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Using METHONTOLOGY to Build a Deep Ontology for African Traditional Medicine: First Steps.

Arnel AYIMDJ^{1,3}, Souleymane KOUSSOUBE², Laure Pauline
FOTSO³, Balira O. Konfé²

¹Département de Génie Informatique, Institut Universitaire de Technologie (IUT) de Douala
BP 8698 Douala, Cameroun.

²Laboratoire Africain d'Informatique et de Mathématiques Appliquées (LAIMA)
Institut Africain d'Informatique (IAI)
B.P. 2263 Libreville, Gabon

³Département d'Informatique, Université de Yaoundé I, BP 812 Yaoundé, Cameroun
ayimdji@gmail.com, skoussoube@yahoo.fr, laurepfotso@yahoo.com, obalira@yahoo.fr

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ABSTRACT. In this paper, we are moving forward in our step to formally deal with “mystical considerations” and contextual information in African Traditional Medicine. We present the first steps to build an ontology for African Traditional Medicine following the ontology development methodology METHONTOLOGY. The aim of our approach is to build a deep ontology by deepening concepts descriptions to formally represent all the semantics underlying the concepts used in African traditional medicine.

RÉSUMÉ. Dans cet article nous poursuivons notre démarche visant à représenter de façon formelle la dimension « mystique » et les informations contextuelles dans la médecine traditionnelle Africaine. Nous présentons les premières étapes dans la construction d'une ontologie de la médecine traditionnelle en utilisant la méthodologie de développement d'ontologies METHONTOLOGY. Le but de notre démarche est de construire une ontologie profonde par approfondissement des descriptions de concepts afin de représenter toute la sémantique des concepts utilisés en médecine traditionnelle Africaine.

KEYWORDS: primary ontology, deep ontology, ontology development process.

MOTS-CLÉS : ontologie primaire, ontologie profonde, processus de développement d'ontologie.

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1. Introduction

The development of ontologies has moved from being an art to become engineering. Some outstanding methodologies to build ontologies are: Uschold and King [1], Grüninger and Fox [2], METHONTOLOGY [3] and Ontology development 101 [4].

According to us, METHONTOLOGY is one of the most complete methodologies. In fact, it can be used to build ontology from scratch or to reengineering already existent ontologies. It clarifies the different steps for ontology building through its seven phases: *specification, knowledge acquisition, conceptualization, integration, formalization, implementation and maintenance*.

Besides, African Traditional Medicine (ATM) is now moving from being this medicine where knowledge is orally transmitted to a more formalized domain where knowledge is represented and conserved with technological means. Our medium-term goal is to provide an ontology for ATM. However, the construction of such an ontology has to be conducted according to the specificities of this particular domain. This paper follows our first proposal [5] in such an attempt and aim to more organize the development process using METHONTOLOGY.

The rest of the paper is organized as follows. Section 2 is devoted to the development of the ATM ontology by following the steps of METHONTOLOGY. Section 3 concludes and discusses how this work could be extended.

2. METHONTOLOGY to build a deep ontology for ATM

In this paper, we focuses on the first five phases of METHONTOLOGY, this is to let the ontology developers free to implement the ATM ontology with their favourite tools.

2.1. Specification

Our work relies on the definition of Traditional medicine, given by WHO¹: *Traditional Medicine refers to the knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, used in the maintenance of health and in the prevention, diagnosis, improvement or treatment of physical and mental illness.*

The aim of introducing an ontology for ATM is to eliminate or at least reduce the conceptual and terminological confusion and to walk towards a common and shared understanding in order to improve communication, sharing, interoperability and reusability. The ontology will take into account the deep semantics of all concepts represented, including those referring to some metaphysics aspects. Indeed, in ATM, the

¹ WHO, World Health Organization. <http://www.who.int>

deep analysis of some concepts may reveal hidden aspects, appearing at a first glance as mystical considerations, but which can be captured and conceptualized in the ontology [5]. The ATM ontology requirement specification document is summarized as follows:

ATM Ontology requirement specification document	
Domain	African Traditional Medicine
Purpose	Ontology about concepts to be used when information is required for prevention, diagnosis and healing of diseases in ATM. This ontology could be used to ascertain a plant is a medicinal one or to identify the process of harvest of certain medicinal plants.
Level of formality	Formal
Scope	List of (all) possible concepts used in the prevention, the diagnosis and the healing of diseases in ATM, including believes and accessories. List of concepts: Disease, Symptom, Potion, Prohibition, Process-of-harvest, attitude-of-Harvest, ritual, calabash, talisman...
Principal Sources of Knowledge	Meditra Project ² , WHO website links on ATM, IPHAMETRA ³ , Ateazing's ATM ontology [6].

Table 1. *Ontology requirements specification in the domain of ATM*

2.2. Knowledge acquisition

As sketched in Table 1, our sources of information include documents published in the frame of MEDITRA Project, WHO website, IPHAMETRA and the first ATM ontology proposed in [6]. We gathered much information at IPHAMETRA where we had discussions with experts (botanists, chemists and biochemists, etc.) and some traditional doctors whose intensive comments and experiences was particularly helpful. We have used all those sources of information to detect concepts, relationships, attributes and some definitions in natural language (both English and French). The gathered information is used to conceptualize ATM domain.

² The MEDITRA project initiated in 1996 at the University of Yaoundé I, to build a knowledge base to preserve and share knowledge on ATM.

³IPHAMETRA, Institut de Pharmacopée et de Médecine Traditionnelle, Libreville, Gabon.

2.3. Conceptualization

To conceptualize the ontology, we have to go deep into ATM by analyzing some statements done by practitioners (healers, soothsayers, fetishists ...etc.). ATM practitioners sometimes make a number of assumptions that seems inconsistent with some principles of modern medicine. Terms used by those practitioners could sometimes refer to some hidden aspects and therefore should not always be considered at the first degree. For example, consider the following two statements (from [5]):

- a) *“Drink a calabash of the potion every morning.”*
- b) *“This plant should be collected by a young man, early in the morning, before the daybreak. Once the plant is collected, the collector must run straight at home without stopping on the way, and the plant must be used immediately.”*

The first statement introduces the term “**Calabash**”, a widely used container in ATM for therapeutic indications and conservation of healing potions. A “naïve” or a purely lexical description of this concept in the ontology would restrict it to a container made from a fruit. However, a deeper observation of this indication shows that the concept “Calabash” in this context can refer to at least three different aspects: a *fruit-based container*, a *dosage* and/or a *restriction* (the medicine must be stocked exclusively in a calabash otherwise it would not be effective). This third aspect apparently superficial has a scientific basis because in many cases, the fruit forming the Calabash helps in a better preservation of the potion than a metal container where there can be a risk of corrosion or some chemical reactions between the liquid (potion) and the container.

The second statement describes the attitude to adopt when collecting some medicinal plants. It has been shown that plants requiring such an attitude contain essential oils for which the concentration is very high in the early morning and their volatility requires a very short delay between the collection and the usage. That is why some traditional doctors, without knowing this scientific explanation, recommend the harvest process described.

These two situations show that in ATM, the ontological description of a concept has to go beyond the shallow conceptualization by structuring the ontology development process into two major steps:

- The first step leads to the first ontology we called the “**primary ontology**” where concepts are defined in a “naive” way; concepts are defined at the first degree ignoring any eventual hidden aspects.
- The second step “deepens” concept descriptions in order to obtain the final ontology we called the “**deep ontology**”. This second step involves various specialists (ethnobotanists, chemists ...etc.) and aims at iteratively and incrementally introducing the different hidden aspects if any, for certain concepts.

The process described here is integrated to already existing proposal for ATM ontology.

2.4. Integration

Apart from our previous work [5], a precedent effort [6] had been done for the development of an ontology for ATM. We used it to identify some concepts and their basic definition in natural language. Unfortunately, this first effort didn't go deep into the definition of concepts and do not consider the different hidden interpretations that can be associated to some concepts. Therefore our effort is to deepen these descriptions where appropriate.

2.5. Formalization

To provide a high level of formalization, we use a description logics (DL) language to represent the ontology as a TBOX in which concepts are formally described using ALC (Attributive Language with Complement). Figure 1 shows the two ontologies (O_D and O_P) obtained during the development process described.

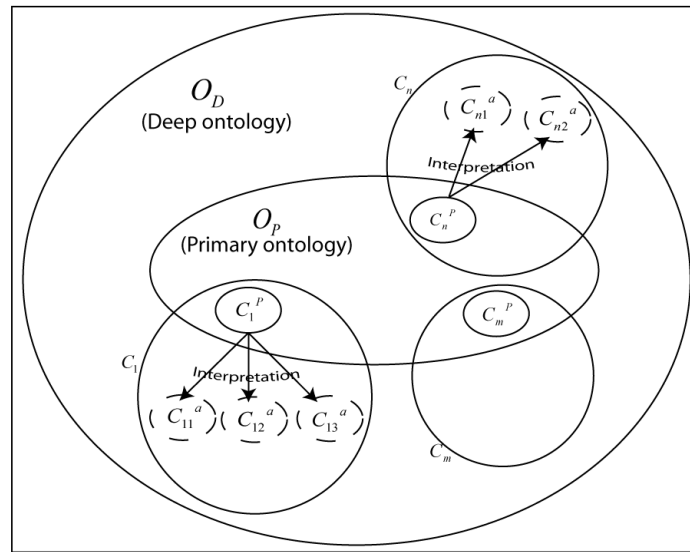


Figure 1. The primary ontology and the deep ontology. (Source: [5])

In this figure, $C_i, i \in N^*$ represents a concept description in the deep ontology, the full description. To reach this, we must go through a primary description C_i^P corresponding to the definition of C_i at the first degree (“naïve” description). We formalize this primary description by the expression:

$$C_i \sqsubseteq C_i^P \quad (1)$$

The set of these concept descriptions constitutes the primary ontology. Let O_p the primary ontology, then:

$$O_p = \{ C_i \sqsubseteq C_i^P, i = 1..n, n \in N^* \} \quad (2)$$

All the aspects related to the various contexts of use of a concept are associated to each deep description of that concept. It should be noted that certain concepts (such as $C_m, m \in N^*$, in Figure 1) will not have any hidden aspects to formalize and no associated interpretation will be given. In this case, only the primary definition is taken into consideration. In order to associate to concepts their respective aspects, we create a primitive role which links concepts to interpretation. Let “*ia*” (an abbreviation for “interpreted as”) this role. It will express the fact that a concept can be interpreted as some aspect. In general, if a concept C_i can be interpreted as j aspects $C_{i_1}^a, C_{i_2}^a, \dots, C_{i_j}^a$, then the following description is used to consider these aspects in the ontology:

$$C_i \sqsubseteq \sqcup_{k=1..j} (\exists ia \bullet C_{ik}^a) \quad (3)$$

Then, from the expressions (1) and (3), we can give the expression of the deep description of each concept C_i :

$$C_i \sqsubseteq C_i^P \sqcap (NI \sqcup (\sqcup_{k=1..j} (\exists ia \bullet C_{ik}^a))), i = 1..n, n \in N^*. \quad (4)$$

Where *NI* (which stands for “Not Interpreted”) is a special concept introduced to indicate the absence of hidden interpretation or hidden aspects. This special concept is used to restrict the concept description to the primary one when there is no hidden aspect found for a concept.

The set of these concepts descriptions constitute the deep ontology O_D defined as:

$$O_D = \{ C_i \sqsubseteq C_i^P \sqcap (NI \sqcup (\sqcup_{k=1..j} (\exists ia \bullet C_{ik}^a))), i = 1..n, n \in N^* \}. \quad (5)$$

Illustration

To illustrate, recall the two statements of the conceptualization phase.

Statement 1: “*Drink a calabash of the potion every morning*”.

This statement can be considered as a therapeutic indication involving a Calabash. Here, to describe the concept “Calabash”, the primary description reduces it to a fruit-based container:

$$\text{Calabash} \sqsubseteq \text{Container} \sqcap \forall \text{madeFrom.Fruit} \quad (6)$$

Then, the deep description extends the concept “Calabash” to the aspects of “*Dosage*” and “*Restriction*”. By introducing a notation that precedes the name of each concept representing an aspect with “*A_*”, we obtain:

$$\text{Calabash} \sqsubseteq NI \sqcup \exists ia.A_Dosage \sqcup \exists ia.A_Restriction \quad (7)$$

From the expressions (6) and (7) we can give the expression of the deep description of the concept Calabash:

$$\begin{aligned} \text{Calabash} \sqsubseteq & (\text{Container} \sqcap \forall \text{madeFrom.Fruit}) \\ & \sqcap (\text{NI} \sqcup \exists \text{ia.A_Dosage} \sqcup \exists \text{ia.A_Restriction}) \end{aligned} \quad (8)$$

The development of expression (8) leads to:

$$\begin{aligned} \text{Calabash} \sqsubseteq & (\text{Container} \sqcap \forall \text{madeFrom.Fruit} \sqcap \text{NI}) \\ & \sqcup (\text{Container} \sqcap \forall \text{madeFrom.Fruit} \sqcap \exists \text{ia.A_Dosage}) \\ & \sqcup (\text{Container} \sqcap \forall \text{madeFrom.Fruit} \sqcap \exists \text{ia.A_Restriction}) \end{aligned} \quad (9)$$

The expression (9) shows that in the deep ontology, a Calabash is a container made from a fruit, or a container made from a fruit and is used to define a certain dosage, or a container made from a fruit and defines the obligation to respect a constraint (of preservation for example).

Statement 2: “*This plant should be collected by a young man, early in the morning, before the daybreak. Once the plant is collected, the collector must run straightly at home without stopping on the way, and the plant must be used immediately*”.

This second statement indicates the attitude to adopt when collecting the medicinal plant. Here, the challenge is twofold. First, we give a shallow formalization of the statement in order to represent the collection process of the plant. Second, we deepen the descriptions of the identified concepts. This statement highlights the importance of some concepts in the plant *collection process*: the specifications of the *collector* (young man), his *attitude* (run nonstop) and the *period* of the collection (early morning). We can use some formal concept to describe the situation. Generally, the specification of the collection process of a plant can be described as:

$$\begin{aligned} \text{Collection_Spec} \sqsubseteq & \forall \text{collector.Collector_Spec} \\ & \sqcap \forall \text{period.Period_Spec} \\ & \sqcap \forall \text{attitude.Attitude_Spec} \end{aligned} \quad (10)$$

By introducing more specific concepts, we refine the collection specification to fit the statement of our example:

$$\begin{aligned} \text{Young_Man} \sqsubseteq & \text{Collector_Spec} \\ \text{Run_Non_Stop} \sqsubseteq & \text{Attitude_Spec} \\ \text{Early_Morning} \sqsubseteq & \text{Period_Spec} \end{aligned} \quad (11)$$

Thus,

$$\begin{aligned} \text{Collection_Spec1} \sqsubseteq & \forall \text{collector.Young_Man} \\ & \sqcap \forall \text{period.Early_Morning} \\ & \sqcap \forall \text{attitude.Run_Non_Stop} \end{aligned} \quad (12)$$

So, Collection_Spec1 (the specification of the collection process of our example) is a particular kind of Collection_Spec.

We can easily imagine factual information (in an ABOX) to model the studied statement:

$$\text{Collection_Spec1}(c1), \text{Medicinal_Plant}(p1), \text{collection_Process}(p1, c1)$$

where *Medicinal_Plant* and *collection_Process* are respectively, the concept satisfied by all medicinal plants, and a relation linking each plant and his collection process.

The concept `Early_Morning`, specifying the appropriate collection time hides the aspect of essential oil while the concept `Run_Non_Stop` specifying the attitude of the collector hides the aspect of the volatility of an active ingredient. These hidden interpretations not explicitly stated by the healer can be formally represented in our TBOX by the deepening process of concepts involved as follows:

$$\text{Run_Non_Stop} \sqsubseteq \text{Attitude_Spec} \sqcap (\text{NI} \sqcup \exists \text{ia.A_Volatility_Constraint})$$

$$\text{Early_Morning} \sqsubseteq \text{Period_Spec} \sqcap (\text{NI} \sqcup \exists \text{ia.A_EssentialOil_Concentration_Constraint})$$

3. Conclusion

In this paper we have sketch the first steps for the development of a deep ontology of ATM using METHONTOLOGY. Applications based on *information retrieval* will find the deep ontology particularly helpful because they will be able to go farther by exploiting all the semantics of the concepts used, joining what is made in the field of semantic Web. To test the deep ontology sketched in this paper, we are developing a Clinical Decision Support System (CDSS) for ATM. The focus of our CDSS is the medical diagnosis and treatment recommendations. The ontology will enable software agents in charge of the diagnosis to have full access to information on patients and traditional healers, including their beliefs and indigenous experiences, in order to infer patient-specific recommendations and to deeply explain these recommendations.

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