TMRF e-Book
Advanced Knowledge Based Systems:
Model, Applications & Research
(Eds. Sajja & Akerkar), Vol. 1, pp 1 – 11, 2010

Chapter 1

Knowledge-Based Systems for Development

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INTRODUCTION

Human brain can store several thousand folds of world's knowledge. Still it is said that human brain is not fully utilized. Advances in human knowledge are tied directly to the ability to analyze to form information, process it into knowledge and communicate it to others. The human brain has approximately 1011 nerve cells called biological neurons. It is probably the most complex and least understood part of the human body. It is continuously thinking in declarative and procedural way for problem solving. But till today it is a mystery that how does the human mind work. This new millennium brought us an opportunity to attack all such questions with the help of new knowledge, new tools and new resources. Development of systems that make use of knowledge, wisdom and intelligence is a step towards meeting this challenge. The ability of the intelligent systems to capture and redistribute expertise has significant implications on development of a nation, commodity or population. Such systems allow documentation of one or more expert knowledge and utilize the knowledge for problem solving in cost effective way. It allows for, in a controlled manner, the import of expertise in various areas that the nation lacks, the export of knowledge relating to domestic areas of expertise, and the duplication and redistribution of scarce knowledge in a cost effective manner (Darek and Jain 1991). Thus areas of expertise that the selected domain/region/nation is deficient in or possesses exclusively are potential candidates of the knowledge-based systems. Though synthesized information is a key element for success, in many businesses it is a missing piece. A significant amount of Gross National Product (GNP) is invested in transferring knowledge through education and training. The AI systems effectively distribute the scarce resources for the development process. The Knowledge-Based Systems (KBS), which are a step towards an intelligent system, can be justified when a few individuals have the majority of the knowledge.

DIKW CHAIN

Data, information, knowledge and wisdom are major elements of human thinking and reasoning process. There are distinctive differences between data, information, knowledge and wisdom. Data concern with observation and raw facts. They are useless without an additional processing viz. comparing, inferring, filtering etc. The processed data is known as information. We may conclude that knowledge is a result of processes like synthesis, filtration, comparison and analysis of available information to generate meaningful outcome. Over the time, the experience, judgment, values, laws etc. are to be added to have the wisdom. This is known as Data-Information-Knowledge-Wisdom

(DIKW) chain. This chain is also known as data pyramid. These entities can be arranged as shown in Figure 1.

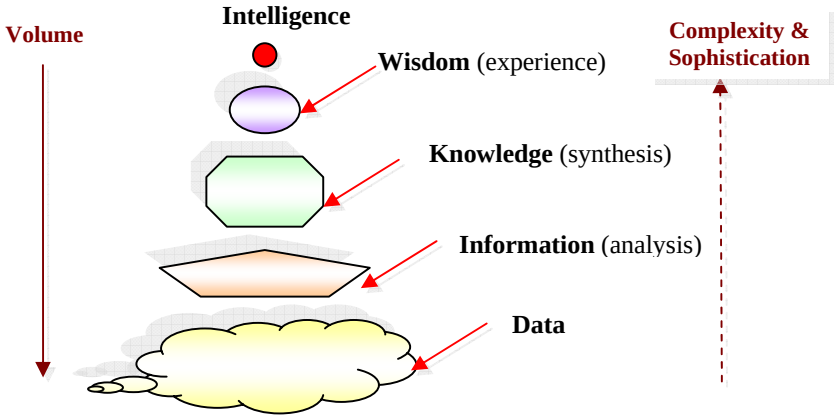

Figure 1: DIKW Chain

Knowledge can be classified in many different ways. Tacit knowledge, explicit knowledge, factual knowledge, procedural knowledge, commonsense knowledge, domain knowledge, meta knowledge, etc. Table 1 briefly introduces various types of knowledge.

Knowledge Type	Description
Domain knowledge	Domain knowledge is valid knowledge for a specified domain. Specialists and experts develop their own domain knowledge and use it for problem solving.
Meta knowledge	Meta knowledge can be defined as knowledge about knowledge.
Commonsense knowledge	Common sense knowledge is a general purpose knowledge expected to be present in every normal human being. Common-sense ideas tend to relate to events within human experience.
Heuristic knowledge	Heuristic is a specific rule-of-thumb or argument derived from experience.
Explicit knowledge	Explicit knowledge can be easily expressed in words/numbers and shared in the form of data, scientific formulae, product specifications, manuals, and universal principles. It is more formal and systematic.
Tacit knowledge	Tacit knowledge is the knowledge stored in subconscious mind of experts and not easy to document. It is highly personal and hard to formalize, and hence difficult to represent formally in system. Subjective insights, intuitions, emotions, mental models, values and actions are examples of tacit knowledge.

Table 1: Types of Knowledge

Knowledge can be represented using components like facts, rules and heuristic. Heuristic, which is a rule of thumb, can be thought as a tactic problem solving methodology, which moves solution towards success. According to J Pearl (1984), "*Heuristic in general terms are the strategies using really accessible though loosely applicable information to control problem solving process in human beings and machines*". For each problem faced in real life, there may not have exact rules and procedure for desired solution but a practically applicable rule of thumb.

KBS Structure

Knowledge-Based System (KBS) is one of the major family members of the AI group. With availability of advanced computing facilities and other resources, attention is now turning to more and more demanding tasks, which might require intelligence. The society and industry are becoming knowledge oriented and rely on different experts' decision-making ability. KBS can act as an expert on demand without wasting time, anytime and anywhere. KBS can save money by leveraging expert, allowing users to function at higher level and promoting consistency. One may consider the KBS as productive tool, having knowledge of more than one expert for long period of time. In fact, a KBS is a computer based system, which uses and generates knowledge from data, information and knowledge. These systems are capable of understanding the information under process and can take decision based on the residing information/knowledge in the system whereas the traditional computer systems do not know or understand the data/information they process.

The KBS consists of a Knowledge Base and a search program called Inference Engine (IE). The IE is a software program, which infers the knowledge available in the knowledge base. The knowledge base can be used as a repository of knowledge in various forms. This may includes an empty WorkSpace to store temporary results and information/knowledge pieces/chunks. As an expert's power lies in his explanation and reasoning capabilities, the expert system's creditability also depends on the Explanation and Reasoning of the decision made/suggested by the system. Also, human beings have an ability to learn new things and forget the unused knowledge from their minds. Simulation of such learning is essential component of KBS. The life of KBS may vary according to the degree of such simulation. KBS may be either manually updated (manual update) or automatically updated by machine (machine learning). Ideally, the basic frame of a KBS rarely needs to be modified. In addition to all these, there should be an appropriate User Interface, which may have the Natural Language Processing facility. These components are shown in Figure 2.

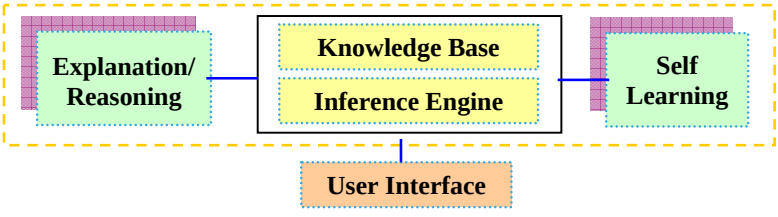

Figure 2: Architecture of a Knowledge-Based System

According to the classification by Tuthhill & Levy (1991), there are main 5 types of the KBS exist:

(i) Expert Systems,

(ii) Hypertext Manipulation Systems,

(iii) CASE Based Systems,

(iv) Database in conjunction with an Intelligent User Interface and

(v) Intelligent Tutoring Systems.

KBS ADVANTAGES AND LIMITATIONS

Knowledge-based systems are more useful in many situations than the traditional computer based information systems. Some major situations include:

- ☞ When expert is not available.
- ☞ When expertise is to be stored for future use or when expertise is to be cloned or multiplied.
- ☞ When intelligent assistance and/or training are required for the decision making for problem solving.
- ☞ When more than one experts' knowledge have to be grouped at one platform.

With the proper utilization of knowledge, the knowledge-based systems increase productivity, document rare knowledge by capturing scare expertise, and enhance problem solving capabilities in most flexible way. Such systems also document knowledge for future use and training. This leads to increased quality in problem solving process. However, the scarcity and nature of knowledge make the KBS development process difficult and complex. The transparent and abstract nature of knowledge is mainly responsible for this. In addition, this field needs more guidelines to accelerate the development process. Following are some of the major limitations with the KBS:

- ☞ Acquisition, representation and manipulation of the large volume of the data/information/ knowledge.
- ☞ High-tech image of the AI field.
- ☞ Abstract nature of the knowledge.
- ☞ Limitations of cognitive science and other scientific methods.

A number of AI/KBS application areas also open up deep philosophical issues. This reveals a promising field of study whose primary concern is to find out more effective ways to understand and apply intelligent problem solving, planning and communication skills to a wide range of practical problems.

KBS DEVELOPMENT

Figure 3 presents the overview of KBS development process. The knowledge of the expert(s) is stored in his mind in a very abstract way. Also every expert may not be familiar with knowledge-based systems terminology and the way to develop an intelligent system. The Knowledge Engineer (KE) is responsible person to acquire, transfer and represent the experts' knowledge in form of computer system. People, Experts, Teachers, Students and Testers are the main users' groups of knowledge-based systems.

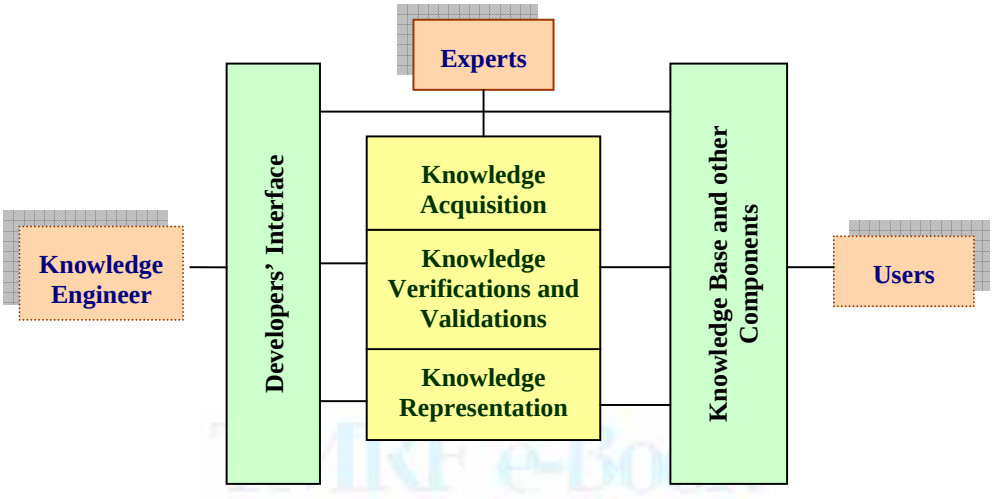

Figure 3: Development of a Knowledge-Based System

The knowledge acquisition process incorporates typical fact finding methods like interviews, questionnaires, record reviews and observation to acquire factual and explicit knowledge. However, these methods are not much effective to extract tacit knowledge which is stored in subconscious mind of experts and reflected in the mental models, insights, values, and actions of the experts. For this, techniques like concept sorting, concept mapping, and protocol analysis are being used.
The acquired knowledge should be immediately documented in a knowledge representation scheme. At this initial stage, the selected knowledge representation strategy might not be permanent. However documented knowledge will lead the knowledge engineer/ developer to better understanding of the system and provides guidelines to proceed further. Rules, frames, scripts and semantic network are the typical examples of knowledge representation scheme. It is responsibility of the knowledge engineer to select appropriate knowledge presentation scheme that is natural, efficient, transparent, and developer friendly. One may think for hybrid knowledge representation strategies like rules within the frames in slots like "on need" and "on request"; semantic network of default frames etc. More about knowledge acquisition, knowledge representation and knowledge-based system development model is available in the book Knowledge-based systems (Akerkar and Sajja 2009).

KBS TOOLS

A KBS tool is a set of software instructions and utilities taken to be a software package designed to assist the development of knowledge-based systems. Personal computers, typical programming languages like java and framework like .NET can also be used in KBS development. These programming languages are general purpose and also being used to develop other application than AI applications. KBS shell with the readymade utilities of self learning, explanation and inference etc. like Java Expert System Shell (JESS), GURU, Vidwan are more specific and can also be useful to develop KBS. Tailor made KBS can be developed using programming languages like LISP and Prolog.

John McCarthy (1960) published a remarkable paper showing a handful of simple operators and a notation for functions, one can build a whole programming language. He called this language Lisp, for "List Processing," because one of his key ideas was to use a simple data structure called a list for both code and data. There are various versions of Lisp available namely KLISP and C Language Integrated Production System (CLIPS).

Prolog is a logic programming general purpose fifth generation (AI) language. It has a purely logical subset, called "pure Prolog", as well as a number of extralogical features. Prolog has its roots in formal logic, and unlike many other programming languages, Prolog is declarative. The program logic is expressed in terms of relations, and execution is triggered by running queries over these relations. The language was first conceived by a group around Alain Colmerauer in Marseille, France, in the early 1970s. According to Robert Kowalski (1988), the first Prolog system was developed in 1972 by Alain Colmerauer and Phillipe Roussel.

Packages software like MATLAB, Java Neural Network Simulator (Java NNS) etc. and markup open sources based tools like Artificial Intelligence Markup Language (AIML) and Project D (developed in AIML and open source) can also be used to develop KBS. Systems which work with multiple agents and intelligent agents may use Knowledge Query Manipulation Language (KQML) for agents' communication. CommonKADS and Protégé also help in assisting KBS development process in user friendly way.

According to Stefan Robertson and John K C Kingston there are approximately 200 KBS tools. Alty (1989) groups the products into three main categories based primarily on functionality which also happen to differ markedly in the platforms on which they are available. These groups are (i) Shells, (ii) Languages, and (iii) Toolkits. Inference ART and KEE were among the first commercially successful toolkits to develop KBS.

Besides support towards knowledge acquisition and representational features, there are other features like price, flexibility, ease of use, user friendliness and vendor availability and support, and documentation support from the tool need top be considered before final selection.

KBS PURE APPLICATIONS

Knowledge-based systems applications are divided into two broad categories namely: (i) pure knowledge-based systems applications and (ii) applied knowledge-based systems application. Pure applications include research contributing in knowledge-based systems and AI development techniques such as knowledge acquisition, knowledge representation, models of automated knowledge-based systems development (knowledge engineering approaches, models and CASE tools for KBS), knowledge discovery and knowledge management types of tools. Table 2 tries to presents a few possible research areas in pure KBS development.

Area	Sub-area	Example Applications
KBS Development	Knowledge acquisition	▪ Automatic knowledge acquisition
	Knowledge representation, Reasoning, explanation and inference	▪ Multi layer KBS ▪ Semantic web ▪ Hybrid representation structures
	Development models, quality standards and protocols	▪ Intelligent software engineering KBS ▪ Automatic programming
Knowledge Management	Knowledge discovery	▪ Knowledge-based data mining ▪ Automatic generation and learning of wrappers ▪ Knowledge creation and reuse
	Knowledge share and disseminations	▪ Knowledge dissemination techniques ▪ Trust based network
Information and Query Based Systems	Information extraction Information retrieval Accessing distributed databases	▪ Meta search engines ▪ Heuristic information filtering functions ▪ Intelligent query formation KBS ▪ Knowledge-based access of data warehouses
User Interface	KBS shell Combining databases with KBS through intelligent user interface KBS and Database Integration	▪ Generic interface in native languages ▪ Customized presentation of information according to user profile ▪ Interface for special target audience say senior citizen or blind people
Expert Systems	Rule based systems Frame based systems	▪ Type 1 and type 2 fuzzy logic based diagnostic systems
Distributed KBS	Network online KBSs Hyper linked KBS Systems on semantic web	▪ Intelligent Routing algorithms
Knowledge Grid	Middleware services Protocols	▪ Deign and implementation of generic k-grid framework
Multi Agent Systems	Agent communication language	▪ Deign and implementation of generic multi-agent framework
Tutoring Systems	e-tutors e-Learning systems	▪ Learning object repositories ▪ General e-content repositories accessed by many applications
Soft computing based KBS	Connectionist system and KBS	▪ Learning paradigms
	Evolving systems	▪ Genetic programming ▪ Genetic fuzzy function ▪ Self evolving NN structures ▪ Automatic generation of rule bases

Table 2: Research Areas in Pure KBS development

KBS FOR INTEGRATED DEVELOPMENT

The Knowledge-based systems can be used for interpretation, prediction, diagnosis, design, planning, monitoring, debugging, repair, instruction, control, etc. Such advanced technology should be made available in urban and rural areas to utilize expert knowledge for holistic development. Such systems export knowledge in underdeveloped and remote area where expertise is rare and costly. Hence, knowledge-based systems KBS should be at the primary consideration while designing the development plan for a nation. The share of AI/KBS systems in IT is improved significantly.
In addition, today's KBS are easier to use, less expensive and integrate well with traditional technologies, so it can provide a fundamental technology to the majority of the applications for today's scenario. The four major dimensions of the rural development process namely; Economical, Social, Physical and Health development are considered for the holistic development. Major resources for development are considered as Natural Resources, Human Resources, Livestock and Agricultural Resources. The KBS applications are classified according to the above dimensions & resources. Figure 4 describes the situation graphically and Table 3 lists some examples in each dimension.

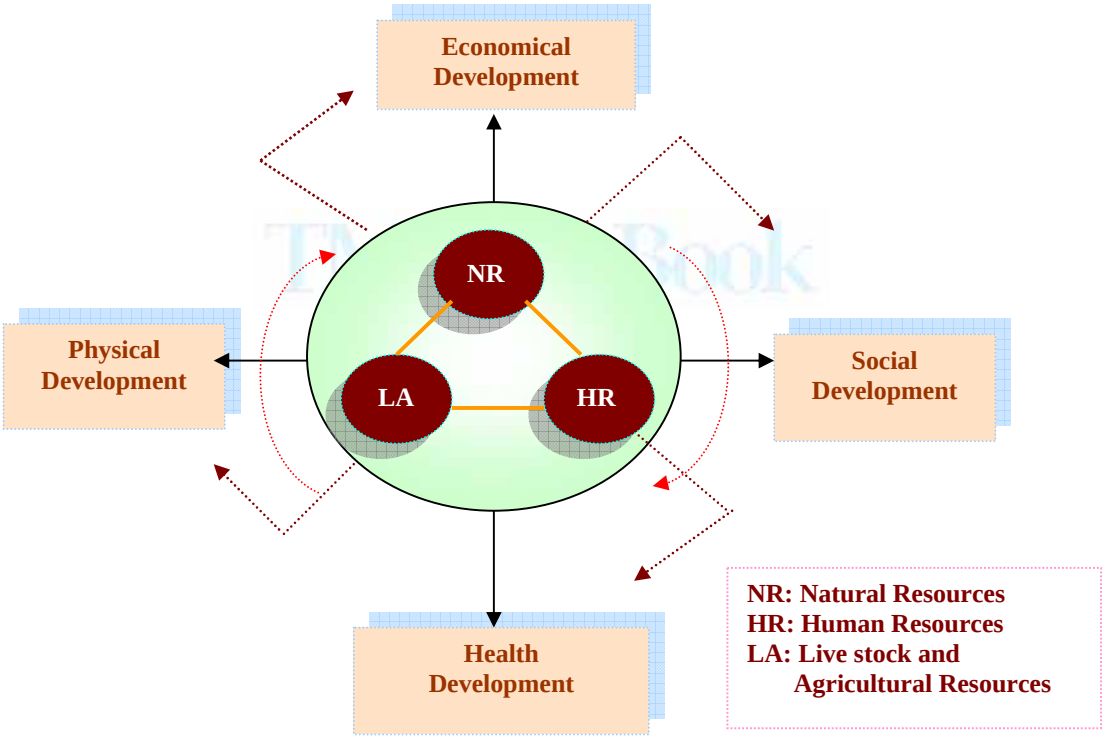

Figure 4: Dimensions of Development through Knowledge-Based Systems

Physical Communication Planning & Administration Forestry, Energy, Agriculture etc.	**Economical** Small Scale Industry Agri-Business & Co-operative etc.
Health Nutrition Sanitation Community Health etc.	**Social** Education & Training Social Awareness Programme etc.

Table 3: Examples of Knowledge-Based Systems in Different Dimensions

Some example of knowledge-based system in the areas listed in the Table 3 can be outlined as follows:

Physical development

KBS for infrastructural planning
Small scale industries like agribusiness and co-operatives
Energy planning and reuse
E-Governance
Irrigation management and supervision
Communication and transportation
Public distribution services
Special programmers like drought prone area planning
Forestry
KBS for natural resource management
Knowledge-based planning for land use and land reform
Network monitoring systems
KBS for resource sand material management
KBS for river and land use management
KBS for soil health card for villagers
KBS for intelligent manufacturing and new product development
KBS for geographic property identification and measuring
Robotics and fly/drive by wire vehicle system
Pilot training and space training through virtual reality
Publication and printing media KBSs
Loan passing system
Fault diagnostic System

Economical Development

Employment exchange services
Market reforms/information systems
New product development advisory
Business selection advisory
Tax planning system
Knowledge-based planning of agricultural products
Knowledge-based planning for agricultural inputs
Knowledge-based diagnosis for plants and animal diseases

Crop land pattern matching system for agriculture
Intelligent manufacturing
Matching buyers and sellers agent in e-commerce
Embedded KBS in the devises like fuzzy washing machine
Robotic and intelligent sensors in manufacturing
KBS for potential risk identification in investments
Software/product quality management
Intelligent ERP based systems

Social Development

Cultural information
Tourism portal
Identity/ration card
Voters identification and election related systems
Intelligent system to identify suitable beneficiaries for Government/NGO schemes
Awareness systems
Child and women health/nutrition systems
Community health
e-learning
Education and training systems
Knowledge-based examination planning system
Games and entertainment KBS
Language translation and tutoring

Health Improvement

Government schemes information system
Diet planning system
Disease diagnostic system
Disease diagnostic system for cattle and live stock
Patient monitoring system
Medical insurance
KBS monitoring in surgical process
KBS for guided neuro-surgery

Knowledge-based systems offer several advantages over humans (Natural Intelligent systems). Some of the major advantages can be listed as follows:

- Knowledge-based systems provide efficient documentation of the important knowledge in a secured and reliable way.
- Knowledge-based systems solve unstructured, large and complex problems in an quick and intelligent fashion and provides justification for the decision suggested.
- Knowledge-based systems offer more than one expert knowledge in an integrated fashion.
- Knowledge-based systems are able to infer (create) new knowledge and learn from cases or data instead of just referring the stored content.

- It is easy to clone and spread knowledge and knowledge-based systems.

Typical information systems deal with data while knowledge-based systems automate expertise and deal with knowledge. Every business in today's competitive world is full of uncertainty and risk. Managing and satisfying customers with quality product/services have become trivial challenge. In this situation the knowledge-based system is wise choice. In spite of plenty of obvious advantages, the knowledge base system development and usage are difficult because of the problems associated (stated earlier in the introductory section) with them. Scientists, researchers and professionals are working on different aspects of knowledge-based system to overcome these limitations and to offer a complete intelligent system which is compatible with the natural intelligent system in controlled fashion.

REFERENCES

Akerkar, R.A. and Sajja, P.S. 2009. Knowledge-based systems: Jones & Bartlett Publishers, Sudbury, MA, USA.

Derek, N. and Jain, H. 1991. The relevance of ES technology for India: A Transborder Perspective, *CSI Digest*, 3(1):68

Pearl, J. 1984. *Heuristic-intelligent search strategies for computer problem solving*: Addison Wesley Publishing Company.

Tuthhill, S. and Levy, S. 1991. *Knowledge-based systems: A managers perspective*: TAB Professional & Reference Books.

McCarthy, J. 1960. Recursive functions of symbolic expressions and their computation by machine. *Communications of the ACM*, 3(4): 184–195.

Kowalski, R.A. 1988. The early years of logic programming, Communications of the ACM, 31(1): 38-43.

Robertson, S. & Kingston, J. 1997. Selecting a KBS tool using a knowledge-based system, AIAI-TR-214. Available at http://www.aiai.ed.ac.uk/project/ftp/documents/1997/97-paces97-select-kbs-tool.ps

Alty J.L. 1989. Expert system building tools. In: eds. Guida, G. and Tasso, C. Topics in Expert System Design: Methodologies and Tools: North-Holland, Amsterdam.

Knowledge-Based Systems focuses on systems that use knowledge-based techniques to support human decision-making, learning and action. Such systems are capable of cooperating with human users and so the quality of support given and the manner of its presentation are important issues. The emphasis of the journal is on the practical significance of such systems in modern computer development and usage. Homepage. Join the conversation about this journal. Knowledge-based systems provide solutions based on the interactions of multiple rules. The rules represent knowledge learned from experts. Individual rules will be relatively understandable, but technical expertise is required to achieve the necessary structure and relationships of the rules for the knowledge-based system to function properly. While the decisions realized with knowledge-based systems are based on clearly defined rules, the results may not be so obvious.Â The use of CBR in intelligent systems is motivated both by considerations for system development and for user interactions. Some key motivations are to facilitate knowledge acquisition, to facilitate knowledge maintenance, to increase problem-solving efficiency and solution quality, and to benefit user acceptance.