Sri Lanka Association for Artificial Intelligence (SLAAI)
Proceedings of the fourth Annual Sessions
31st October 2007 - Colombo

Computational Modeling in Conceptual Models: Widening Scope of Artificial Life

D. S. Kalana. Mendis[1], Asoka. S. Karunananda[2] , U. Samaratunga[3]
[1]Department of Information Technology, Advanced Technological Institute, Labuduwa, Sri Lanka
[2] Faculty of Information Technology, University of Moratuwa, Sri Lanka
[3] Gampaha Wickramarchi Ayurvedic Institute, University of Kelaniya, Sri Lanka

kalanaatil@mail.com[1] ,asoka@itfac.mrt.ac.lk[2]

Abstract

Artificial Life or Alife is concerned with computational models invented by considering explicit knowledge in biological systems. However conceptual models have not been addressed for Alife due to involvement of informal practising methodologies. This leads to concern with tacit knowledge in conceptual models. This paper presents a research, which is incorporated with a computational modelling in diagnosis of human constitutions in Ayurvedic medicine considered as conceptual model. Further Tacit knowledge is the key issue of knowledge modelling aspect because all knowledge is rooted in tacit knowledge. An Intelligent Hybrid system involved with artificial intelligent techniques, namely fuzzy logic and expert system technology has been used to implement the computational model. The result of the modelling of Ayurvedic domain using fuzzy logic has been compatible with the experiences of the Ayurvedic experts. It has shown 77% accuracy in using the tacit knowledge for reasoning in the relevant domain.

1. Introduction

Artificial Life or Alife is a new, multi-focused field of research. Like theoretical biology, it is concerned with formal, computational models of life, but it has expanded its scope by claiming the possibility of *synthesizing* lifelike behaviors within computers and other artificial media [34]. Traditional biology has been primarily *analytic* and reductionist in outlook, taking an organic whole apart and analyzing its components. Chris Langton introduced the field, Artificial Life complements based on explicit knowledge in traditional biology [36]. This has been classified into *Computational Alife, Robotic Alife* and *Chemical Alife based computational models using explicit knowledge of biological systems. But conceptual models for biological systems have not been addressed due to* involvement of informal practicing methodologies [39,40, 41]. This leads to research tacit knowledge modeling in conceptual model. Here we used diagnosis of human constitutions in Ayurvedic medicine as conceptual model.

Ayurvedic medicine has a very strong bearing on the concept of *Prakruti,* which means nature (natural form) of the build and constitution of the human body. According to Ayurveda the path to optimal health is different for people depending on their *Prakruti.* For individuals the Prakurthi is defined as a combination of *(Vatha, Pittha* and *Kapha*) [6]. A balanced state of the *Tridoshas* makes a healthy and balanced person (Physically and Mentally).

Since we all have different combinations of the *Tridoshas,* The diagnosis of p*akruti* offers unique insights into understanding and assessing one's health. It is not merely a diagnostic device but also a guide to action for good health.. It assesses the, dominance of *Tridoshas* and give advice for preventive and primitive health care. The ancient science of Ayurveda is the oldest known form of health care in the world. According to Ayurvedic classification individuals can be grouped into 7 types of their dominancy of components such as

Vata, *Pita*, *Kapha*, *Vata Pita*, *Vata Kapha*, *Pita Kapha*, or *Vata*

Pita Kapha. One of the main principles in Ayurvedic medicine is based on the importance of individual differences with regard to treatments. Ayurveda has gone beyond mere classification and identified possible diseases for each category of people. In general population, human constitution is combination of *Vata*, *Pita*, and *Kapha*. Recognition of human constituent in Ayurveda, is currently based on a standard questionnaire on subjective criteria based on ancient theories of Ayurvedic scholar *Charaka,* 1000 BC and *Susruta,* 600 BC. Questions in concerned are very much user-friendly and based on conceptual model of Ayurveda [6], which is used for finding constituent type, has probes such as repeating questions and classification of constituent type. This has been used for classification of individuals for many centuries. There has been no research into improve the questionnaire although people have realised that the classification is not acceptable sometimes.

Knowledge modeling is concerned with languages, tools, techniques and methodologies for developing abstract models of some target domain or problem solving behavior. Knowledge modeling technologies - in particular problem solving methods and ontologies - are relevant to many disciplines, including knowledge engineering, knowledge acquisition and knowledge management [11]. All knowledge can be considered as tacit or rooted in tacit knowledge[27]. It is important to investigate the methods available for tacit knowledge acquisition. Since tacit knowledge is embedded in implicit nature, fuzzy logic gives great interest of handling such kind of nature. Further more, this can be considered as a method for tacit knowledge acquisition using fuzzy logic. Despite fuzzy logic has been used for knowledge acquisition in such domains, a large portion of the process is manually operated. XpertRule Knowledge Builder extends [31] the graphical knowledge representation paradigm, established since 1988, by its predecessor XpertRule KBS, to new levels of scalability and flexibility. Although the knowledge acquisition accompanied with the methods based on fuzzy logic, but it is exploited the level of transparency and accuracy due to handling manually constructed membership functions. There is a great issue of dealing with constructing membership functions, especially on determinations about intervals of membership functions. Most of the time the knowledge engineer is expected to do this task which leads to arise questions about system validation. Another knowledge acquisition tool for computer assisted diagnosis of postmenopausal osteoporosis using a fuzzy expert system shell [2] is also seen in a position of a manually operated tool for knowledge acquisition. Although WinProlog LPA [5] gives a toolkit (FLINT) based on fuzzy logic for constructing membership functions effectively, but it appears a

manual method for determining the intervals of membership functions. However, in these approaches fuzzy membership functions are defined in an ad-hoc manner entirely based on expert's knowledge. When domains consist of tacit knowledge, expert's decisions are also not consistent. Therefore, we argue that the use of fuzzy logic for modeling tacit knowledge should be formally supported at least to some extend.

In modeling tacit knowledge of diagnosis of human constitutions in to Hybrid Intelligent systems, we invented a novel approach for computational model of diagnosis of human constitution []. An Intelligent Hybrid system involved with artificial intelligent techniques, namely fuzzy logic and expert system technology has been used to implement the computational model. We primarily used fuzzy logic together with statistical technique of principle component analysis for modelling tacit domains. Existing practising methodology of Ayurvedic sub-domain of individual classification has been considered as tacit knowledge. This has been acquired through a questionnaire and analyzed to identify the dependencies, which lead to make tacit knowledge in the particular domain.

2. Classification of Alife

Alife has been classified into Computational Alife, Robotic Alife and Chemical Alife based computational models based on biological systems [35].

2.1 Computational Alife

The purpose of Alife is to make computationally based models of natural biological systems. The ultimate goal is the realization of life in another medium -- i.e., the computational medium of a computer (`computer life'). This can be achieved, because life is a medium-independent phenomenon, a question of form or processes, not a specific material that constitutes `aliveness'.

2.2 Robotic Alife

Robots and animats built for technical purposes may behave in a `lifelike' manner. This, however, is a by-product of our interpretation, the behaviour of these systems represents a category quite distinct from the behaviour of the carbon-based biological cells and organisms. The ultimate goal is the creation of autonomous, self-reproducing animats, capable of living a life of their own, adapting to a changing environment and eventually evolving into new species if located in an appropriate environment. A more proximate goal is the creation of robots or animats with the full behavioral capacities of living organisms. If any differences are at all recognized between systems based on biochemical mechanisms and `animat' devices based on human design, eventually in very small scale (`nano-technology'), these differences are not judged to effect the principal possibility of achieving the goal.

2.3 Chemical Alife

This view comprises attempts to make real material systems with lifelike characteristics, eventually as *in vitro* models of prebiotic processes; primitive metabolic systems; the so-called Eigen hypercycle systems, etc.

3. Proposed Approach

We postulate a novel approach enhancing the ability of modeling tacit knowledge in conceptual model by using an Intelligent Hybrid system []. It has been exploited the process of the new approach in following steps.

3.1 Acquiring Knowledge

The approach begins with by acquiring tacit knowledge. This can be done as an interview between domain experts and the knowledge engineer. Using the interviewing process between expert and knowledge engineer, tacit knowledge has been acquired and mapped in to a questionnaire based on Likert scale technology [27], We have chosen to acquire tacit knowledge into a questionnaire since it is more convenient for further analysis. Once tacit knowledge has been acquired then we should analyses the knowledge for finding dependencies. The questionnaire has been analyzed using principle component analysis (PC) to find dependencies [3].

3.2 Principle Components for Tacit Knowledge Modeling (Model Refinement)

Let *S* be the set of all questions in the questionnaire and *P* be the set of all extracted principle components.

Further, $P = \{PC_1, PC_2, ..PC_{n-1}, PC_n\}$

$$S = \{S_1, S_2, ..S_{m-1}, S_m\}$$

$\Rightarrow$

$$PC_i = a_{1i}S_1 + a_{2i}S_2 + .. + a_{m-1,i}S_{m-1} + a_{m,i}S_m$$

Let *M* be the principle components Matrix for filtered tacit knowledge.

$$M = \begin{bmatrix} a_{11}a_{12}..a_{1n} \\ a_{21}a_{22}..a_{2n} \\ . \\ . \\ a_{m1}a_{m2}..a_{mn} \end{bmatrix} \quad (2)$$

$$\therefore PC_1 = a_{11}S_1 + a_{21}S_2 + .. + a_{m1}S_m \quad (3)$$

$$PC_2 = a_{12}S_1 + a_{22}S_2 + .. + a_{m2}S_m \quad (4)$$

$$PC_{n-1} = a_{1n-1}S_1 + a_{2n-1}S_2 + .. + a_{mn-1}S_m \quad (5)$$

$$PC_n = a_{1n}S_1 + a_{2n}S_2 + .. + a_{mn}S_m \quad (6)$$

For n number of extracted principal components, following computation is concluded.

$$X = \sum_{j=1}^{n} PC_j \qquad (7)$$

$$\therefore X = \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij} S_i$$

(8)

Generating Membership Function (Fine–Tuning Analysis)

Let LS be the Likert scale, then

$$LS = [L,..,U]$$

(9)

X_L and X_U values are derived from results of the filtered tacit knowledge. It is computed as given below.

$$\therefore X_L = L \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij}$$

(10)

$$\therefore X_U = \text{U} \sum_{j=1}^{n} \sum_{i=1}^{m} a_{ij}$$

(11)

Let A be fuzzy set defined on a fuzzy concept using the interval of $[X_L,..,X_U]$. Then membership function is as follows.

$$A(X) = \begin{cases} 0 & X =< X_L \\ (X-X_L)/(X_U-X_L) & X_L < X < X_U \\ 1 & X >= X_U \end{cases} \qquad (12)$$

3.4 Fuzzy Rule Base (Reasoning)

Fuzzy rules can be constructed as follows,

Rule 1: If $X <= X_L$ then A (X)=0 %

Rule 2: If $X_L < X < X_U$ then $(X-X_L)/(X_U-X_L)$ %

Rule 3: If $X >= X_U$ then A (X)=100 %

Further, fuzzy rule base can be extended by adding dynamically, in order to function the reasoning process for answers given by the fuzzy rules.

4. Towards modeling of tacit knowledge

The approach has been converted for an implementation using the architecture given below (Figure 1). It is consisted of with modules such as principle component analyzer, database, knowledge base, and fuzzy logic module and inference engine.

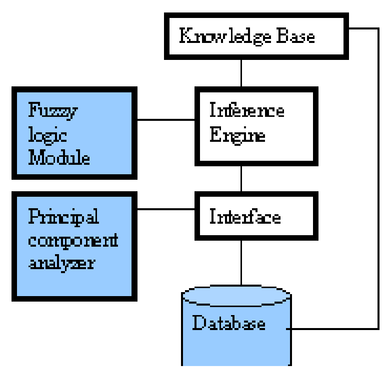

Figure 1: Top-level architecture

Tacit knowledge has been extracted from the expert and formulated in a questionnaire. It is evaluated using Likert scale technology. In the first instance of knowledge acquisition, a pilot survey has been done for the purpose of extracting principal components. The SPSS is used for conducting the functions of principle components extracting.

4.1 Fuzzy Logic Module

The output results of the principle component analyzer would be the input for the fuzzy logic module. In the case of generating membership function, finding the interval is considered as an automated process in this module due to instead of using runtime inputs. This module has been implemented using Visual Basic for widening scope of generating membership function. Further, fuzzy rules have been constructed in the fuzzy logic module.

4.2 Database

Extracted principle components have been stored in Ms Access database, which integrated with the principle component analyzer through the developer interface that is considered as a sub interface of the user interface. The questionnaire consisted of tacit knowledge also been stored in the database that integrated with the user interface.

4.3 Knowledge Base

Explanations for output generated by the fuzzy logic module have been processed using fuzzy rules in the knowledge base. Further, knowledge engineer is given a facility to add new rules in the runtime. The knowledge base has been implemented using FLEX expert system shell, which embedded in WinProlog.

4.4 User Interface

The user interface facilitates for both developer and general user. Once knowledge engineer develops a particular framework for required tacit domain with interaction of the expert, and then general user will be given a facility of using the framework for decision-making purposes. So, it has been divided the user interface in developer interface and general user interface. General user will be able to use a developed framework using a questionnaire, which has been implemented as a web page linked to the database.

4.5 Inference Engine

The inference engine carries out the reasoning whereby the expert system reaches a solution. This is the inference engine of the FLEX expert system shell. Since this is built in to the system there are no development activities with regard to this component in the system. Note that inference engine has nothing to do with the modeling of tacit knowledge but it runs the expert system.

5. Computational model of diagnosis of human constitutions

We have evaluated our approach using Ayurvedic medicine as a domain with tacit knowledge []. In doing so, classification of individuals through clinical examination in Ayurveda has been considered [6]. The clinical examination of Ayurveda is divided into 2 paths, namely: examination through patient and examination through disease.

Prescribing drugs for a disease is depended on both 2 examinations. Classification of individual (human constituents) is included in examination through patient, which defined as a concept called *′prakurti pariksha.′*. Individual can be categorized into *vata* or *pita* or kapha based on the *′prakurti pariksha.′*. It was defined that one type can be dominated but in combination of all 3 types. In the exciting system, the method of analysing constituents is not consistent. Although Ayurvedic practitioners use a questionnaire but leads several problems like dependencies among the questions in the questionnaire and analysis of the constituent type. We addressed these problems to solve using following stages by a computational model.

5.1 Extracting Tacit Knowledge in Ayurveda

In the first instance we mapped tacit knowledge regarding to analysis of constituents to a questionnaire with interaction of an Ayurvedic expert. It is consisted of 72 questions to analyse *vata*, *pita* and *kapha*. It is shown as Figure 2.

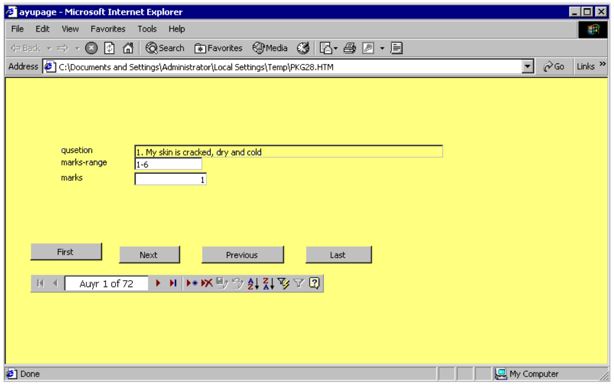

Figure 2: Questionnaire window

no.of students for statistical modeling. Principal component analyzer has been used to remove dependencies. It has been identified 25 principal components using SPSS [17] as shown below in a matrix form. Here V1, V2..V24, K1, k2..K24, P1, P2..P24 denotes question-numbering system in the questionnaire.

M =

		1	2 ..	24
V=	V1	-0.228622	0.249362 .	-0.073945
	V2	0.08431	0.20654 .	-0.097192 -
	.			
	.			
	V23	-0.645803	0.232312 .	0.0067 -
	V24	-0.222147	-0.06453 .	-0.073514
K=	K1	0.012511	-0.096332 .	0.141314
	K2	-0.005642	0.268145 .	-0.179992
	.			
	.			
	K23	0.409442	0.073812 .	-0.115118 -
	K24	0.696973	0.126679 .	0.098213
P=	P1	0.430044	0.14608 .	0.023669
	P2	0.243781	0.373485 .	-0.040468
	.			
	.			
	P23	0.009727	0.012529 .	-0.072224
	P24	-0.378091	0.096985 .	0.158006

5.3 Analysis Of Human Constituents

Human constituents can be computed in to *vata, pita* and *kapha* in percentages as shown in Figure 3. Membership functions for *vata, pita* and *kapha* have been constructed using the out puts of principle component analyzer.

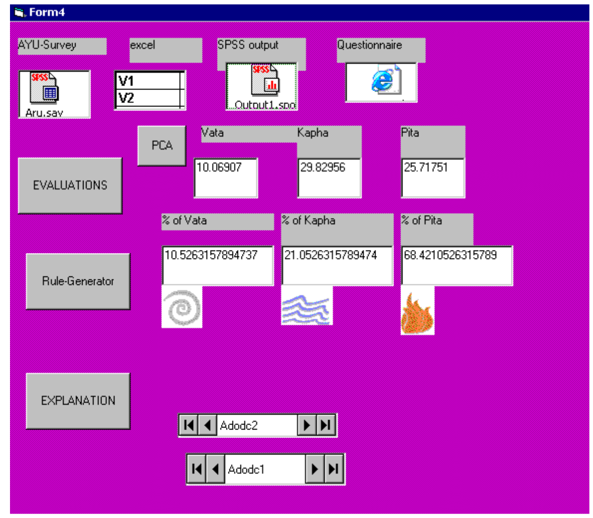

Figure 3: Analysis of human constituents

5.4 Explanations for Derived Human Constituents

Possible diseases can be occurred due to dominated constituent type. It is illustrated as shown in Figure 4, which has been implemented through FLEX expert system shell.

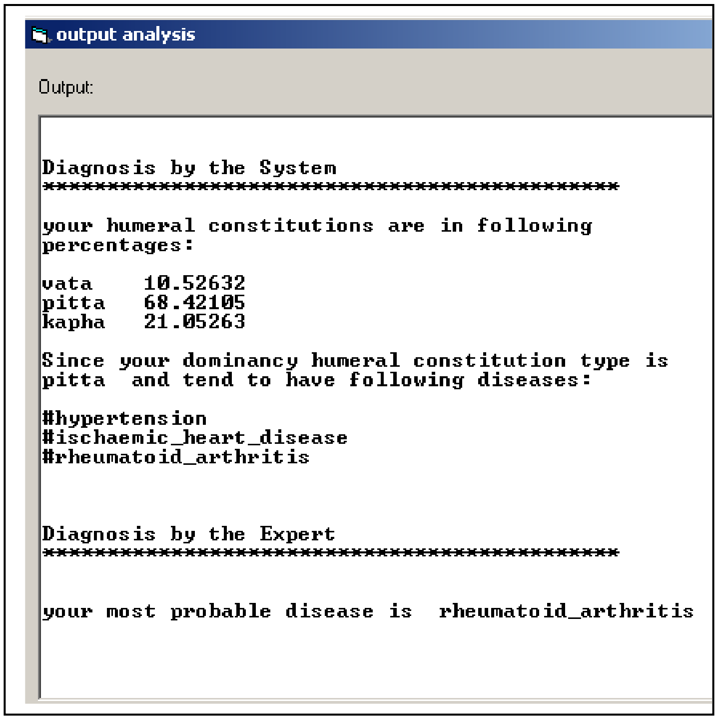

Figure 4: Explanation Window

6. Discussion and conclusion

The expert system developed using this approach was tested with a group of 35 persons of Ayurvedic experts and Ayurvedic medical students. The evaluation was conducted to see far the answers generated by the system matches with the identification by Ayurvedic experts and the students. Further, the system's ability to fine-tune the answers was also tested. It is investigated that 77% of conclusions matches with the system and expert using descriptive statistics.

The system facilitated to derive constituents types in percentages while Ayurvedic experts obtain only the constituent type. As recommendation given by the Ayurvedic experts, determining constituent's types in percentages is an important criterion for prescribing drugs for a disease. Further, our system provide as an option to find out possible diseases. In generally, the system can be used as a self-assessment for finding constituents. According to Ayurvedic medicine, regiments can be done easily by knowing the constituent type. The human constituents can be computed as a combination. So it would help to find the effectiveness of minimum type in a diagnosis.

In doing so, a novel approach was formulated namely, tacit knowledge of experts can be acquired via questionnaire and informal interviews, statistical techniques of principle component analysis (PCA) can be used to identify preliminary dependencies in acquired tacit knowledge and fuzzy logic with PCA as the input can be used for developing a model for modeling tacit knowledge. This leads to present a formal practicing methodology for tacit knowledge modeling in conceptual models. It has been achieved a computational model for diagnosis of human constitution. This leads to convince of computational modeling using conceptual models in Alife.

6. References

[1] Bellman and Zadeh, (1970). R.E. Bellman and L.A. Zadeh , Decision making in a fuzzy environment. Management Science 17, pp. 141–164.

[2] Binaghi E., De Giorgi O., Maggi G., Motta T., Rampini A (1993), *A knowledge acquisition tool for computer assisted diagnosis of postmenopausal osteoporosis using a fuzzy expert system shell*, Computers and Biomedical Research, 26,pp.498-516.

[3] Chatfied C(1996)," Introduction to Multivariate Analysis", Chapman and Hall.

[4] Coppin G, Skrzyniarz A (2003), "*Human−centered processes : Individual and distributed decision support*", IEEE Intelligent systems, pages 27–33.

[5] Dave Westwood, Flex reference guide, LPA, U.K

[5] Dubey G.P , (1978)The Physiological concepts in Indian medicine, Science and Philosophy of Indian medicine, Shree Beldyanath Ayurved Bhawan Ltd.

[6] Evangelos Petroutsos,(1998), Mastering Visual Basic 6, BPP Publications, New Delhi

[7] George J (1997), "Fuzzy sets and Fuzzy Logic", Prentice Hall of India.

[8] George J.K, Yuan B.(1995), Fuzzy sets and Fuzzy logic, prentice hall of India, pp. 280–300.

[9] Hayashi Y, Tazaki E, Yoshida K, Dey P (1988), "Medical diagnosis using simplified multi-dimensional fuzzy reasoning", In: Proceedings of

IEEE 1988 International Conference on Systems, Man and Cybernetics, Beijing, China, 1988. p. 58–62.

[10] http://kmi.open.ac.uk/knowledge-modeling.html

[11] Jonson L (1988), Expert system Architectures, Kopan Page Limited.

[12] Karl B, Klaus P, A,Yoichi H, Thomas E. Rothenfluh and Harald L (2004), "Knowledge acquisition in the fuzzy knowledge representation framework of a medical consultation system" International Journal of Artificial Intelligence in medicine, pages 1–26.

[13] Karunananda A.S (2000), How To Do Research Author Publication.

[14] Kolousek G (1997), ″The system architecture of an integrated medical consultation system and its implementation based on fuzzy technology", Doctoral thesis, Technical University of Vienna, Austria.

[15] M. Dzbor, 2000. Explication of Design Requirements Through Reflection on Solutions. In Proc. of 4th IEEE Conference on Knowledge-based Intelligent Engineering Systems. Brighton, UK, pages 141-144.

[16] Matei Ciobanu Morogan, (1997), SPSS for windows, release 8.0.0, DSV KTH⁄ SU, Sweden.

[17] Mendis D. S. K., Karunananda A. S. and Samarathunga U. (2004), *An Expert system for analysing Aurvedic human constituents,* Shamisha – Journal of Aurveda

[18] Mendis D. S. K., Karunananda A. S. and Samarathunga U. (2004), *Multi-Techniques Integrated tacit knowledge modelling system*, International Journal of Information Technology, Vol 9, pp 265-271

[19] Mendis D. S. K., Karunananda, A.S. and Samarathunga U. (2003), *Framework for modelling of tacit knowledge – Case study using Ayurvedic domain,* In proceeding of the International Information Technology Conference (IITC'2003), pp 76-82, Colombo, Sri Lanka

[20] Mendis D.S.K, Karunananda A.S, Samaratunga U. (2003), "*Reasoning with Uncertainty*", Health Informatics Conference, Colombo.

[21] Mendis D.S.K, Karunananda A.S, Samaratunga U. (2003), "*Tacit knowledge modeling*", (2003), Sri Lanka Association for Artificial Intelligence Annual Session and Annual General Meeting, Colombo.

[22] Morrison D.F(1990), "Multivariate Statistical Methods", Mc Graw-Hill, Inc. PP. 312 - 357.

[23] Noak V(2000), "Discovering the world with Fuzzy logic", A Springer – Verlag Company, PP. 3 – 50.

[24] Peter J. (1995), Introduction to expert systems, Pearson education Asia, pp. 182–199.

[25] Rajeev K (1995), "Integrating knowledge bases in expert system shells: an open system approach", International Journal of computer application in technology, pages 78–89.

[26] Richards D. and Bush P., "Measuring, Formalizing and Modeling Tacit Knowledge" IEEE/Web Intelligence Conference (WI-2003) Bejing.

[27] Ross Dawson, (2001), "Developing Knowledge-Based Client Relationship ", Butterworth Heinemann.

[28] Senkar J (1995), ″Network and tacit knowledge in innovation″, Economics et societies, pp. 99-118.

[29] Tripathi S.N(1978), "Clinical Diagnosis", Science and Philosophy of Indian medicine.

[30] XpertRule Knowledge Builder, www.attar.com.

[31] Zadeh L. A (1988),Fuzzy Logic, Computer IEEE, pp. 83-93.

[32] Zimmerman H.J (1985), Zimmerman Fuzzy set theory and its applications, Kluwer–Nijhoff, Boston