A Commonsence Knowledge Modeling systems for Qualitaive Risk Assessment

D.S.Kalana Mendis, Asoka S. Karunananda and Udaya Samaratunga

Abstract— Knowledge is the fundamental resource that enhances to function intelligently. Knowledge can be defined into two types such as explicit and implicit. Commonsense knowledge is one type of in implicit knowledge. Explicit knowledge can be presented formally and capable of effective (fast and good quality) communication of data to the user where as implicit knowledge can be represented in informal way and further modeling needed for gaining effective communication. Constructions of risk assessment using spatial data for disaster management have a problem of effective communication because of implicit knowledge. Risk assessment is a step in a risk management process. Risk assessment is the determination of quantitative or qualitative value of risk related to a concrete situation and a recognized hazard. Quantitative risk assessment requires commonsense knowledge related with the hazard. This complicates the effective communication of data to the user in real-time machine processing in support of disaster management. In this paper we present an approach to modeling commonsense knowledge in Quantitative risk assessment. This gives three-phase knowledge modeling approach for modeling commonsense knowledge in, which enables holistic approach for disaster management.

At the initial stage commonsense knowledge is converted into a questionnaire. Removing dependencies among the questions are modeled using principal component analysis. Classification of the knowledge is processed through fuzzy logic module, which is constructed on the basis of principal components. Further explanations for classified knowledge are derived by expert system technology. We have implemented the system using FLEX expert system shell, SPSS, XML and VB. This paper describes one such approach using classification of human constituents in Ayurvedic medicine. Evaluation of the system has shown 77% accuracy.

Keywords- *Commonsence knowledege modeling; Fuzzy logic; Principal componenet analysis; Expert system*

I. INTRODUCTION

Knowledge is the fundamental resource that enhances to function intelligently. Knowledge can be defined into two types such as explicit and implicit. Commonsense knowledge is one type of in implicit knowledge. Explicit knowledge can be presented formally and capable of effective (fast and good quality) communication of data to the user where as implicit knowledge can be represented in informal way and further modeling needed for gaining effective communication. Constructions of geo Information systems using spatial data in disaster management have a problem of effective communication because of implicit knowledge. This complicates the effective communication of data to the user in real-time machine processing in support of disaster management for qualitative risk assessment. In this paper we present an approach to modeling commonsense knowledge in geo-information technology. This gives three-phase knowledge modeling approach for modeling commonsense knowledge in geo- information technology, which enables holistic approach for disaster management in qualitative risk assessment.

At the initial stage principle component analysis has been used to model refinement. Modeling commonsense knowledge in term of classification has been done using fuzzy logic at the second stage. The final stage of modeling commonsense knowledge has been conducted using expert system technology, which enables reasoning ability.

II. KNOWLEDGE

Knowledge originates in the minds of knowing subjects, who evaluate and interpret it in the light of the framework provided by their experiences, values, culture and learning. In the organizational context, knowledge takes a range of explicit forms and formats, including values, belief, emotions, judgments and prejudices. If properly applied, all forms of knowledge can provide the driving force for action [37].

A. Types of Knowledge

The two types of knowledge are generally known as explicit and tacit. In order to harvest the different types successfully, different strategies are required. Of the two concepts, explicit knowledge is what most people think of when the term 'knowledge' is used. This is because explicit knowledge is easier to understand than tacit knowledge, and easier to manage and manipulate [21][21]. Explicit knowledge is precise and able to be codified, while tacit knowledge is more intangible, involved with commonsense it cannot be directly codified [15].

III. GEO – INFORMATION TECHNOLOGY

Some of the lessons learned in the last several years give clear indications that availability, management and presentation of geo-information play a critical role in disaster management

[31]. Geo-information technologies offer a variety of opportunities to aid management and recovery in the aftermath of industrial accidents, road collisions, complex emergencies, earthquakes, fires, floods and similar catastrophes.

It is often stated that the major problem in disaster management is not the lack of technology or the existence of relevant information, but lack of 'information' about the information. This is especially true for geo-information. Typically, disaster management depends on large volumes of accurate, relevant, on-time geo-information that various organizations systematically create and maintain. This information may be described in catalogues and made available through geo-information infrastructures, such as the Infrastructure for Spatial Information in Europe (INSPIRE), based on OGC, ISO, and CEN standards. While the semantics of geo-information might be clear to the producer, this may not be the case for users less familiar with the data. Therefore explicit, and preferably formal semantics are required, but currently seldom available [35]. This complicates the effective (fast and good quality) communication of data to the user in real-time machine processing in support of disaster management because of commonsense knowledge.

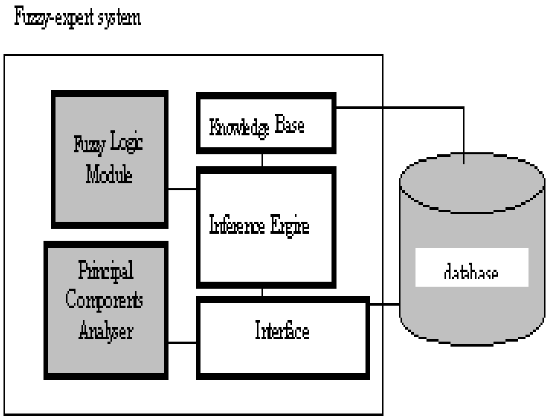


Fig. 1. Top-level Architecture of the system

IV. QUALITATIVE RSIK ASSESMENT

Qualitative risk assessment is a step in a risk management procedure. Risk assessment is the determination of quantitative value of risk related to a concrete situation and a recognized hazard. Our framework for modelling of commonsense knowledge has been developed on the basis of three-phases for qualitative risk assessment. As such the framework enables PC analysis, Knowledge classification and intelligent Reasoning using the expert system technology [7].

In this sense, the framework comes out as a hybrid intelligent system by integrating the techniques. 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.

V. THREE-PHASE KNOWLEDGE MODELLING

The process of the new approach is given in the following steps. It has been proposed a framework for modeling tacit knowledge. The framework has been designed as a three-phase knowledge modeling approach [38]. The related design underlies the following steps.

A. *Removing dependencies*

Removing of dependencies in the questions that are constructed in qualitative approach on the basis of tacit knowledge has been a key concern of the approach. Principal Component Analysis (PCA) is used as the first step towards the removal of dependencies.

The approach begins 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 [14]. We have chosen to acquire tacit knowledge into a questionnaire since it is more convenient for further analysis. On the other hand, the questionnaire can be automated to interact directly with the domain expert without involving a knowledge engineer. Once tacit knowledge has been acquired then we should analyze the knowledge for finding dependencies. The questionnaire has been analysed using principal component analysis (PC) [7] to find dependencies.

B. *Knowledeg classification*

However, PC alone could not give a statistically significant classification for the tacit knowledge gathered through the questionnaire. We have used Fuzzy logic in Artificial Intelligence to fine-tune the derived answers by principle components analysis.

Classification of tacit knowledge is achieved by integrating PCA with Fuzzy logic. This is the key contribution in our approach, as PCA alone could not provide statistically significant classification for the tacit knowledge.

C. *Reasoning*

The reasoning process in the proposed approach has been carried out using the expert system technology. Fuzzy expert system has been designed and implemented to emulate reasoning on the tacit knowledge.

Reasoning process pertaining to forecasting of the knowledge infrastructure in electricity market restructuring has been modeled into a fuzzy expert system. As such the knowledge base of the expert system contains fuzzy rules about the tacit knowledge of the domain at hand. Fuzzy rules for the domain have been constructed as per the following rules.If necessary the system can also be extended to accept fuzzy rules dynamically.

VI. RESULTS OF DIAGNOSIS SYSTEM

The system has been tested with the medical experts in the domain of Ayurvedic medicine. It was revealed that the system was able to identify human constituents approximating the classification by human experts in Ayurvedic medicine. Below is a justification for these results on the basis of three-phase framework that we have proposed

A. *Removing dependencies*

The questionnaire used to capture commonsense knowledge of humans consists of 72 questions pertaining to constituents of *vata*, *pita* and *kapha.* We have done a pilot survey for 100 numbers of students for statistical modeling using the questionnaire. Principle component analyzer has been used to remove dependencies in the questionnaire. 25 principal components have been identified using SPSS as shown in matrix given below. Here V1, V2..V24, K1, k2..K24, P1, P2..P24 denotes question-numbering system in the questionnaire.

$$M = \left(\begin{array}{llrrlrr}
 & & 1 & 2 & .. & 24 & 25 \\
V1 & & -0.228622 & 0.249362 & . & -0.073945 & 0.058179 \\
V2 & & 0.08431 & 0.20654 & . & -0.097192 & -0.112795 \\
. & V= & & & & & \\
. & & & & & & \\
V23 & & -0.645803 & 0.232312 & . & 0.0067 & -0.083959 \\
V24 & & -0.222147 & -0.06453 & . & -0.073514 & 0.084404 \\
K1 & & 0.012511 & -0.096332 & . & 0.141314 & 0.25113 \\
K2 & & -0.005642 & 0.268145 & . & -0.179992 & 0.111715 \\
. & K= & & & & & \\
. & & & & & & \\
K23 & & 0.409442 & 0.073812 & . & -0.115118 & -0.056431 \\
K24 & & 0.696973 & 0.126679 & . & 0.098213 & 0.045471 \\
P1 & & 0.430044 & 0.14608 & . & 0.023669 & 0.09045 \\
P2 & & 0.243781 & 0.373485 & . & -0.040468 & 0.149644 \\
. & & & & & & \\
. & P= & & & & & \\
P23 & & 0.009727 & 0.012529 & . & -0.072224 & 0.177827 \\
P24 & & -0.378091 & 0.096985 & . & 0.158006 & 0.069821
\end{array}\right)$$

$$V = \begin{pmatrix}
-0.228622 & 0.249362 & . & -0.073945 & 0.058179 \\
0.08431 & 0.20654 & . & -0.097192 & -0.112795 \\
 & & & & \\
-0.645803 & 0.232312 & . & 0.0067 & -0.083959 \\
-0.222147 & -0.06453 & . & -0.073514 & 0.084404
\end{pmatrix}_{24*25}$$

B. *Analysis of human constituents*

According to Ayurvedic medicine, human constituents can be computed into three categories as *vata, pita* and *kapha, and* percentages of these components are shown below. Note that the Membership functions for *vata, pita* and *kapha* have been constructed in fuzzy logic module using the out puts of principle component analyzer.

- Membership function for classifying *Vata* constitution

Boundary values of membership function have been constructed using the output of the principal component analysis.

$$\because X_L = 1 \sum_{i=1}^{25}\sum_{j=1}^{24} a_{ji} = 8.510004 \tag{1}$$

$$\because X_U = 6 \sum_{i=1}^{25}\sum_{j=1}^{24} a_{ji} = 51.06002 \tag{2}$$

Here X_L denotes lower bound value at the minimum level of evaluation scale (Does not apply) in the questionnaire. X_U denotes upper bound value at the maximum level of evaluation scale (Applies most) in the questionnaire

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

V(x) denotes membership function for classifying *vata* constitution.

C. *Explanations for derived human constituents*

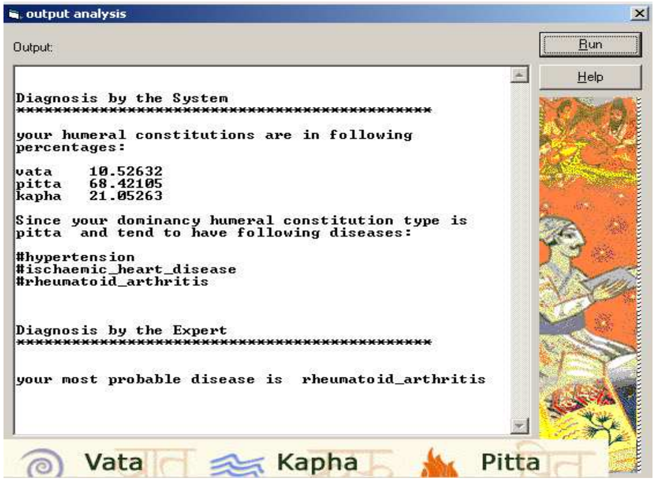
Explanations for output generated by the fuzzy logic module have been processed using fuzzy rules in the knowledge base of the expert system.

So following fuzzy rules can be illustrated for classing humeral constitutions in to *vata, kapha* and *pita* in term of percentage values

For *Vata* constitution:

Rule 1: If $X <= X_L$ then $V(X) = 0$ %
Rule 2: If $X_L < X < X_U$ then $V(X) = (X-X_L)/(X_U-X_L)$ %
Rule 3: If $X >= X_U$ then $V(X) = 100$ %

The knowledge base has been implemented using FLEX expert system shell, which is embedded in WinProlog. In relation to Ayurvedic domain, possible diseases can occur due to dominated constituent type. It is illustrated as shown in Figure 1.



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Diagnosis by the System
********************************************

your humeral constitutions are in following
percentages:

vata     10.52632
pitta    68.42105
kapha    21.05263

Since your dominancy humeral constitution type is
pitta  and tend to have following diseases:

#hypertension
#ischaemic_heart_disease
#rheumatoid_arthritis


Diagnosis by the Expert
********************************************


your most probable disease is  rheumatoid_arthritis
```

Fig. 1 Explanations for derived human constituents

VII. TESTING OF DIAGNOSIS SYSTEM

The expert system developed using this approach was tested with a sample of 30 persons of Ayurvedic experts and students (see Table 1).

TABLE I. SYSTEM TESTING: EXPERT VS. SYSTEM

vata	pitta	Kapha	Expert_decision
25.71	20.71	53.57	KV
32.95	23.86	43.18	VP
39.88	23.81	36.31	VP
27.65	46.1	26.24	KP
25.69	29.36	44.95	KV
33.58	24.09	42.34	KV
25.71	34.28	40	KP
32.21	31.54	36.24	KV
22.51	29.8	47.68	KP
20.37	30.56	49.07	PK
30.6	35.52	33.88	PK
29.71	17.39	52.9	KV
41.07	10.71	48.21	KV
34.5	32.16	33.33	KV
23.46	28.57	47.96	PK
35.27	30.77	33.97	KV
42.36	36.11	21.53	VP
23.01	35.71	41.27	PK
47.94	19.86	32.19	KV
14.03	35.96	50	PK
19.15	36.88	43.97	PK
22.46	25.36	52.17	PK
40.47	26.78	32.74	PK
30.28	29.58	40.14	KV
12.71	44.92	42.37	PK
11.18	40	48.82	PK
11.24	40.24	48.52	PK
23.44	26.9	49.66	PK
17.09	36.75	46.15	KV
33.09	30.15	36.76	KV

The evaluation was conducted to see how 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 has been investigated that 23 (77%) of conclusions matches with the system and expert (see Table 2), which leads to determine the accuracy of the system.

TABLE II. SYSTEM TESTING: EXPERT VS. SYSTEM

vata	pitta	kapha	Expert decision	conclusion
25.71	20.71	53.57	KV	matched
33.58	24.09	42.34	KV	matched
25.71	34.28	40	KP	Matched
32.21	31.54	36.24	KV	Matched
22.51	29.8	47.68	KP	Matched
20.37	30.56	49.07	PK	Matched
30.6	35.52	33.88	PK	Matched
29.71	17.39	52.9	KV	Matched
41.07	10.71	48.21	KV	Matched
34.5	32.16	33.33	KV	Matched
23.46	28.57	47.96	PK	Matched
35.27	30.77	33.97	KV	Matched
23.01	35.71	41.27	PK	Matched
47.94	19.86	32.19	KV	Matched
14.03	35.96	50	PK	Matched
19.15	36.88	43.97	PK	Matched
22.46	25.36	52.17	PK	Matched
30.28	29.58	40.14	KV	Matched
12.71	44.92	42.37	PK	Matched
11.18	40	48.82	PK	Matched
11.24	40.24	48.52	PK	Matched
23.44	26.9	49.66	PK	Matched
33.09	30.15	36.76	KV	Matched

VIII. TRANSEFERING OF THE SYSTEM INTO ELECTRICITY MARKET RESTRUCTURING SCENARION

Testing of the framework through the tacit knowledge domain of Ayurvedic medicine shows the feasibility of applying our approach for any domain with commonsense knowledge. With regard to any domain, one can acquire the commonsense knowledge through a questionnaire and find the PC with the use of the system. Fuzzy Logic and reasoning modules work on the identified PC. In fact, beyond the acquisition of commonsense knowledge, the system is also automated to a large extent.

As per the disaster management systems too, we need to begin with acquisition of commonsense knowledge pertaining to this particular domain. For example, several critical inputs described in spatial data library for disaster management are required in order to take preventive measures through vulnerability analysis, hazard zonation, and prior risk assessment to minimize loss of life and damage and facilitate timely and effective rescue, relief and rehabilitation of the affected population. Measuring approach of these inputs are subjective and involved with commonsense knowledge. Further commonsense knowledge is classified as a type of tacit knowledge. Many organizations, which involve in disaster management, require to access the right data in the right time to make the right decisions. So vulnerability analysis, hazard zonation and prior risk assessment are considered as critical impacts in disaster management. Accessing methodologies of these inputs through vulnerability analysis, hazard zonation and prior risk assessment are involved with commonsense knowledge. So modelling commonsense knowledge is required. The system is capable of addressing the issue of modelling commonsense knowledge using three-phase knowledge modelling approach. This concludes the capability of transferring of the system into a disaster management scenario. In simple terms, with regard to any domain it is proposed to design a questionnaire to capture commonsense knowledge of a particular problem solving scenario. This can be done by domain experts. One can use our framework to enter such questionnaires and let the framework to come up with a fuzzy expert system for reasoning on commonsense knowledge.

IX. CONCLUSIONS & FURTHER WORK

We have developed a framework for modeling commonsense knowledge of knowledge infrastructure for qualitative risk assessment with the help of Statistics and Artificial Intelligence techniques. The framework is based on the use of principal component analysis and fuzzy logic for modeling tacit knowledge into an expert system. The proposed framework comes up with a fuzzy expert system for reasoning on commonsense knowledge in risk assessment. With the use of Ayurvedic domain we have demonstrated how our approach works in practice. We have also explained how the framework can be used to model any domain, for example, disaster management, concerning commonsense knowledge.

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 with FLEX expert system shell, we have already shown that the framework can be linked up with expert system shells. With these results of applications of the framework, this appears to be more general and customizable for any domain. As an immediate step of further work, we intend to get a questionnaire of commonsense knowledge pertaining to disaster management domain and customize our system for reasoning in disastrous situations in a novel manner. We also intend to make the system available as a web application that is accessible by general public in a disastrous situation. Therefore, we conclude that our framework can be used as a generic approach to develop fuzzy experts systems for reasoning in domains with common sense knowledge.

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