Modeling of Tacit Knowledge

D.S. Kalana Mendis
Department of Information Technology,
Advanced Technical Institute,
Labuduwa.
kalanaatil@mail.com

Asoka S. Karunananda
Department of Mathematics & Computer Science,
Open University of Sri Lanka,
Nawala.
asoka@ou.ac.lk

U. Samarathunga
Institute of Indigenous Medicine,
University of Colombo,
Rajagiriya.

Abstract

Tacit knowledge has always been influential in changing the directions and emphasis of explicit models of knowledge. All explicit knowledge is rooted in tacit knowledge. Due to these reasons modelling of tacit knowledge is of great interest. A research has been conducted to develop an approach to model tacit knowledge. In this research, we have used Artificial Intelligence technique of fuzzy logic for developing an approach to model tacit knowledge. We have considered domain of "Ayurvedic" medicine as a case study domain with tacit knowledge. Tacit knowledge in Ayurvedic sub-domain of individual classification has been acquired through a questionnaire and analysed to identify the dependencies, which lead to make tacit knowledge in the particular domain. In the first place analysis was done using statistical techniques of principle components and the results were not compatible with the experiences of Ayurvedic experts. As such, fuzzy logic has been used to further model the Ayurvedic sub-domain. The result of the modelling of Ayurvedic domain using fuzzy logic has been compatible with the experiences of the Ayurveic experts. A framework for modelling tacit knowledge has been integrated with an expert system shell thereby enabling the development of expert systems for domains with tacit knowledge. Framework has been successfully applied for several tacit domains.

1. Introduction

As Michal Polany stated all knowledge is either tacit or rooted in tacit knowledge [14]. So, modelling of tacit knowledge is a key research area in knowledge modelling in Artificial Intelligence. Among others, we have selected Ayurvedic domain as a case study as it is a domain with tacit knowledge. There are various reasons for this choice. Firstly, by nature, Ayurvedic medicine is full of tacit knowledge since the Ayurveda uses lots of experience-based knowledge without much research into nature of knowledge in the domain for many centuries. Secondly, Ayurvdeic medicine is becoming very popular as a successful alternative system of medicine in the world. Thirdly, we have easy access to resources in this field. In our research we have considered Ayurvedic sub-domain, called *classification of individuals*, which is a key basis for deciding on treatment for patients according to Ayurvedic medicine. Until recently, western medicine has not recognised the importance of individuality for medical treatment. Western technologies, such as DNA technology [6] in this context are complicated and expensive. Therefore it is worth exploiting domain of Ayurveda as a case study for modelling of tacit knowledge.

This paper describes our research work into the development of a framework for modeling of tacit knowledge. The insight for the construction of the framework is based on the study of classification of individuals according to Ayurvedic medicine.

The rest of the paper is organized as follows. Section 2 describes Ayurvedic classification of individuals. Section 3 presents the technologies behind modelling of tacit knowledge. Section 4 describes our framework for modelling tacit knowledge. Section 5 explains how the framework can be used in practice. Section 6 concludes the paper.

2. Ayurvedic Classification of individuals

Ayurvedic medicine has given a strong emphasis on individual classification when deciding treatment [6]. According to Ayurvedic classification, human constituent is made of three basic physical properties, namely, *Vata*, *Pita*, and *Kapha*. Individuals can be further classified as *Vata*, *Pita*, *Kapha*, *Vata-Pita*, *Vata -Kapha*, *Pita-Kapha*, and *Vata-Pita-Kapha* [5]. Therefore, the fundamental classification of individuals itself shows that a given human is a combination of three basic physical properties. This leads to tacit nature of classification of individuals in Ayurvedic domain.

In general, Ayurvedic experts interview patients and decide on the constitution of the patient. The set of questions used in the interview have some dependencies and inconsistencies, which lead to make the knowledge rather tacit. As a result, the expert's perception and experiences also go into the process of decision-making. In practice, the interview is presented as a questionnaire to a patient. Afterwards, the expert analyses the questionnaire and decides on the constituent of the patient. At present, Ayurvedic experts have also recognised the need for improving the questionnaire by removing any inconsistencies. This needs some research work. From computer science viewpoint, this is a research in modelling of tacit knowledge, which is an area of research in Artificial Intelligence.

3. Towards modelling of tacit knowledge

We propose to use Artificial Intelligence techniques to model tacit knowledge. We primarily use fuzzy logic together with statistical technique of principle component analysis for modelling tacit domains. Then we use expert systems technology to demonstrate how the modelled tacit knowledge can be used. Next we briefly describe essence of fuzzy logic and expert systems since these are the key techniques that we have adopted to develop our framework for modelling tacit knowledge.

3.1 Fuzzy Logic

Fuzzy logic handles situations, where conclusions do not fall into one extreme. As compared with classical logic, fuzzy logic can handle real world problems, which deal with more than two truth-values. In fuzzy logic, everything is a matter of degree. Therefore fuzzy logic can be used to make decisions in domains with tacit knowledge [4]. Individual classification in Ayurveda is a classic example, where the decision has more than one possible truth-value.

In our research we have used fuzzy logic for addressing the vagueness involved in tacit knowledge. For example, vagueness (dependencies & inconsistencies) involved in Ayurvedic classification of individuals has been manipulated using fuzzy logic.

3.2 Expert systems

An expert system is a computer program, which emulates the decision-making ability of a human expert [9]. As compared with other techniques, the expert systems are capable of giving alternative answers, explaining reasons for conclusions, handling incomplete information and uncertainty in answers. An expert system contains knowledge derived from an expert in some narrow domain. Over the last many decades, his technology has been successful for modeling the domains with explicit knowledge. However, there is a need for developing expert systems for domains with tacit knowledge too, since experts knowledge is always not explicitly defined.

In our research we have used expert system technology for demonstrating, how the modeled tacit knowledge can be used in practice. Obviously database like technology cannot be used to demonstrate the use of tacit knowledge. Note that except for the demonstration purpose, expert system technology has no importance in modeling the tacit knowledge in our research. The modeling of tacit knowledge is completely done with the help of fuzzy logic. However, fuzzy logic engine has been integrated with an expert system to make the entire product useful.

Since the knowledge-modeling framework using fuzzy logic is integrated with an expert system, next we briefly describe major components of an expert system.

3.2.1 Components of an Expert System

An expert system consists of these three components, namely, user interface, knowledge base and inference engine.

User interface facilitates the interaction between user and the expert system. This is most of the time a natural language interface.

Knowledge base consists of domain knowledge. This knowledge can be represented in the form of rules, diagrams, etc. Knowledge base is the knowledge reservoir of an expert system. Once we have modeled the tacit knowledge, such knowledge will also be stored in the knowledge base. Our expert system consists of set of fuzzy rules on Ayurvedic domain.

Inference engine explores the knowledge for finding answers. An inference engine consists of various problem-solving strategies including search techniques, and forward/backward chaining mechanisms. All special features of expert systems such as explanation ability, handling uncertainty are embedded in the inference engine of an expert system.

4. Framework for modelling tacit knowledge

We have designed and developed a framework for modelling of tacit knowledge. It comes out as a hybrid artificial intelligent system. Functionally the entire system can be seen as a fuzzy-expert system. Figure 1 shows the top-level architecture of the framework. It consists of a user Interface, Inference engine, knowledge base, fuzzy logic module, principal component analyser and a database.

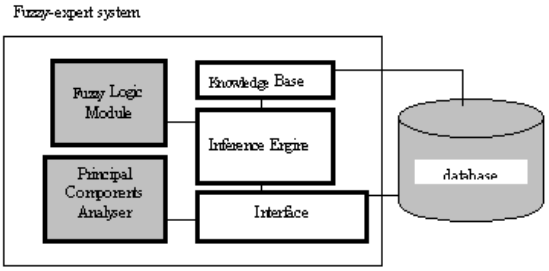

Figure 1: Top-level Architecture of the system

4.1 User Interface

The interface of the fuzzy-expert system supports the user interaction with the entire system. It gives direct access to the database while the expert system is accessed through the inference engine. Access to principle component analyser is also provided via the interface. Both ordinary users and the developers can access the system subject to various levels of authentication.

4.2 Knowledge base

The knowledge base contains the domain knowledge useful for problem solving. The knowledge is represented as a set of fuzzy rules of a particular domain. Note that, as shown in Figure 1, knowledge base of the system has been constructed by using the fuzzy rules generated by the fuzzy logic module. The development of the knowledge base has been done using the FLEX expert system shell tool kit [16]. Since FLEX consists of a powerful inference engine, it is easy to use this in a development environment.

4.3 Database

Database consists of domain knowledge in the original form. According to our approach, tacit knowledge of the domain is stored in the database. Further, domain knowledge has been stored in the form of a questionnaire. The result obtained by analysing the questionnaire is also stored in the database. More importantly, derived principle components are stored in the database. This has been developed using MS-Access.

Questions are evaluated using Likert scale methodology [14]. This module can be directly accessed through the interface without going through the expert system.

4.4 Fuzzy logic module

The Fuzzy logic module has been implemented to further analyse the results from the principle component analysis. It fuzzyfies the tacit knowledge in a manner that can be used in the knowledge base. This is the key module in the proposed framework. This has been written using Visual Basic [19]. This module can be delivered as an added feature for standard expert system shells to model the tacit knowledge. At present this module works with FLEX expert system shell.

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 is no development activities with regard to this component in the system. Note that inference engine has nothing to do with the modelling of tacit knowledge but it runs the expert system.

4.6 Principal component analyser

This module reads from database and gets collected data and feeds into statistical package SPSS [18]. It analyses data with the support from SPSS and sends extracted principle component into database. In our Ayurvedic model 25 principal components have been extracted. This is a necessary input for fuzzyfication of the tacit knowledge so as to suit the knowledge base.

4.7 Algorithm for modelling tacit knowledge

Based on our research, the algorithm emerged for modelling the tacit knowledge is given below.

```
Gather knowledge from a tacit domain
Present the knowledge as a questionnaire
Add the questionnaire into the Database
Conduct a survey to fill the questionnaire
Extract principle components
        Define fuzzy membership functions
        Construct the Knowledge base
Add more rules to knowledge base when
```

Algorithm for modelling tacit knowledge

5. Framework in Practice

This section describes how one can use the tacit knowledge-modelling framework together with the corresponding fuzzy-expert system. Use of the fuzzy-expert system would be simpler than modelling a domain.

Once a user starts the expert system it comes with main control panel as shown in Figure 2.

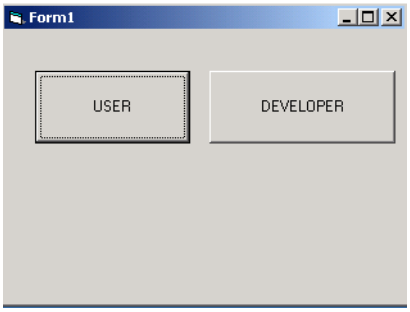

Figure 2: Main interface of the Expert system

The main interface provides two modes as *Developer* and *User*. Suppose a person wants to find his constituents. He clicks on User. This brings the user to Analysis window that shows options to be entered by the user. Figure 3 shows data required for analysis of human constituents.

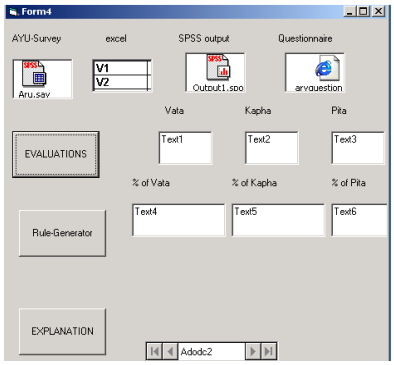

Figure 3: Data required for Analysis

5.1 User mode

User mode of the system facilitates the ordinary use of the system. For example, this mode provides an option for calling the questionnaire to be filled by the user. Here we take an example to show, how the user finds his constituents. Double clicking on the questionare icone in Figure 3, a user can open a questionnaire as shown in Figure 4.

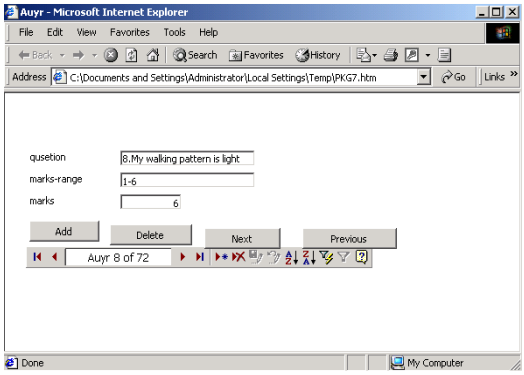

Figure 4: Questionnaire window

Having answered the questionnaire, user can press on the Evaluation button. Then the system shows the results of the analysis as shown in Figure 5. Note that system has shown percentage of the Vata, Kapha and Pita as the main result of the analysis. The percentage values show that constituents are fuzzy, but not exact.

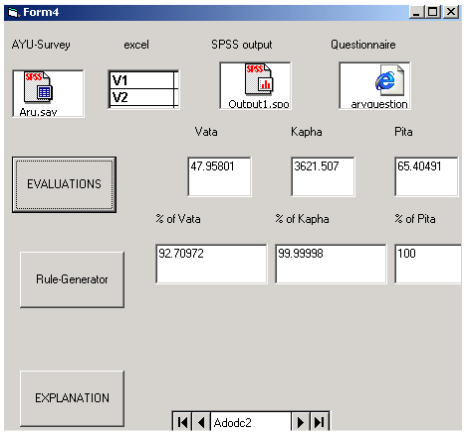

Figure 5: Results of the analysis

This analysis is done with the help of principle components analyser, Fuzzy logic module and the expert system. At this point the user can communicate with the expert system.

For example, user can click on the "Explanation" button on the Figure 5 and request reasons for deciding the user's constituents as shown in the window. Figure 6 shows the explanation together with most susceptible diseases for the user.

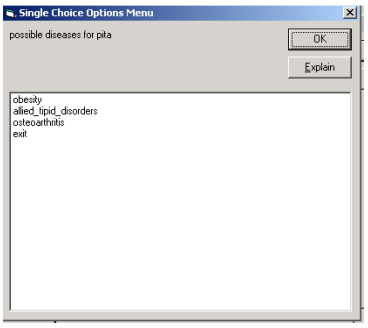

Figure 6: Explanation window

5.2 Developer mode

In contrast to User mode, the "Developer" mode of the system allows to modify an existing fuzzy-expert system or model a new tacit domain leading to an expert system. For example, existing expert system can be modified by invoking the "Rule Generator" option shown in Figure 3. This facilitates to update the rule base of the FLEX expert system dynamically. Figure 7, Shows the Rule generator window.

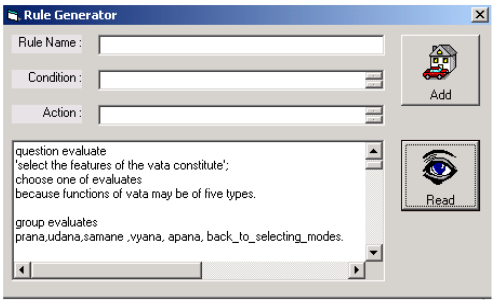

Figure 7: Rule Generator window

Modelling of any domain with tacit knowledge has also been supported by the system. For this purpose, a person must use the "Developer mode". In this sense, firstly, the developer should enter domain knowledge in the form of questionnaire. Secondly, the developer can use the system to generate principle components and also do fuzzyfication of the domain knowledge. Thirdly, the developer should use the Rule generator to introduce additional rules into the system. Note that developer should be a person with knowledge in fuzzy-expert systems.

We have already used this framework for modelling tacit domains of land selection in architectural constructions (based on [17]) and credit evaluation in the banking sector.

6. Conclusion

We have developed a framework for modeling tacit knowledge with the help of Artificial Intelligence techniques. The framework is based on the use of principle component analysis and fuzzy logic for modeling tacit knowledge. The proposed framework has been developed to work with the expert system technology. This demonstrates how the modeled tacit knowledge can be used in practice. Although the framework was developed on the basis of the insight gained from the study in the tacit domain of Ayurvedic classification of individuals, the framework can be used for modeling of any domain with tacit knowledge. So, we have used the framework for modeling tacit domains such as land selection for architectural constructions.

Since the framework has been developed as a system that can be linked up with any expert system shell, the end result can be delivered as a commercial product. At present expert system shells do not provide mechanisms for modeling of tacit knowledge. Since we have developed our framework in association FLEX expert system shell, we have already shown that the framework can be linked up with expert system shells.

At present the fuzzy-expert system that emerged from our research in modeling of Ayurvedic domain is used at the Faculties of Indigenous Medicine, University of Colombo and University of Kelaniya, Sri Lanka. This expert system is used by both Ayurvedic consultants and Ayurvedic medical students. We have also used the framework for modeling several other tacit domains. With these results, we expect to deliver a more generic framework for modeling of tacit knowledge

7. References

[1] Karunananda A.S (2000), How To Do Research Author Publication.
[2] Jonson L (1988), Expert system Architectures, Kopan Page Limited.
[3] George J (1997), Fuzzy sets and Fuzzy Logic", Prentice Hall of India.
[4] Noak V(2000), "Discovering the world with Fuzzy logic", A Springer – Verlag Company, PP. 3 – 50.
[5] Dubey G.P , (1978)The Physiological concepts in Indian medicine, Science and Philosophy of Indian medicine.
[6] Tripathi S.N(1978), "Clinical Diagnosis", Science and Philosophy of Indian medicine.
[7] Chatfied C(1996)," Introduction to Multivariate Analysis", Chapman and Hall.
[8] Morrison D.F(1990), "Multivariate Statistical Methods", Mc Graw-Hill, Inc. PP. 312 - 357.
[9] Ross Dawson, (2001), "Developing Knowledge-Based Client Relationship ", Butterworth Heinemann.
[10] Karunananda A.S (2001),Pinki – A motivation for Artificial Intelligence projects.
[11] Mendis D.S.K, Karunananda A.S, Samaratunga U. (2003), "Reasoning with Uncertainty", Health Informatics Conference, Colombo.
[12] 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.
[13] Bellman and Zadeh, (1970). R.E. Bellman and L.A. Zadeh , Decision making in a fuzzy environment. Management Science 17, pp. 141–164.
[14] Richards D. and Bush P., "Measuring, Formalizing and Modeling Tacit Knowledge"

IEEE/Web Intelligence Conference (WI-2003) Bejing.

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

[17] M.Sc.in Architecture, (2003),Field projects, University of Moratuwa.

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

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