, educational courseware are mainly to train learners to acquire content knowledge. The socially-derivable knowledge is not obtainable from formal sources such as books or formal training but rather by talking to colleagues or counterparts. Without making a claim that ICC is a substitute to other computer-based training system, ICC is rather a complement to the other training system including the traditional learning methods.

The strength of ICC in supporting knowledge construction is to allow complex knowledge that is implicit to be presented in a simple form through story-telling. Consequently, the process of knowledge extraction is made by the human effort collaboratively which adds up to the speed of system development. At the same time, the community is given freedom to design the knowledge and shape its content according to the interest of the

community. The traditional approach in expert system or case-based system only allows the knowledge to be designed according to a specific human expert when the system is developed. However, the knowledge in the ICC depends on the community who builds them continuously and the structure is fluid rather than rigid.

The system can be extended in many ways. Among them, the immediate ones are to enable agents to access the learning space where the multimedia objects can be processed and the knowledge can be extracted. The agents can assist the community by not relying totally on the knowledge extraction done manually by the community through story telling.

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