A PRACTICAL APPLICATION OF AN ONTOLOGY-BASED DIAGNOSTIC AND THERAPEUTIC SYSTEM FOR YORUBA TRADITIONAL MEDICINE.

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ABSTRACT

Traditional Medicine (TM) has an important place in health care delivery among developed and developing nations of the world. It is a first point of call before western medicine and a last resort when all orthodox efforts fail. The objective of this study was to provide a way to share knowledge of Yoruba Traditional Medicine (YTM) in a machine-readable form and to use this method to build a treatment system base on Traditional Medicine. The treatment system constructed in this study is an ontology-based application that can be used for treatment. Description Logics formalism is used to model YTM knowledge with visual reasoning capabilities and processes. Ontological approach is used to express formal specification of YTM domain knowledge and this is implemented using Web Protégé application. In order to ensure the knowledge model and ontology view is well defined, a prototype of knowledge based system is developed based on the ontology classes or concepts and relationships defined which require conversion of OWL ontology into the relational database system at first hand.

Keywords: Traditional Medicine, Knowledge Based System, Patient-Centered healthcare, Indigenous knowledge, Herbal-Based Treatment, ontology, knowledge representation.

1. INTRODUCTION

For thousands of years, Africans in general and Yoruba Speaking people of South-Western region of Nigeria in particular, have practiced various forms of healing and medicine through diagnosis and therapy that involves both natural and supernatural explanations and remedies using plants, animals and minerals. Traditional Medicine includes medical activities stemming from practices, customs and traditions which were integral to the distinctive African cultures. These last decades witness the rebirth of herbal-based treatments and Traditional Medicine (TM) across the world. Several factors can explain the increasing success of TM: it is a local medicine, less restrictive and very often cheaper than the Modern Medicine (MM). Moreover, it is a credible alternative for low-income households (Adeshina, 2011). In many regions in the world (including Africa, Asia and America) traditional medicine is a socio-cultural reality which has provided a scientific contribution to modern medicine. Given the deficiency of medical doctors in developing countries, traditional health practitioners (THPs) contribute tremendously to healthcare coverage. In some cases, traditional medical practitioners use medicinal plants that have not been actively used in modern medicines (Cragg and Newmann, 2005). Traditional medicine is ‘‘the total sum of knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health and in the prevention, diagnosis, improvement or treatment of physical and mental illness.’’ (WHO, 2004).

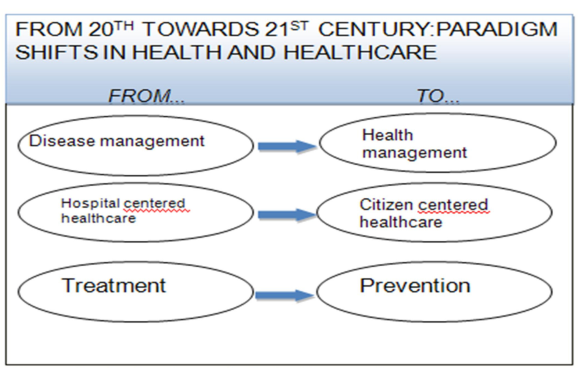

Figure 1. Paradigm Shift in Health Care

African Traditional Medicine (ATM) has a holistic view on healthcare involving extensive use of physiotherapy and herbalism sometimes combined with some aspects of African spirituality (Onwuanibe, 1979). A disease is often seen in TM as the failure of complex physical, social and spiritual relationships. Therefore, a diagnosis starts with an examination of both human and supernatural interactions. For instance, when the ailment is mystical, ritual diagnosis is a fundamental part of the traditional healing process for re-establishing social and emotional equilibrium (Tella, 1979). Particularly, the philosophical clinical care embedded in African traditions, culture and beliefs have contributed to making TM practices acceptable and hence highly demanded by the population (Mhame et al., 2010). Indeed, compared to modern practitioners, African Traditional Practitioners (ATP) interact very differently with their patients, using a more patient-centered communication style, to reach common ground with sick persons (Labhardtetal.,2010).

Considering sociological and economical factors, TM is a vital healthcare resource in developing countries and it contributes positively to the primary healthcare delivery of the local populations, as usually TM appears to be more affordable and less expensive than pharmaceutical drugs for the majority of patients living in Africa. Considering the unstructured and unformalized problems facing Traditional Medicine (TM), bearing in mind that indigenous knowledge is being transferred or transmitted orally from father to son, mother to daughter or from master to disciple by apprenticeship. Therefore as time goes by, this knowledge tends to deteriorate or get lost when practitioner has no child or does not pick interest in TM. In almost all traditional societies today, the knowledge of traditional medicinal practices is most concentrated in the older generation of practitioners of TM (Kebede et al, 2006). Hence there is a rapid disappearance of genuine traditional practitioners and decline in authentic knowledge in traditional treatment (Kebede et al, 2006).

Due to the lack of a common and structured vocabulary specifically dedicated to ATM, as it is a particular and sometimes efficient way of many traditional healers in Africa to contribute to health issues of the native population, a well structured computational representation of ATM domain can therefore be used to manage knowledge and information gathered from the field practices. In addition, using the same concepts for the description of this domain in other similar ontologies would facilitate interoperability among them. To address these needs, this paper presents an ontology that describes the ATM domain, which can be used by experts of the field and the scientists' community with interests in the development and the expansion of a different way of treatment and cure. The benefit is the protection by the means of new technologies of many centuries of oral transmission knowledge, which is in the way of disappearance. The use of the ATM ontology intends to promote an harmonization and integration of data from diverse sources.

Our aim is to provide a formal approach for capturing knowledge about YTM and selecting the best medicinal plant for a given disease. To do so, first we need to have a formal model of YTM knowledge and then use this formal model to design a formal selection process of the best treatment of a given disease. As in many African countries, modern medicine is not accessible to the majority of people. Thus, a significant fraction of people, estimated to about 80%, use traditional medicine for their daily care. This is true both for rural and urban areas. For the WHO, the challenge is for any country to encourage local production of herbal medicines and their integration into the healthcare system of the country as this is seen as a way to improve the access to culturally sensitive primary care services. Information science, as it exists today, already provides many of the foundations for knowledge management. After all, the documentation tradition has a long history of developing methods and practices for organizing the vast expanses of human knowledge so that it is accessible by diverse users (Jurisica, 2004).

The rest of the paper is structured as follows. Section II exposes the state of the art concerning knowledge acquisition and formalization for YTM and Description Logics formalism. We outline preliminaries and background regarding the way research scientists and medical doctors capture practices of Traditional Medical Practitioners. In addition, a motivated case study from the West African sub-region (Yoruba) is presented in order to give an actual illustration of the reality in TM. We detail in Section III our approach of formal representation of a set of concepts of TM domain knowledge and their relationships. Section IV presents the framework used to implement the Description Logics ontology for YTM knowledge formalization and in Section V our approach is showcased through an illustrative example Herbal Alternative for Cure System. We demonstrate that the proposed formalization approach is capable of tracking and evaluating situations with medicinal plants that may affect Nigerian health. Finally, Sections VI and VII conclude and discuss future challenges.

2. TRADITIONAL MEDICINE TREATMENTS

From the start, it must be indicated that Traditional Medicine is holistic in approach. The patient is not only seen as a physical being, but also as a body with soul and spirit. The traditional healer seeks to strike some sort of equilibrium amongst these three components of the human being. According to Kafaru, (1990) this equilibrium can be brought about by herbs because herbs are natural and the patient's body which is only momentarily in disequilibrium is natural. Following this view, only nature can restore nature. Some of these means of treatment as Dime (1995) suggests are: Herbalism, therapeutic dieting, hydrotherapy, bone-setting, massage, psychotherapy etc. Some of these shall be briefly explained.

Herbalism is the application of herbs, roots, leaves etc to bring about cure. Herbs may be used alone or used with other components, such as animal and mineral products.

Therapeutic dieting is the aspect of Traditional Medicine which has to do with taking certain foods or avoiding certain foods. This form of traditional therapy is more common with traditional healers who are also spiritualist.

Hydrotherapy, traditional medicine involves water in various forms, which may be used alone or with other forms of treatments to achieve cure.

Bone-setting is a specialized aspect of traditional medicine. Many bone-setters are specialists whose only medical interest revolves around orthopaedics.

Massage, what the massager does is to use the fingers to trace where the problem is. This kind of treatment is effective in the treatment of muscle and bone problems and the proper functioning of the nerves (Dime, 1979).

Table 1: Some Yoruba Plants and their Medicinal Use (Source: Oladunmoye and Kehinde, 2011)

S/N	Local Name	Botanical Name	Common Name	Part(s) use	Medicinal Use
1	*Jaoke*	*Ehretina cymosa*	Puzzle bush	Leaves	Measles
2	*Otili*	*Cajanus cajan*	Pegeon pea	Leaves	Chicken pox
3	*Baba awodi*	*Capparis thonmoyi*	Capper bush	Leaves	Chicken pox, Measles
4	*Emiyemi*	*Psuedocera kotschyi*	Pseudocedrala	Stem bark	Hepatitis
5	*Ata*	*Capsicum annuum*	Bell pepper	Stem bark	Hepatitis
6	*Okuuku*	*Ancistropphylum secundi*		Roots	Measles
7	*Apasa (Inu-esu)*	*Ageratum conyzoides*	Goat weed	Leaves	Poliomyelitis, Measles
8	*Eeru*	*Xylopia cethipica*	Ethiopia pepper	Fruits	Measles
9	*Yanrin*	*Lactucal tarazacflora*	Wild lettuce	Stem bark	Poliomyelitis
10	*Osan jajan*	*Citrus ciurantifulia*	Lime	Leaves, Fruits	Measles
11	*Oruwo*	*Marinda luada*	Brimestone tree	Roots	Jundiai, Yellow Fever
12	*Tagin*	*Laganania breviflorus*	Pseodclocyth	Fruits	Small pox, Chicken pox
13	*Yanrin*	*Lactuca capensis*	Wild lettuce	Whole plant	Light chicken pox
14	*Ewe were*	*Momordice charantia*	Bitter cucumber	Whole plant	Jaundice, Yellow Fever
15	*Dongoyaro*	*Azadiranchita indica*	Neem tree	Stem bark	Jaundice
16	*Efinrin*	*Ocimum cannum*	Tea bush	Leaves	Jaundice
17	*Atare*	*Aframomum melejoeta*	Alligator pepper	Leaves	Measles
18	*Orogbo*	*Carcia cole*	Bitter cola	Roots	Small pox
19	*Taba*	*Nicotiance tabacum*	Tobacco	Leaves	Poliomyelitis
22	*Afomo*	*Viscum albus*	Mistletoe	Stem back, leaves	Hypertension, heart problem, insomnia, infertility

Table 2: XML table for Diagnosis and Health Status Description.

DiagID	Disease	Herbal Therapy	Parts Use	StatID	HealthSymp.
1	Yellow fever (Iba ponju ponto)	Ewere were + half bottle of boiled water	whole plant	1	Oju pipon (yellow eye)
4	Infertility+Diabetes	Powdered afomo + boiled water	stem bark	2	Watery sperm
4	Diabetes+Infertility	Powered afomo + boiled water	stem bark	8	Ito didun+watery sperm
5	Ulcer	Efinrin(Tea bush) + hot water + honey	Leaves	10	Inu didun

2. The Semantic Web and Description Logics

There are many different notations and languages for expressing knowledge content or ontologies (even within the logicist AI school alone) and the major problem hampering its universal usage is that of standardization. The semantic web (Hendler and van Harmelen, 2008) offers this possibility with the additional edge of making it possible to make representations available on the web. The popularity of semantic web based ontologies point to the current success of the standardization effort and the potentials it has to be the technology of the future. The most popular products of this standardization are the languages RDF, RDF(S) and OWL.

Resource Description Framework (RDF) is a language for representing simple assertions of the form (subject predicate object). This kind of assertions are represented as predicate(subject, object) in predicate logic. RDF only allows variables that are of a local scope. Otherwise, all arguments to its predicate must be ground values. RDF has no means for describing its predicates. RDF Schema (RDFS) provides the means to describing such vocabulary. RDFS allows class specifications and class and predicate hierarchies. RFDS also makes possible the drawing of inferences class membership and subclass relations. Neither RDF nor RDFS allow negation or disjunction (OR).

The language OWL has three sub languages OWL Lite, OWL DL and OWL Full. OWL is more expressive than RDF. OWL DL, (DL for description logics) is the most commonly used form of the OWL language. OWL has a model theoretic

semantics based on Description Logics. Description Logics (DL) are a decidable fragment of first order logic. The decidability of DL guarantees the possibility of building sound and complete reasoners for OWL DL. This makes it possible for OWL DL to provide tools that draw inferences concerning class membership, sub-concept relations among concepts.
Description Logics are a family of logic based knowledge representation languages designed for building terminological knowledge bases in a structured way (Horrocks, 1995). In DL there is a framework for defining concepts in a structured and stratified way.

Description Logic Language (DL) syntactically is expressed as;

$$AL = (T, \perp, \neg A, C \cap D, \forall r.C, \exists r.C)$$

where:
- T = *Universal Concept*
- $\perp$ = *Bottom Concept*
- $\neg A$ = *Atomic Negation*
- $C \cap D$ = *Intersection*
- $C \cup D$ = *Union*
- $\forall r.C$ = *Value Restriction and*
- $\exists r.C$ = *Limited Existential quantification that declares the existence of a relationship (or Role) to a concept C (called existential role restriction).*

To handle different kinds of relationships, we interpret concepts and relationship using Description Logics. For example, Some Mistletoes are herbal therapy, this can be interpreted as follows:

Examples:

"Some mistletoes are herbal therapy"

M(x) denotes ***x*** is a mistletoe
H(x) denotes ***x*** is herbal therapy

The statement can be symbolized as follows:

$$(\exists x)M(x) \rightarrow H(x).$$

The descriptions employ the ***'and'*** Boolean operator interpreted as set intersections, and the ***'or'*** Boolean operator interpreted as set union. In addition to this are two kinds of restriction constructors: the existential restriction operator ($\exists r.C$) and the value restriction operator ($\forall r.C$). The restriction operators have the following meaning in predicate logic using the meaning functions.

$$\pi_x(\exists r.C) \cong \exists y.\ r(x, y) \wedge \pi_y(C)$$
$$\pi_x(\forall r.C) \cong \forall y.\ r(x, y) \Rightarrow \pi_y(C)$$

Where $\pi_x(P) \cong P(x)$.

Similarly the operators are translated thus:

$$\pi_x(P \cap Q) \cong \pi\, x(P) \wedge \pi_x(Q)$$
$$\pi_y(P \cup Q) \cong \pi\, y(P) \vee \pi_y(Q)$$

Thus the translation of the definition of Herbal therapy above into predicate logic is as follows:

"Mistletoe(X) is a plant, which can be used to cure Hypertension(Y). Hypertension is a kind of ailment that affects patient(Z), the treatment relation holds between the plant and patients and patients are different from plant".

$$KB = Plant(MistletoeX), cure(MistletoeX, hypertension), \quad (1) \quad ailment(hypertension), affects(hypertension, patient), \quad (2)$$
$$\forall x,y,z : (ailment(y) \cap cure(x,y) \cap affects(y,z) \rightarrow curedBy(y,x), \quad (3)$$
$$\forall x,y : curedBy(y,x) \rightarrow plant(x) \cap ailment(y), \quad (4)$$
$$\forall x : (plant(x) \rightarrow \neg patient(x)) \quad (5)$$

Similarly, query can occur by saying:
ask(KB, cure(mistletoeX, hypertension))
ask(KB, patient(plant))

The answer to the first query is **YES** because mistletoe can be used to cure hypertension, while the second query answer will be **NO** because patient is not plant. As a result of the fact that Description Logics are a fragment of first order logic, it is less expressive than first order logic. In fact there are representational tasks for which DLs are not up to the task (Devambu and Jones, 1997). However they are very effective for terminological knowledge bases. There are many domains in which terminological knowledge bases are really needed.
One such domain according to Devambu and Jones is that of Software Engineering. Thus in spite of its limitation in terms of expressiveness, Description Logics are quite useful in a number of domains.

4. KNOWLEDGE REPRESENTATION MODELS

There is a diversity of knowledge representation languages that include mainly the graph-based approach (e.g. conceptual graphs and semantic networks) and the frame-based approach [e.g. Frames and Descriptions Logics (DLs)]:
The frame-based approach represents knowledge using an object-like structure (e.g. individual elements and their organized classes) with attached properties. The semantics of frames is not entirely formalized, whereas the fully defined set-theoretic semantics of DLs supports specialized defined deductive services (e.g. knowledge consistency and information retrieval).
Research within artificial intelligence has formalized interesting specialized ontologies and has developed techniques for using them to represent and analyze knowledge.

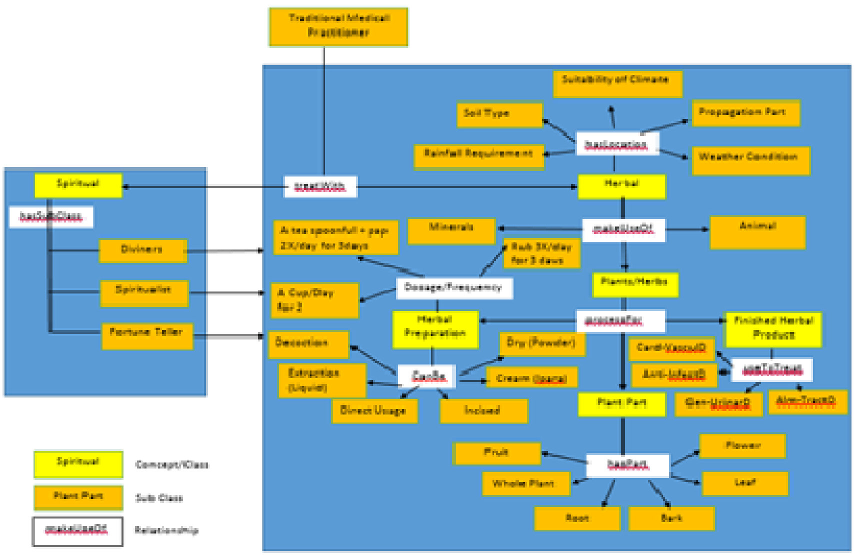

Figure 1: Conceptual Model of Yoruba Traditional Medicine (YTM)

Ontologies are now ubiquitous in many information-systems enterprises. They constitute the backbone for the Semantic Web as well as they are used in all e-activities domain. As a result, developers are designing a large number of ontologies using different tools and different languages. This work employ Web-based ontology specification language (OWL-DL language) in the context of the World Wide Web. At the same time as these ontology languages have been developed, tools have emerged for creating, editing and managing ontologies written in the various languages. Protégé 4.3 is used to build ontology in YTM. (See Figure 2 and 3)

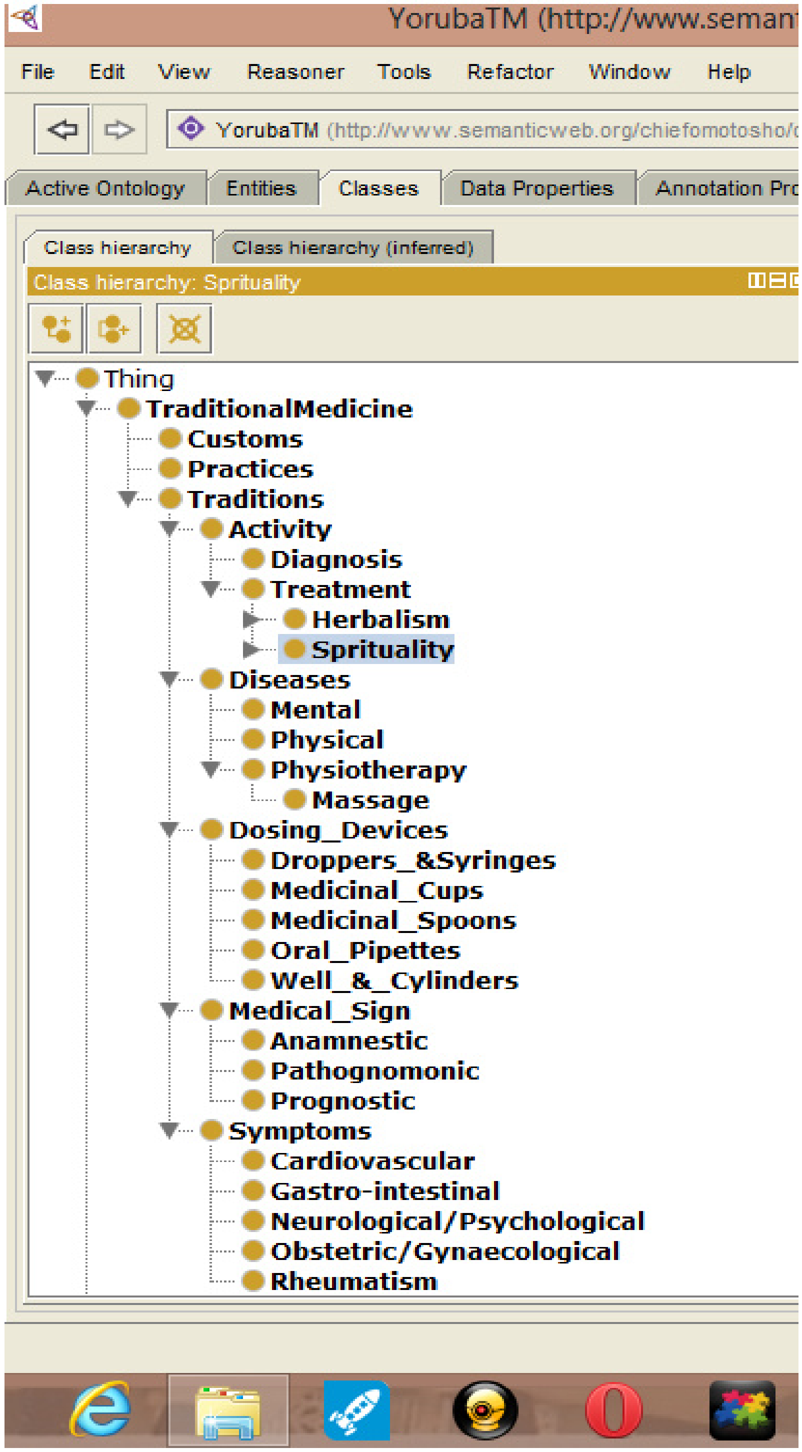

Figure 2: Ontology Class Hierarchy of YTM

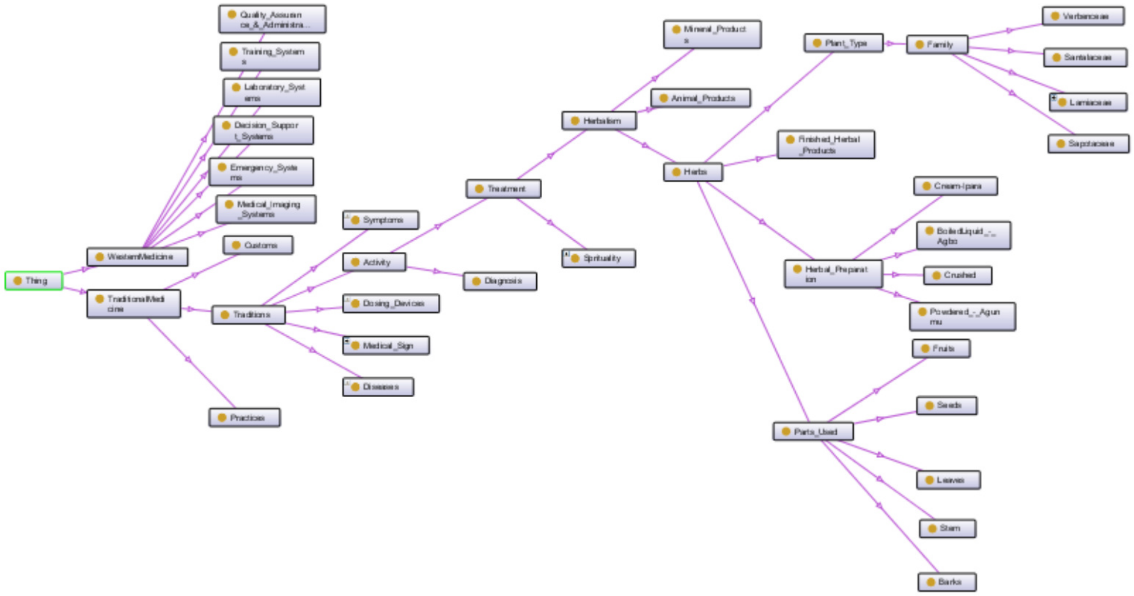

Figure 3: Ontology Encoded in OWL-DL format

5. DEVELOPMENT AND APPLICATION OF ONTOLOGIES IN TRADITIONAL MEDICINE

For a given domain, the representation of relevant knowledge can be based on primitive concepts derived from any one or all of the proposed four ontological categories. Regardless of which category is used to cover a particular application domain, information system development benefits from using tools that support ontology design and integration processes. For example, DAML and OIL define a semantic markup language for Web resources (Connolly et al. 2001; Horrocks et al. 2002). DAML (the DARPA agent markup language) has been designed as an extension of XML (extended markup language) and RDF (resource description framework). It offers a language and tools developed to facilitate the concept of the semantic web. OIL (an Ontology Interface Layer) provides classification using constructs from frame-based AI, combined with the expressiveness and reasoning power of description logics. DAML+OIL provides modelling primitives similar to ones defined in frame-based languages and a set of constructs for creating ontologies (Fensel and Rousset 1998). Ontolingua supports authoring ontologies by providing tools for assembling and enhancing a library of modular, reusable ontologies (Gruber 1992). Once ontologies are defined for one or several domains, they may be organized into libraries, thereby enhancing their reusability (Van Heijst et al. 1995).

6. DISCUSSION

Current literature on knowledge management generally agrees that the main challenges ahead lie in the realm of organizational culture and practices (Ruggles 1998). However, the impact and potential of advanced information technologies, both positive and negative, should not be underestimated. Given today's vast, complex and dynamic information environments, the potential for using information technology to help discover, deliver and manage knowledge is enormous (Jurisica et al. 2001). Unfortunately, the pitfalls are also plentiful. This is why the complementary use of concepts and techniques from information science and information systems is crucial. The ontological approach with an information modelling bias described in this paper derives its power from formal models of domain knowledge. Such models can be formally analyzed and processed for useful purposes. However, many domains resist precise formalization. In such domains, formalization can become a straitjacket. For this reason, formal modelling techniques need to be integrated with informal ones. For instance, the Unified Modelling Language (UML) has gained a foothold in software engineering practice, even though parts of it are informal. Informal models can help understanding a domain and bring consensus among collaborating software engineers. Here again, the experience and expertise in information science for dealing with much more open-ended kinds of human knowledge can be invaluable. Technical frameworks are increasingly paying attention to these factors, as exemplified in the intentional and social ontologies outlined above. However, technological support for dealing with these issues, such as con- textual mechanisms for knowledge scoping and sharing, multiple perspectives and meanings, negotiation support, knowledge evolution, etc., can only be partial – again due to inherent limits to the formalization of human knowledge.

Figure 4: Snapshot of HAFC Home page

The home page interface of Herbal Alternative for Cure is as shown above. In this module the user is able to log onto the web portal for the consultation.

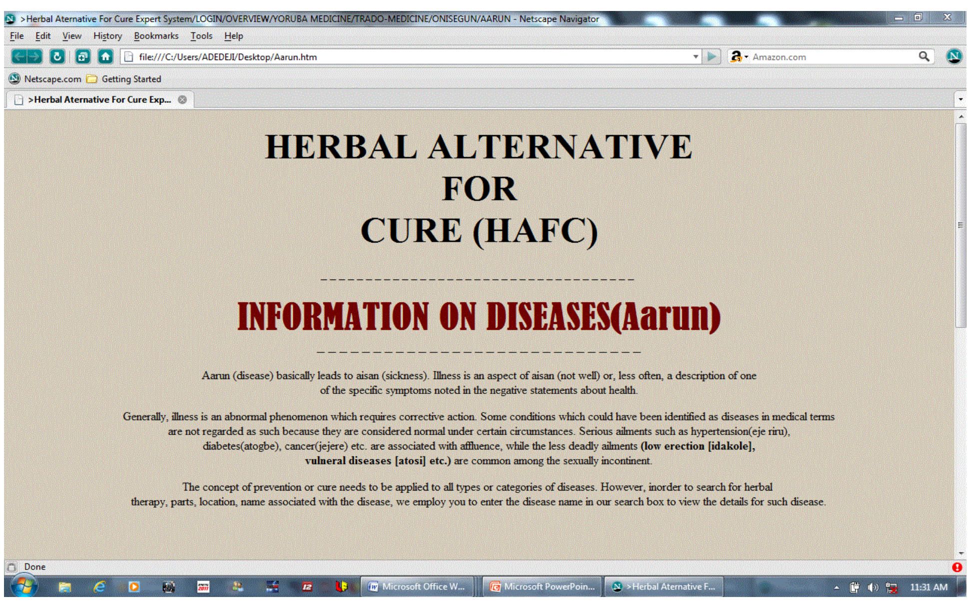

Figure 5: Snapshot of HAFC Disease Information

In this module user is privileged to consult (using symptoms as input), the output is more information about the disease, , herbal therapy and how to apply the herbs

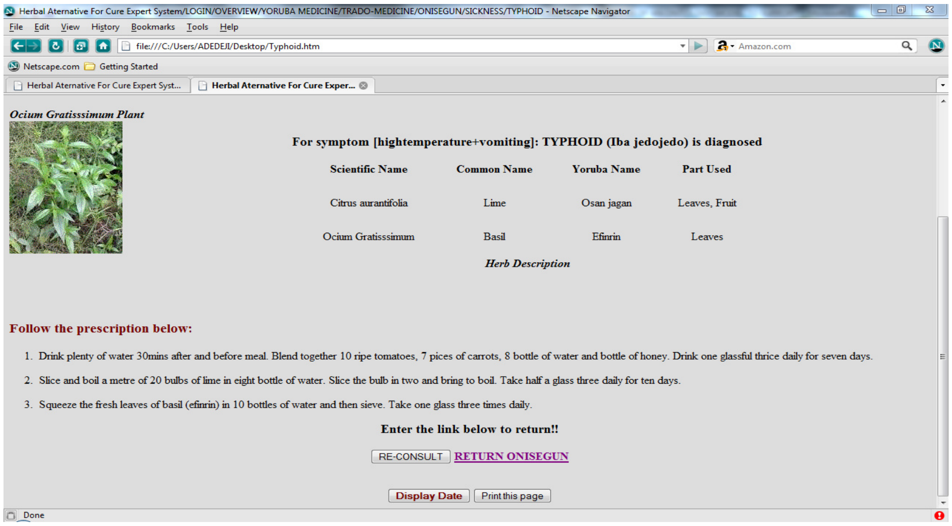

Figure 6: Snapshot of Herbal Therapy Prescription

7. CONCLUSION

The developed ontologies in this research (as shown in figures 2 and 3) illustrate the idea how ontology bridge the gap between chaos of unstructured data (names of different models and techniques for knowledge representation) and clear knowledge of modern classification. Our approach shows that ontology development process needs some creative efforts of meta-concepts definition that helps to name the groups and structure the chaos. These ontologies may be used as an assessment procedure. Researchers show their knowledge and understanding while creating ontologies. Knowledge entities that represent static knowledge of the domain are stored in the hierarchical order in the knowledge repository and can be reused by other Practitioners. At the same time those knowledge entities can be also reused in description of the properties or arguments of methods of another knowledge entity. On the other side, Medical Practitioners should be aware with the ontology-based approach as a robust technique for knowledge representation. This work is also a contribution to the collective efforts aimed at achieving the educative goals, by ensuring that the necessary indigenous knowledge been handed down by traditional healers are well preserved to prevent further loss of these valuable assets from generation to generation. The methodology used in development of this project was based on data collection, documentation, and site-visits to traditional medicine practitioners. It was designed on a windows platform as front-end, Java (for scripting) and MySQL (database as back-end). Our approach presents the advantage of militating knowledge loss with conceptual development assistance to improve the quality of YTM care in terms of medical diagnosis and therapeutics.

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