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Knowledge Acquisition Techniques and Tools: A Review

R.Hepziba Gnanamalar¹, C.Janani², T.Devi³

¹Junior Project Fellow, Department of Computer Applications, Bharathiar University, Coimbatore, India

²Research Scholar, Department of Computer Applications, Bharathiar University, Coimbatore, India

³Head i/c, Department of Computer Applications, Bharathiar University, Coimbatore, India

Abstract: This research analyses the modern subject of knowledge acquisition techniques and tools. The purpose of this research is to enable one to understand knowledge acquisition tools and techniques, perform analysis, and review processes in a structured way. This review investigates the efficiency of the knowledge acquisition tools and techniques.

Keywords: Knowledge Management (KM), Knowledge Acquisition (KA), Knowledge Extraction, KA Techniques and Tools

I. Introduction

This paper studies and analyses the modern literature on knowledge acquisition techniques and tools based on certain industries progress practices. Knowledge management is rapidly becoming an integral business function for many organizations as that realize that competitiveness hinges on effective management of intellectual resources [Varun and Thomas 2001]. To be empowered to face these challenges means not only accessing technology, but also developing the ability to manage knowledge. There is plenty of room for change in the way of work and communications and in relationships and processes among people within and across organizations. Organizations that try to acquire knowledge formally have relatively few available alternatives. For application areas with large amounts of transaction data, data mining can induce rules from that data such as credit approval. Even then, the knowledge creation effort is highly resource-intensive [Lee 2001]. When insufficient data volumes thwart data mining efforts, the acquisition activity has to elicit knowledge directly from experts as rules and facts or formal representations [Christian 2006]. The main objective of this paper is to conduct an empirical research in order to describe the knowledge acquisition tools and techniques. The major research questions formed based on the objective are:

- Why is knowledge acquisition necessary?
- What are the techniques that are used for KA in an enterprise?
- What are the various tools that are used for KA in an enterprise?
- How to deduce knowledge in a particular domain?

This paper is organized into eight sections. Section II is an outcome of the study in the concepts of KM. Section III studies the conceptual and theoretical background, and outlines the factors critical to successful KA. Section IV briefly specifies the KA Techniques and its features. In Section V, the KA Tools and their workflow are described. Section VI discusses how KA techniques are effectively used in the workflow of KA tools. Section VII reports the limitations of the KA Techniques and tools, as well as possible directions for future research. The final section summarizes the overall contributions of this study.

II. Knowledge Management

Knowledge Management is a newly emerging, interdisciplinary business model dealing with all aspects of knowledge within the context of the firm, including knowledge creation, codification, sharing, and how these activities promote learning and innovation [Elias and Hassan, 2004]. Researchers describes the term KM as follows: "Knowledge management is concerned with the exploitation and development of the knowledge assets of an organization with a view to furthering the organization's objectives. The knowledge to be managed includes both explicit, documented knowledge, and tacit, subjective knowledge. Management entails all of those processes associated with the identification, sharing, and creation of knowledge. This requires systems for the creation and maintenance of knowledge repositories, to cultivate and facilitate the sharing of knowledge and organizational learning. Organizations that succeed in knowledge management are likely to view knowledge as an asset and to develop organizational norms and values, which support the creation and sharing of knowledge". [Rowley 2000] [Jayanthi and Saani, 2007].

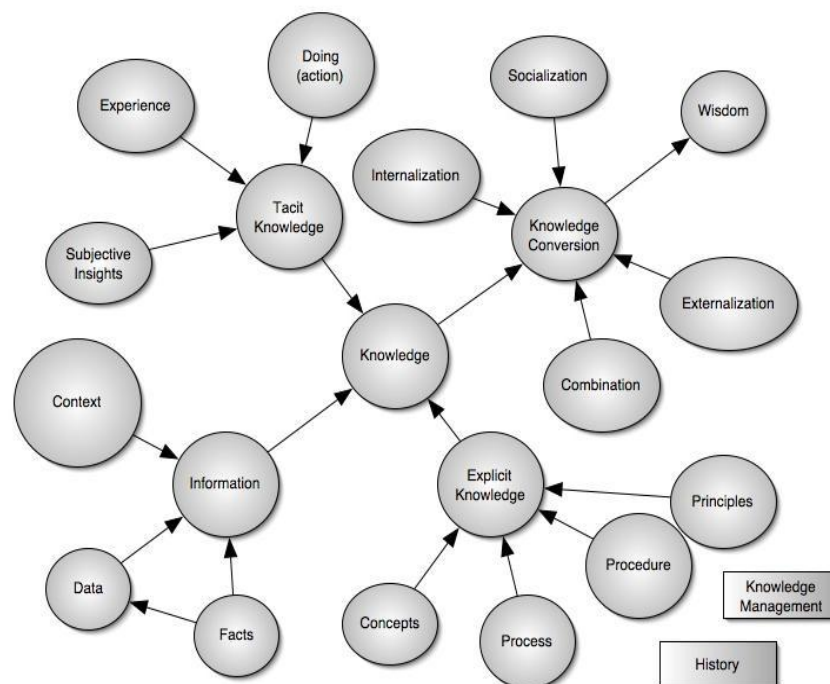
Knowledge management increases the ability to learn from its environment and to incorporate knowledge into the business processes by adapting to new tools and technologies. While it is generally understood that a robust technological infrastructure plays a crucial role in helping businesses gather and analyze data to improve outcomes, the barriers to successful technology and information systems implementation in businesses can be attributed to a narrow understanding of just how these systems and technologies manifest themselves within organizations [Jayanthi and Saani, 2007]. Those who want to think and act in integrated, creative ways and solve complex problems need rich, integrated, up-to-date knowledge management environments to support them. The

gulf between traditional and knowledge-driven organizations is growing as knowledge-driven organizations concentrate not only on present success but also on their own evolution so they can better take advantage of the new knowledge-intensive environment [priweb.com].

A. Types of Knowledge

There are two types of knowledge. One is explicit knowledge, which is expressed in words and numbers and shared in the form of data, scientific formulae, product specifications, manuals, universal principles, etc. This knowledge type can be readily transmitted across individuals formally and systematically. Next one is tacit knowledge, which is not easily observable and expressible. Tacit knowledge is highly personal and hard to formalize, making it difficult to communicate or share with colleagues. Subjective insights, intuitions and hunches fall into this category of knowledge. Additionally, tacit knowledge is deeply rooted in an individual's action and experience, as well as in the ideals, values or emotions he or she embraces [knowledgecompass.com]. The Fig-1 depicts how information is gathered to deduce knowledge from different kinds of knowledge for knowledge conversion [nwlink.com, 2012].

Figure 1. Knowledge Typology Map [nwlink.com, 2012].



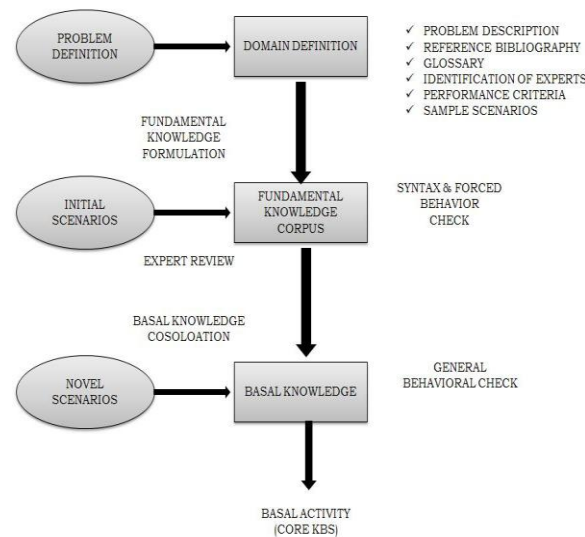
III. Knowledge Acquisition

A. Knowledge Acquisition

Knowledge Engineering mainly focuses on how to extract knowledge successfully from the manuscript. Therefore the knowledge engineer typically spends a great deal of time educating knowledge from domain experts and even more trying to craft intellect knowledge of the data gained. Knowledge Acquisition is the process of obtaining, gaining, extracting, receiving, and acquiring knowledge from the human experts, machines, specialist and high-qualified persons for an expert system, which must be carefully organized into rules or some other form of knowledge representation. Knowledge acquisition ropes the generation of knowledge-based systems through the growth of ethics, procedures, methodologies and tools.

B. Significance of Knowledge Acquisition

In the beginning years of knowledge engineering were determined by problems. Knowledge engineers established to obtaining enough high-quality knowledge to construct a robust and helpful system was a very extended and expensive activity. As such, knowledge acquisition was identified as the bottleneck in building an expert system. This led to knowledge acquisition becoming a major research field within knowledge engineering [Lee, 2001]. The goal of knowledge acquisition is to enlarge methods and tools that make the difficult task of imprisoning and validate an expert's knowledge in efficient and effective way. Forever important and busy people are experts; hence, Knowledge Acquisition important role is, used to reduce the time each expert use off the profession taking part in knowledge acquisition session engineering.

Figure 2. Knowledge Acquisition Cycle [Nedhal, Adel, Intisar and Amman-Jordan, 2011].

C. Knowledge Acquisition Cycle

This represents a "software architectural design" domain according to the designer's interests, using a flexible, dynamic and slightly supervised agent based components. It is improvements above of the standard way of bring out knowledge expertise. The knowledge Acquisition process (as shown in Fig-2) requires the identification of: ① The Problem Domain, ② The Knowledge Engineer (reads many sources of information and discusses many issues with different persons), ③ The Knowledge Experts (people who are experts in solving specific type software design problems and identify their strength), ④ Software Design Task and subtasks (to identify what information is absolutely necessary), and ⑤ The Question Form (Know-how, Know-what, Know-why) [Nedhal, Adel, Intisar and Amman-Jordan, 2011].

IV. Knowledge Acquisition Techniques

Many techniques have been developed to help elicit knowledge from an expert. The vertical axis on the figure represents the dimension from object knowledge to process knowledge, and the horizontal axis represents the dimension from explicit knowledge to tacit knowledge [Epistemic]. The following list introduces a few types of techniques used for acquiring, analysing and modelling knowledge:

A. Protocol Generation Techniques

The aim of these techniques is to produce a protocol, i.e. a record of behavior, whether in audio, video or electronic media. Audio recording is the usual method, which is then transcribed to produce a transcript. It is include various types of interviews (unstructured, semi-structured and structured), reporting techniques (such as self-report and shadowing) and observational techniques [Mostafa, Peyman and Maryam, 2011] (Epistemic).

Interviews: The interview is the most commonly used knowledge elicitation technique and takes many forms, from the completely unstructured interview to the formally planned, structured interview. It is a KA technique in which the knowledge engineer asks questions of the expert or end user [Mostafa, Peyman and Maryam, 2011].

Observation: Simply observing and making notes as the expert performs their daily activities can be useful, although a time-consuming process. Videotaping their task performance can be useful especially if combined with retrospective reporting techniques (Epistemics) [Mostafa, Peyman and Maryam, 2011].

Commentary: These techniques generate protocols by having the expert provide a running commentary on a typical task used in the domain. In on-line PA, the expert is being recorded solving a problem, and concurrently a commentary is made. The nature of this commentary specifies two sub-types of the on-line method [Shadbolt and Burton, 1995]. The basic technique here is the self-report: The expert performing the task may be describing what they are doing as problem solving proceeds (Epistemics) [Mostafa, Peyman and Maryam, 2011].

Shadowing: A variant on this is to have another expert provide a running commentary on what the expert performing the task is doing. This is called shadowing [Shadbolt & Burton, 1995] [Mostafa, Peyman and Maryam, 2011].

Off-line PA: This allows the expert(s) to comment retrospectively on the problem solving session - usually by being shown an audio-visual record of it. An advantage of this is that the video can be paused or run at slow speed to allow time for full explanation. Variants of these reporting techniques involve a second expert commenting on another expert's performance or there could be group discussion of the protocol by a number of experts including its originator [Shadbolt and Burton, 1995] [Mostafa, Peyman and Maryam, 2011] (Epistemics).

B. Laddering Techniques

Laddering techniques involve the construction, reviewing modification and validation of hierarchical knowledge, often in the form of ladders (i.e. tree diagrams). Here the expert and knowledge engineer both refer to a ladder presented on paper or a computer screen, and add, delete, rename or re-classify nodes as appropriate. Laddering means setting elements in a ladder according to a common criterion in order to visualize them (easier for the expert) and confirm model completion (and, in rule systems generate the knowledge in the form of rules) [Mostafa, Peyman and Maryam, 2011] (Epistemics).

Concept Ladder: It shows classes of concepts and their sub-types. All relationships in the ladder, there is a relationship, also is more commonly known as a taxonomy and is vital to representing knowledge in almost all domains [Mostafa, Peyman and Maryam, 2011].

Composition Ladder: It shows the way a knowledge object is composed of its constituent parts. All relationships in the ladder are the part or part-of relationship. Also is a useful way of understanding complex entities such as machines, organisations and documents [Mostafa, Peyman and Maryam, 2011].

Decision Ladder: It shows the alternative courses of action for a particular decision. It also shows the pros and cons for each course of action, and possibly the assumptions for each pro and con. It is a useful way of representing detailed process knowledge.

Attribute Ladder: It shows attributes and values. All the adjectival values relevant to an attribute are shown as sub-nodes, but numerical values are not usually shown it is a useful way of representing knowledge of all the properties that can be associated with concepts in a domain [Mostafa, Peyman and Maryam, 2011].

Process Ladder: It shows process (tasks, activities) and the sub-processes (sub-tasks, sub-activities) of which they are composed. All relationships are the part of relationship; it is a useful way of representing process knowledge [Mostafa, Peyman and Maryam, 2011].

C. Matrix-based Techniques

It involves the construction of grids indicating such things as problems encountered against possible solutions. Important types include the use of frames for representing the properties of concepts and the repertory grid technique used to elicit, rate, analyze and categorize the properties of concepts [Mostafa, Peyman and Maryam, 2011].

Frames: Frames are a way of representing knowledge in which each concept in a domain is described by a group of attributes and values using a matrix representation. The left-hand column represents the attributes associated with the concept and the right-hand column represents the appropriate values. When the concept is a class, typical (default) values are entered in the right-hand column. The use of frames can also be adopted, although this would typically be used for validating previously acquired knowledge rather than for eliciting knowledge from scratch (Epistemics) [Mostafa, Peyman and Maryam, 2011].

Timeline: A timeline is a type of tabular representation that shows time along the horizontal axis and such things as processes, tasks or project phases along the vertical axis. It is very useful for representing time-based process or role knowledge. It can also be used to acquire time-based knowledge. It is a simple representation that is often used in the early stages of knowledge elicitation to capture the basic of processes from the expert [Milton, 2007] [Mostafa, Peyman and Maryam, 2011].

Matrix: A matrix is a type of tabular representation that comprises a 2-dimensional grid with filled-in grid cells. Ticks, crosses or comments in the matrix cells indicate which row object is applicable to which column object. Two kinds of matrix are attributed matrix and relationship matrix [Mostafa, Peyman and Maryam, 2011].

Forms: A more recent form of knowledge model is the use of hypertext and web pages, in which relationships between concepts, or other types of knowledge, are represented by hyperlinks. This affords the use of structured text by making use of templates, i.e. generic headings. Different templates can be created for different knowledge types [Mostafa, Peyman and Maryam, 2011].

Repertory Grid Technique: This technique is based on the "Personal Construct Psychology" theory by Kelly, which postulates that people view the world in terms of "constructs" (Montero et al) The technique is essentially matrix-based although it is more complex than simply filling-in a matrix of elements. Usually involves the following four main stages [Milton site] It encourages the classification of data using elements and constructs, such that the extent of mutual relationships and differences between entities or constructs are established (pages.cpsc.ualgary.ca).

V. Knowledge Acquisition Tools

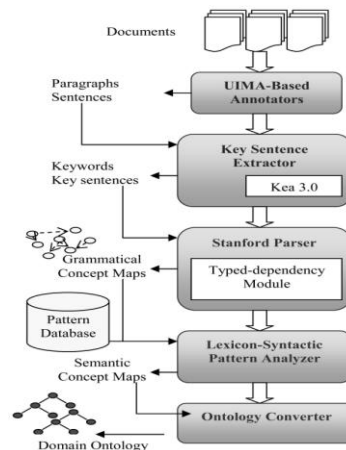
Huge efforts have gone into development of each knowledge acquisition tools by the developers. A great number of advanced KA tools are available to manage the knowledge from different types of resources. This section discusses about the structure of three knowledge acquisition tools: TEXCOMON, NOCTUA and SuperMatrix.

A. TEXCOMON

Ontology represents knowledge of a domain typically in taxonomic form. A form of Meta knowledge is Ontology mappings, it allows the translation of concepts in one domain into the concept of another domain [Doan, Madhavan, Domingos and Halevy, 2002]. This Ontology helps in supporting how to understand the

natural and structural language [Gruber, 1993]. Several knowledge acquisition tools are developed for the ontology mapping. Nevertheless, the TEXCOMON (TEXT Concept Map Ontology) is the very specific one for the ontology mapping.

Figure 3. TEXCOMON Process [Amal and Roger, 2009].



Process of TEXCOMON: The Knowledge Puzzle is a versatile research to build and exploit knowledge bases in the field of education. One of its goals is to promote ontology learning from any text, and particularly, from textual learning objects through the TEXCOMON tool. Overall, the ontology engineering process with TEXCOMON works as follows (Fig-3): Textual documents act as inputs to the TEXCOMON [Amal and Roger, 2009]. Decomposing the document into the paragraphs and sentences are creating the index. The machine-learning algorithm is used to extract the key sentences from the documents. Here the statistical natural language parsers are used for parsing the key sentences. Dependency networks are outputs of this parser. The networks are mined in order to identify lexico-syntactic patterns, which transform the grammatical representations into semantic ones TEXCOMON. The semantic representations are then used to create concept maps. Finally, the concept maps are exported as OWL ontology [Amal and Roger, 2009].

Merits of TEXCOMON: Always the textual representation is difficult to identify and manage, because the texts usually have a number of annotators, verb, noun, patterns and grammatical orders. The TEXCOMON is one of the best tools to generate the map from the plain text documents. May be the text documentation contains thousands of sentences and words. Therefore, the readers have to spend lot of time to know the matter from the documents. It is wastage of time to read each line from the documents. The TEXCOMON knowledge acquisition tools generate the map from the textual information so that one can easily identify and know about the documentation by seeing the map.

B. SuperMatrix

The Super Matrix is a Knowledge Acquisition tool to construct the Knowledge from corporation. The knowledge is semantic lexical relations from the corpora. Lexical semantics is the categorization and rotting of word meaning, the dissimilarities and similarities in lexical semantic structure between various languages, and the association of word meaning to sentence meaning and syntax.

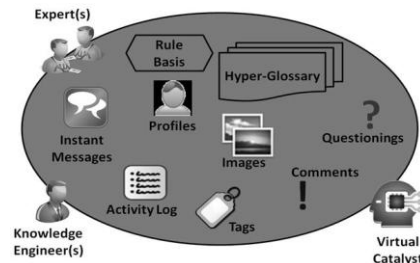
Process: The tool has following modules for constructing lot of semantic lexical knowledge from corporation [Doan, Madhavan, Domingos and Halevy, 2002] : 1) Matrices – a library for storing matrices, 2) Comparator – a library enabling computation of similarity between rows of matrices using different Measures of Semantic Relatedness, 3) Set of tools, including tools for creation of matrices: Lexical Units by features, tools for evaluating of MSRs, tools for joining different matrices and analysis of the matrix content, 4)Clustering – package consisting of several clustering algorithms. SuperMatrix can interact with: a) CLUTO – CLUstering Toolkit [Karypis, 2003], b) CBC - Clustering by Committee(CBC) [Pantel, 2003], c)ROCK - Robust Clustering using links [Guha, Rastogi, and Shim, 2000], d) GHSOM - Growing Hierarchical Self-Organizing Maps [Rauben, Merkl, and Dittenbach, 2002] ; and 5) Set of helper scripts and SWIG wrappers for main classes of the Matrices and Comparator libraries; a) SWIG - Simplified Wrapper and Interface Generator [knowledge-management-tools.net]

C. NOCTUA

Main Goal: Noctua is to stimulate the exploitation of knowledge by the collaborators. The catalyst is asking interviewee automatically generated questions and requiring their opinions. Acting as a newcomer among experts, sometimes the catalyst could ask insolent questions, but sometimes its questions could require experts to rethink their concepts, so they may not only make their knowledge explicit but also wider. This is Noctua's main goal is

to explicit the knowledge from the experts and knowledge engineers. The catalyst attention on Production Rules, it presents to the collaborators new combinations of conditions and conclusions, trying to form new rules. To reduce the chances of making uninteresting questions, the catalyst seeks this information among knowledge containing the same tags as the one being changed [Geraldo Boz Jr, Milton P. Ramos, Gilson Yukio Sato, Júlio Nievola, Emerson C. Paraiso, 2011]. *The Virtual Catalyst*: The Fig-4 schematically shows the components of the proposed system. The virtual catalyst keeps in touch with collaborators such as experts and knowledge engineers.

Figure 4. Components and Uses of NOCTUA [Boz Jr, Milton, Gilson, Júlio, Emerson, 2011].



Process: Noctua allows every user to create knowledge acquisition projects. Knowledge constructions have many types [Milton, 2007]. Noctua supports for the following types of constructions: 1) Conceptual Knowledge: tells what something is; and 2) Procedural Knowledge: tells how to do something.

Conceptual Knowledge and Noctua: Categorizations, principles, generalizations, theories, and models of knowledge or structures relevant to a particular penal area are referred as Conceptual Knowledge. The acquisition tool represents Conceptual Knowledge using Knowledge Pages (KP). The Knowledge Page may contain mandatory fields. If they are related to countries, they should necessarily cite, for instance, each country's name, area, official language, capital and population. In our system, users can create KP templates to be used inside a project. Supposing that the project is about books, it could have a template for books and another template for authors. Other templates could be added such as publishers and bookshops [Geraldo Boz Jr, Milton P. Ramos, Gilson Yukio Sato, Júlio Nievola, Emerson C. Paraiso, 2011].

Procedural Knowledge and Noctua: Procedural knowledge is related to the procedure to carry an action out. For example, a method to balance a checkbook would be considered procedural knowledge. Knowledge about "how" to do something is procedural knowledge. Procedural knowledge is instruction-oriented [Turban and Aronson, 1988]. It focuses on how to obtain a result. Procedural Knowledge is represented by Production Rules like decision-making conditions:

If <list of conditions> Then <list of conclusions>
Else <list of conditions> Then <list of conclusions>

The representation used to unfamiliar people to use the computer easily and they can express their knowledge through this easy way. The below steps are explaining Characteristics of Noctua [Geraldo Boz Jr, Milton, Gilson, Júlio, Emerson C. Paraiso, 2011]:

- Collaboration and Interaction: Noctua allows synchronous and asynchronous collaboration, offers forums and instant messaging to help collaborators reach consensus and a mentored coordination for conflict resolution;
- Social Translucence: the system keeps record and publishes information about the authors of every knowledge piece, and all the participants of each project;
- Reliability: the proposed system considers all no questioned knowledge as reliable;
- Automatic hyper linking: words inside Knowledge Pages are automatically transformed into hyperlinks whenever they coincide with the names of other Knowledge Pages or equivalent words provided by collaborators. Noctua also shows as hyperlinks the logical interconnections between Production Rules, in the case that a conclusion of a rule is used as condition by another rule. In doing so, Noctua integrates all the existing knowledge within a project, whether it is represented as Rule Production, or as a Knowledge Page.

The Noctua's functions are described as: ①Creating, updating and closing KA/CKC projects; ②Recording users' profiles; ③Assigning users to activities such as projects and roles; ④Recording notes, forums , instant messages and historical data; ⑤Creating documents such as Knowledge Pages and Rules; ⑥ Supporting discussion and negotiation by questioning knowledge and also in forums and instant messages; ⑦Supporting the awareness of the level of participation and contribution by logging the authorship of every knowledge and by showing statistics of each one's participation; ⑧ Supporting multimedia elements, text and image; ⑨Supporting awareness mechanisms for both synchronous and asynchronous interaction, informing about contributions added by the members; and ⑩Finally, the Noctua provides virtual catalyst [Geraldo Boz Jr, Milton, Gilson, Júlio, Emerson, 2011].

VI. Assessment Of Ka Techniques and Tools

This section describes how certain knowledge acquisition techniques are combined with few knowledge acquisition tools to deduce relevant knowledge in a particular locale. Table-I discusses the various KA techniques and its features and Table-II reviews the comparison of the three KA tools TEXCOMON, Super Matrix, and NOCTUA Table-III analyses the relationship between KA Tools and Techniques discussed in this paper.

Table I - Comparative Study of KA Techniques.

Techniques	Input	Output	Result	Efficiency	Type
Unstructured	Interview	Based on Procedure followed, Knowledge used.	Varies depending on the Questions asked	Time Consuming	Direct
Structured				N/A	
Semi-Structured				Based on Application	
Observation	Observed Data	Taxonomy of tasks/subtasks or functions/procedures, Problem-solving strategy, knowledge and skills needed for tasks	Information used, Procedure Followed	Time Consuming	
Commentary	Self Report	Problem-solving strategy	Online/Offline Reporting		
Laddering	Documents, Interview, Verbal Question	A Hierarchical Map	Varies by Procedure followed, Rationale	Based on Application	Indirect
Matrix	Interview	Attributes, Relationship	Attribute and Relationship Matrices	Time Consuming	
Frames		Representing properties of Concepts.	Validating captured Knowledge		
Time Line		Flowchart	Capture of basic Processes		
Forms	Software Application, Interview	Attributes and Entities (if provided by subject)	Hyper Text, Web Pages	Based on Application	
Repertory Grid			Entities, Attributes and Relationship		

Table II - Corroboration of KA Tools

KA Tool	Knowledge Format	Objective	Best For	Tool Domain
TEXCOMON	Ontology Map	To elicit knowledge (ontology map in tree structure) from textual documentations	Puzzle Projects, Semantic Web language Representation	Stand-Alone
SuperMatrix	Matrix-Oriented Knowledge	To perform Document Indexing, Clustering, Retrieval and Search Engine Construction and Semantic Correction of hand-written documents	Natural Language Processing, Pattern-Based Paradigm (e.g. lexico-syntactic patterns)	Automated Tool
NOCTUA	Knowledge Production Rule	To stimulate the Explicit Knowledge by asking the collaborators, Automatically Generated Questions and requiring their Opinions	To develop Knowledge Acquisition Project and Virtual Online Interview	Automated Tool

In Table 1, column “Techniques” represents a few knowledge management techniques, which is carefully organized into a set of acquisition rules. Second and third column of Table 1 defines the structure of inputs and outputs for the respective KA techniques. The column “Result” depicts what form of knowledge data is obtained via the given input. The last two columns portray the robustness of each technique.

Table III - Techniques tracked in KA Tools

Tool	Knowledge Form	Techniques Applied	Purpose of Technique (Analyzing / Generation)
TEXCOMON	Process, Natural Language	Observation, Interview, Documents	Generation
SuperMatrix	Explicit, Constructive	Matrix-Based, Measures of Semantic Relatedness	Generation
NOCTUA	Explicit, Procedural and Conceptual	Virtual Interview, Laddering	Analyzing

In Table III, the authors attempt to convey the downsides of each KA techniques and tools described so far in this paper. It also portrays how each acquisition techniques are being employed in acquisition tool processes.

VII. Conclusion

The goal was to compare the concepts, attributes, hierarchical, and relationships in KA tools and techniques. In summary, there is no single right way to elicitate knowledge in all enterprises. This confirms the interest of the comparative evaluation as proposed in this paper. Future work can also include making a tool that uses other forms of knowledge showing the interconnections between each rule as well as timelines that could show how the knowledge so far deduced has evolved along the collaboration process. This paper gives a picture of the further improvement necessary in knowledge acquisition process.

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