Formal Representation in Defining Indigenous Knowledge Framework

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***Abstract*—This paper presents a prototype designed to evaluate the framework of indigenous knowledge representation. A sample result of the fuzzy analysis is computed from the prototype designed. The set of algorithm to compute the truth values of the uncertain knowledge is also presented in this paper. The framework is expected to provide a baseline to derive the logical explanation of the indigenous knowledge acquired (set of taboos and set of beliefs) at the same time providing a platform of knowledge repository. The framework is design by using formal-fuzzy method.**

Keywords—formal-fuzzy, uncertain, fuzzy logic, formal method, truth value, knowledge repository

I. Introduction

This paper presents a prototype designed for evaluating the framework of indigenous knowledge representation. The main objective of designing this prototype is to extract and capture knowledge from the beliefs, taboos and consequences for the indigenous communities in Borneo and at the same time, to evaluate the truth values of the knowledge captured.

The complex and multi-relationships between beliefs, taboos and their consequences are expected to be captured and stored in the repository of the prototype designed. Capturing, modeling or manipulating the information and relationship between taboos, beliefs and the consequences are not easy due to the uncertainties of the relationships [1].

The relationships in between the captured knowledge are very uncertain and complex. In order to solve this, the prototype is designed to enable the mapping of the indigenous knowledge to the logical explanation. The degrees of relationships between the knowledge are represented by the truth values which are formulated based on fuzzy calculation. The fuzzy calculation is based on the data captured from indigenous community.

VDM++ tool is applied to derive the knowledge representation for the knowledge acquired. VDM++ tool also applied to come out with the formal specification to model the essential algorithm of the prototype.

A. Problem Statement

To evaluate the truth values for the indigenous knowledge acquired is not easy due to the uncertainties. There are multi-relationships in between the knowledge acquired but, there were no concrete evidence to represent the abstract and logical values of the knowledge.

There are also no knowledge representation for the taboos, consequences and logical explanation (indigenous knowledge).

In order to solve the problem statement mentioned, the proposed framework is designed [1], and evaluation of the framework is presented in this paper.

II. Related Work and Literature Review

This work is a part of the continuous research in modeling the indigenous knowledge [1, 2]. The basis of the modeling of this prototype is knowledge representation and solving the uncertainties of knowledge acquired by using fuzzy logic. Fuzzy logic computation of the truth values is applied to come out with the truthfulness of the logical explanation for the knowledge acquired.

Hasan et.al, in their web article concluded that relationships between knowledge acquired are intuitive and based on prima facie plausible [8].

Knowledge Representation (KR) is often applied in modeling knowledge acquired based on two components: reasoning and inference. Basically, knowledge representation techniques are: KR using predicate logic, KR using semantic net, KR using Frames and KR using formal scripts [6].

One of the knowledge representations presented in semantic web framework or taxonomical form is Ontology [3].

Sahri et.al proposed an ontological method in knowledge representation for the indigenous knowledge. The authors designed a method of representing knowledge for the indigenous herbal medicine [4]. Mustaffa et.al in their research also adopted ontological method in doing knowledge representation to solve the challenges in unstructured format of knowledge [5].

The similarities in both [4] and [5] are both authors studied herbal medicine knowledge representation based on Ontology model. The effectiveness of knowledge representation by using ontology technique is more relevant to the studies in the herbal medicine knowledge representation, as the semantic web or taxonomy of the knowledge acquired is well-defined.

However, for the study of complex and multi-relationships between beliefs, taboos and their consequences, the Ontology techniques is not feasible due to the behavioral of the relationship. The complex and multi-relationships between the knowledge acquired, is best defined by using formal specifications which provide a more precise mathematical model [7].

III. Methodology

This section discussed on the formal specification and algorithm designed to provide a precise model in developing the prototype of the knowledge repository.

In the paper presented in [1], the framework designed inclusive of 3 main phases, namely: Data Collection, Data Mapping and also Computation of Logical Explanation's truth values.

In data collection phase, the collected data is stored in the knowledge repository.

Data mapping phase involved derivation of formal specification to manipulate the collected data sets. Data mapping specification as follow:

```
Kin : map Tn to Cn;
Krn : map Kin to Ln;
Tv : map Krn to Tv;
```

Fig.1. Data mapping

To perform knowledge representation, the indigenous knowledge (Ki_n) collected is defined as set of taboos (T_n) mapped to set of consequences (C_n).

The knowledge (Kr_n) is further defined in the form of initial knowledge acquired (Ki_n) mapped to the logical explanation (L_n). Finally, to establish the truth values in a scientific behavior (scientific knowledge), the derivation of knowledge (Kr_n) is mapped to the truth values (fuzzy values) derived.

```
operations
public dataRetrieval: Taboo ==> Krn
dataRetrieval (taboo) == (
  dcl resultList : Krn := {|->};
  for all kr in set dom KrnList
  do(
     if(kr.taboo = taboo) then
     (
resultList := resultList   munion ({kr}<: KrnList);
     );
  );
   return resultList ;
);
```

Fig.2. Data retrieval for the data repository

An example of the data retrieval algorithms is shown in Figure 2. This algorithm is applied when there is a query of taboo from the operation. The result retrieved from a list of consequences and logical explanations (KrnList) based on the taboo entered.

For the total of responses collected, the following algorithm in Figure 3 is used to calculate the truth value for the logical explanation of the knowledge.

```
public TruthValue : seq of nat * seq of real ==>real
TruthValue(Kr, N) ==
(
   let totalRespond =totalRespond(Kr),
   totalMembership =totalMembership(Kr,N)
   in return (totalMembership/totalRespond );
)
pre inds Kr = inds N and forall i in set inds N &( 0.0<= N(i) and N(i) <=1.0);
```

Fig.3. Truth value computation

Referring to Figure 3, the truth value computation is done by calculating the average value for the membership values to evaluate the truth values of the knowledge acquired based on the responses from the expert domain.

$$\mu_{x_i} = \frac{\sum x_i}{N} \quad (1)$$

The data samples are collected from the expert domains of the indigenous communities, for example, if N = 6 samples, X_i, where i = [1, 6].

The membership values are assigned to the knowledge acquired as shown in Table II. The value calculated for the knowledge acquired will render result captured in Table I.

The recursive algorithm of rendering the truth values for the relationship of the knowledge is as shown as Figure 4:

```
public totalMembership: seq of nat * seq of real==> real
totalMembership(Xn, Fm)==
(
  dcl total:real :=0;
     for all i in set inds Xn
   do(
          total:=total+ (Xn(i) * Fm(i));
   );
          return total;
  );
```

Fig.4. Recursive algorithm in rendering the truth values for the relationships

The total of the fuzzy values collected and fuzzy membership collected from the expert domains for instance of T_{v1} of Kr_1 is as shown as in Table I below:

TABLE I. Responses Collected from the Sample Respondents

No	Respondent	Response	Fuzzy membership
1	X_1	3	0.50
2	X_2	3	0.50
3	X_3	2	0.25
4	X_4	3	0.50
5	X_5	3	0.50
6	X_6	4	0.75

The derivation of the truth values (fuzzy computation) from Table I is as below:

$$\mu_{x_1} = \frac{(4X0.5)+(1X0.25)+(1X0.75)}{6} = 0.5 \quad (2)$$

The truth value of $\mu_{x_1} = 0.5$ is recorded in Table II, in the matrix of T_1|->C_1.

TABLE II. THE SAMPLE SUMMARIZATION OF THE OF THE TRUTH VALUES FOR THE KNOWLEDGE ACQUIRED FOR FOUR SAMPLES OF TABS

	T_1	T_2	T_3	T_4
C_1	0.5	-	-	-
C_2	-	0.8	-	-
C_3	-	-	0.3	-
C_4	-	-	-	0.8

The results obtained in Table II, for example, (T_1 |-> C_1) |-> Kr_1 = 0.5. T_{v1} = 0.5, is computed from formula (2) above, where T_{v1}=0.5 is the truth value for the logical explanation of T_1 |-> C_1. This result will be discussed further in section V.

IV. Prototype

A. Data Repository Module

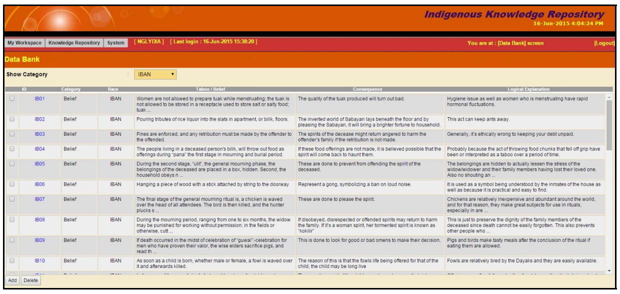

Fig.5. Data repository (data collected)

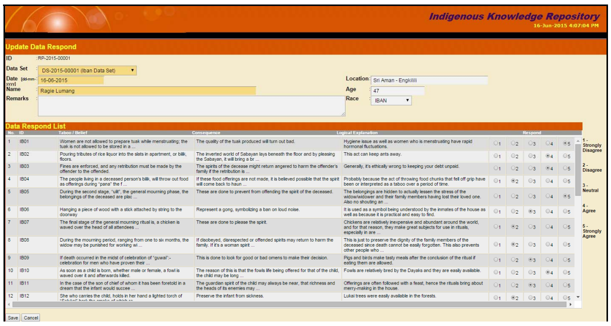

Fig.6. Data repository (render data respond list)

In data repository module, the main function is to collect data and performing data mapping according to the rules as defined in Figure 1.

The knowledge collected can be used to render sets of questionnaires to collect responses from the domain experts based on their specific ethnic.

The responses collected from the domain experts (Figure 6) will be used in fuzzy values computation module to compute truth values for the relationships.

For example, by adopting the fuzzy set theory, fuzzy membership defined for response 1 is 0, response 2 is 0.25, response 3 is 0.5, response 4 is 0.75 and response 5 is 1.0 [9], where response 1 is defined as not true, response 2 is unlikely to be true, response 3 is likely to be true, response 4 is quite true and response 5 is definitely true.

For Kr_1 listed in Figure 6 (first row of the data respond list), response collected from X_1 is 3. Responses collected for X_1… X_6, (as shown as Table I) are used to undergo the fuzzy analysis to compute the truth value in Figure 7.

B. Fuzzy Values Computation Module

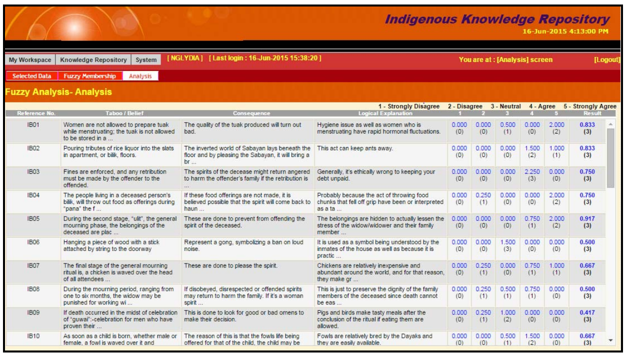

Fig.7. Fuzzy analysis

The fuzzy analysis for knowledge acquired (Kr_n) will be tabulated as shown as in Figure 7.

As an example:

T_1, Women are not allowed to prepare *tuak* (rice wine) while having menstrual period; C_1, The quality of *tuak* will turn out bad; and L_1, Hygiene issue as well as women who is menstruating having rapid hormonal fluctuations.

From the above example:

Kr_1:= ((T_1|->C_1) |-> L_1) is assigned with the fuzzy value of 0.50 after the fuzzy computation, refer to Table I. The final result (truth values) is mapped to the knowledge (Kr_1) acquired and stored in the data repository. Indicate that the degree of truth of Kr_1 is 0.5 refer to section V for further explanation.

V. Discussion

The facts of the set of data collected are refined and went through a data mapping process in the repository as mentioned in section III, Figure 1: data mapping.

The results obtained in Table II, is based on the μ values of each taboos and consequences mapped, for instance: μ_{TnCn}, is the truth value for T_n mapped to C_n, where T_n |-> C_n after it went through the data mapping process, will have the truth value : T_v = μ_{TnCn}. As knowledge acquired is complex and multi-relationship, thus, T_1 having a possibility of mapping to C_1, C_2,…, C_n.

In the sample result as shown as in Table II, T_1 is mapped-to C_1; T_2 is mapped-to C_2; T_3 is mapped to C_3 and T_4 is mapped to C_4.

The truth values computed is within the range of 0 to 1. T_v = [0,1], where 0 indicated that the logical explanation of the knowledge acquired is unlikely to happen, and when the number increases to 1, the logical explanation of the knowledge acquired is very likely to be true.

For example of Kr_1:= ((T_1|->C_1) |-> L_1), the degree of truth obtained is 0.5. Thus, the logical explanation of the knowledge acquired is 0.5 likely to be true. Therefore, the logical explanation of L_1, Hygiene issue as well as women who is menstruating having rapid hormonal fluctuations is only 0.5 true with regards to the degree of truth obtained

VI. Conclusion

The main idea of this research is to propose a better solution to solve the uncertainties of knowledge for the indigenous communities. The source of documents for the data collection for this research is very limited, as the knowledge passed from generation to another are done verbally by the communities. There are no proper or lack of documentations of the indigenous communities' knowledge in Borneo. The data repository plays an important role in the data collection to preserve the knowledge passed down. On the other hand, the computation of the truth values is able to determine the truthfulness of the knowledge scientifically of the knowledge acquired.

At this stage, the prototype is able to perform data collection for the indigenous knowledge, which form the repository for the knowledge collected. There is data retrieval algorithms embedded in the query of knowledge from the repository.

On the other hand, this prototype has a feature of fuzzy analysis to compute the truth values for the logical explanation of the indigenous knowledge acquired. The truth values also known as fuzzy values are able to evaluate the relationship scientifically.

To date the development of indigenous repository is still in the progress of enrichment of the data. Data collection and evaluation of knowledge truth values will be continuously done in order to build a more comprehensive data repository.

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