Building a Computational Ontology Model for Yoruba Traditional Medicine Knowledge Management.

Omotosho, L.O., Akanbi, C.O & Ogundoyin, I.K.
Department of Information & Communication Technology,
Osun State University
Osogbo, Nigeria.
akanbico@uniosun.edu.ng

ABSTRACT

Ontological modelling encourages standardization of terms used to represent knowledge about a domain by providing means of rep-resenting conceptual knowledge using expressive formal logics. In Yorubaland, most of people like to use herbal medicine for their traditional medical treatment. Information related to the use of herbal medicine are scattered across various data sources and they are repre-sented in an unstructured manner. This paper develops a theoretically-grounded computational ontology and tackles a number of conceptual modelling problems in Yoruba Traditional Medicine world-view. The formal computational ontology model was designed and implementa-tion was done using Protege 4.3, proof of concept was used to validate the model developed.

Keywords: Herbal medicine, ontology, inference, health care de-livery, knowledge representation.

1. INTRODUCTION

Traditional Medicine is a body of knowledge that has been developed and accumulated by African thousands of years ago, concerned with examination, diagnosis, therapy, treatment, prevention and rehabilitation of the general well-being of humans (Ritcher, 2003). Adebisi and Gbagir (2006) stated that herbal medicine is a well-recognized system of medicine throughout the world and is used as remedies for illness such as fever, diarrhea, sore throat, sinus problems, respiratory problems and skin condition.

There is increased worldwide attention on alternative (herbal) medicines as a result of `increased side effects and lack of curative treatment for several chronic diseases, as well as high cost of new drugs, microbial resistance, and emerging diseases (Patwardhan et. al., 2005). Wangchuk (2008) reported that out of 30,000 human diseases or disorder only one-third can be cured with modern medicines. The reason of this is because of the fact that the drugs available today are not very effective to fight against drug resistant pathogens and newly emerging infections. Therefore it is important to pre-serve the value of these medicinal and economical resources and its vast valuable indigenous knowledge. The need for computing artefacts about herbal medicine emerges in the context of the development of software for medical decision support system using appropriate ontological engineering.

Ontology, originally a fundamental part of philosophical inquiry, is concerned with the analysis and categorization of what exists. In recent years, a complementary focus of ontological inquiry gained significant momentum, fueled by the advent of complex information systems which rely on robust and coherent formal representations of their subject matter.

The systematic study of such representations, their axiomatics, their corresponding reasoning techniques and their relations to cognition and reality, are at the center of the modern discipline of formal ontology. Formal ontology in this modern sense is now a research focus in such diverse domains as conceptual modeling, database design, software engineering, artificial intelligence, computational linguistics, the life sciences, bio-informatics, geographic information science, knowledge engineering, information retrieval, and the semantic web. Ac-cording to Gruber (1993), ontology in the context of computer science is `a description of the concepts and relationships that can exist for an agent or a community of agents; it is generally written as a set of definitions of formal vocabulary'. It is an explicit and formal conceptualization of a domain of interests (Gruber, 1993). `Representation of entities, ideas and events, along with their properties and relations, according to a system of categories' are common in Ontology in both philosophy and computer science. There are extensive works on `ontological relativity' in both fields (Diego and Luciano, 2011).

This research aims to develop an ontology-based framework for representing Yoruba Traditional Medicine. To this aim, the rest of the paper is structured as follows. Section 2 focuses on review of relevant literature. Section 3 discusses the main ontology development methodologies and how we have adapted different methodologies to de ne the Yoruba Traditional Medicine domain ontology. Section 4 is about result and discussion. Finally, section 5 is devoted to conclusion and future research direction.

2. LITERATURE REVIEW

African traditional medicine has an important place in health care delivery among Africans. It is a first point of call before \western" or \orthodox" medicine and a last resort when all orthodox e orts fail (Adeshina, 2012). African is endowed with many plants that can be used for medicinal purposes to which they have taken full advantage. Approximately, 64,000 plants species are used in tropical Africa, more than 4000 are used as medicinal plants (Sofowora, 2008). Medicinal plants are used in the treatment of many diseases and ailments, the uses and effects of which are of growing interest to WM. Yoruba Traditional Medicine (YTM) has an important place in health-care delivery among Africans. Africans do not see medicine as inanimate pills or solutions; rather medicine is seen as that with its owl vital force (Adeshina, 2012). However, the use of natural methods to treat patients is often employed. Medicinal preparations (remedies) made up of mixture of roots; leaves, herbs, fruits, parts of animals, etc. These are compounded into various forms to treat various diseases. The remedy type may include: concoction, decoction, ointment and soap, powders and liquid (Olatokun, 2010). Some of the plants used in the treatment of various diseases include:

Developing ontologies that cover domain and application can be used not only to support system integration but also system development by reusing the ontology. Fonseca (2009) proposed that ontologies should deal with general assumptions concerning the explanatory invariant of a domain using identification and measurement of the object along dimensions of possible variations which will represent a natural evolution in the field of modeling, but limitation emphasizes on links between ontologies and conceptual schema still remains unclarified. Another category of developing ontology was introduced in Jurisica et. al. (1999) where he analyzed past frameworks used in knowledge representation (i.e. static, dynamic) then relates techniques to in-formation science in the domain of knowledge management research, however, was unable to come to a standard in knowledge capturing and formalization compared to the existing works.

Some of the ontology modeling tools have been reviewed such as, work on Chen-Heui and Fatemeh (2008), that identifies the instances and relationships of the web elements and coded using XML. The XML schema is visualized as a DOM tree. Protege (Gennari and Musea (2002)), helps knowledge engineers and domain experts to perform knowledge management tasks. It includes support for class and class hierarchy with multiple inheritances, slots having cordially restrictions, default values, inverse slots, meta-class and meta-class hierarchy. However, the work here was unable to explicitly formalize knowledge in the domain world-view.

Table 1: Plant materials, preparation and method of administering some traditional medicines for treating typhoid fever (Source: Adebisi and Gbagir (2006)

S/N	Plant materials	Preparation	Unit of measurement and method of administration
1	Leaves of *Pennisetum purpureum*, *Cajanus cajan*, *Chromolaena odorota*, leaves and roots of *Morinda lucida*, roots of *Nauclea latifolia*, dropped leaves and roots of male *Carica papaya* and its sliced unripe fruits, bark of *Anthocleista djalonensis*, bark and dropped leaves of *Blighia sapida*, bark of *Khaya grandifolia*.	These are all put together in a pot and clean water added. It is boiled for 30 minutes.	Tea cup of the extract is taken three times daily for a whole week.
2	Bark of the fruit of *Cocos nucifera*, and *Alábùkún* powder.	The coconut is decocted.	Half tea cup of the decocted coconut is taken twice daily with the *Alábùkún* powder for a week.
3	*Kigelia africana*, *Citrus medica*, fruits of *Ananas comosus*, leaves of *Ficus exasperata*, water from pap (Ẹ̀kọ àkàmù).	The materials are put together and boil in pap water.	A tea cup is taken three times daily for one week.
4	Roots and leaves of *Calotropis procera*.	These are boiled for 30-40 minutes.	A tea cup is taken twice daily.
5	Roots of *Nauclea latifolia*, fruits of *Colocynthis citrullus*.	These are boiled together in water for 30 minutes.	A full tea cup is taken 3 times daily.

3. Methodology

3.1 Building Yoruba Traditional Medicine Ontology.

In order to develop the ontology presented in this paper, the methodology outlined in Figure 1 has been followed. The methodology (which is iterative process) was divided into phases: Specication, Conceptualization and Implementation according to METHONTOLOGY Framework, This frame-work provided the idea of support activities: Knowledge Acquisition and Validation/Verification

3.1.1 Specication Phase: Domain Elicitation

The goal of the specication phase is to acquire informal knowledge about the domain. In YTM knowledge elicitation, interactive discussions and participant observations were used to collect facts from people who are knowledge-able about herbal medicine. To really understand the basic fundamentals of YTM, it was observed that there are so many ways by which different cultures approach the issue of ensuring healing and good health of the people. Some cultures deal extensively with physical well-being of the people alone. This is achieved by providing a curative process to physical diseases and ailments. This is characteristic of Western Medicine. But Yoruba culture, not only heal the physical ailment, but it also ensures the healing of the spiritual part of the patient. This is what is referred to as the holistic healing (Gbadegesin and Frederick, 1988). To achieve holistic healing, there is the need for the understanding of the constitution of man. Abimbola (2006) argues that a person has two parts which are the physical body (ara) and the soul complex (emi, ori, ese). For Makinde (1988), a person in the Yoruba belief is made up of ara, emi and ori-inu This ultimately distinguishes Yoruba traditional healing from other mode of healings.

The question that readily comes to mind is why is it not possible for the Yoruba traditional system of medicine to be made empirically verifiable. In the orthodox medicine, the ingredients used, the proportion of mixture and the precision of use are all clearly specied, i.e. it is empirically verifiable. To achieve standardization in YTM, ontology construction is needed.

3.1.2 Conceptual Phase: Domain Conceptual Model

The conceptualization phase is to organize and structure this knowledge using external representations that are independent of the implementation languages and environments. The YTM conceptual model was transformed into a formal model by writing it in a formal form. Figure 2 shows conceptual
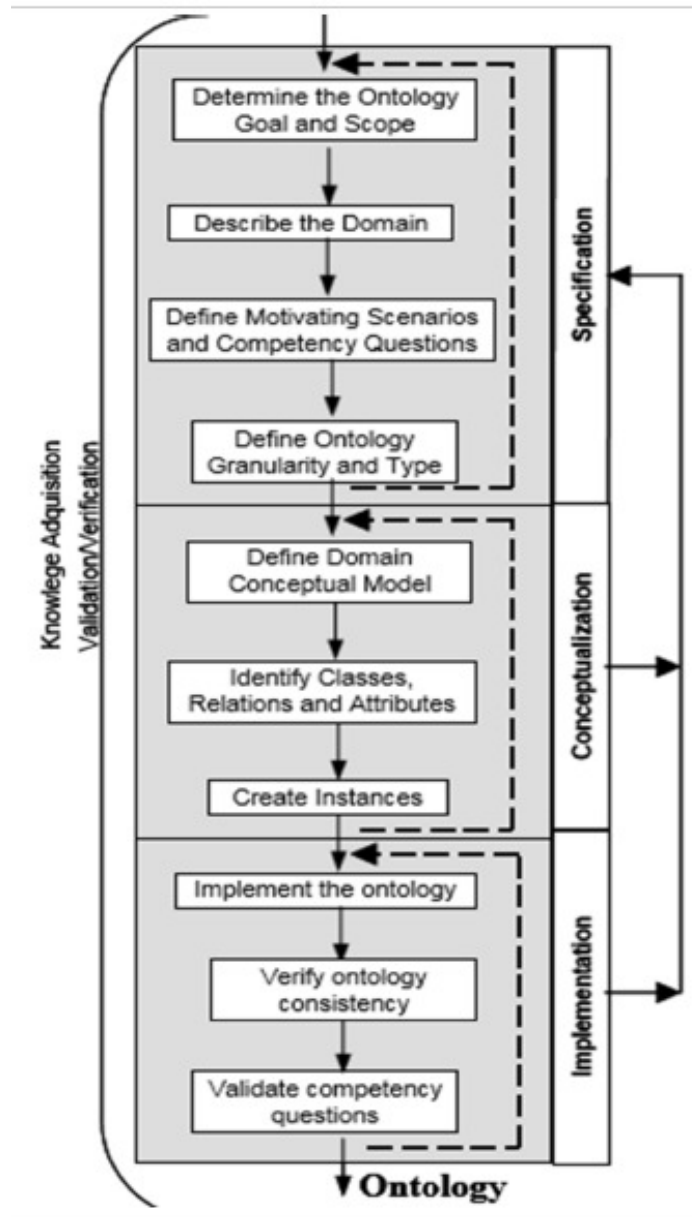
Figure 1: A Domain Ontology Development Process (Source: Brusa et. al. (2006))

Model diagram for the Yoruba Traditional Medicine. The necessary concepts and the relationships between the classes are shown. Example of such concepts include Disease, Herbal Medicine, Plant Parts, Animal Product, Mineral Resources etc and the relationships include isUsedBy, isA, treatWith, partOf, isUseToTreat etc. These are shown in an hierarchical form.

3.1.3. Formalization Phase: Description Logics and Inference Engine

The formalization phase transforms the conceptual model and domain ontology into semi-formal representation, this can be done either in Description Logics or UML formalisms (Fahad et. al. (2008); Ceccaroni and Kendall (2003)). In this section, we present the transformation of the conceptual model or domain ontology into its semi-formal representation, using Description Logics (DLs).

Description Logics (DL) are knowledge representation formalisms used to describe concepts in a given domain. A knowledge base (KB) described in DL has two components, the TBOX and the ABOX. The TBOX introduces the terminology, i.e., the vocabulary of an application domain, while the ABOX contains assertions about named individuals in terms of this vocabulary. The vocabulary consists of concepts, denoting sets of individuals (identifed objects of the domain), and roles (binary relationships between individuals).
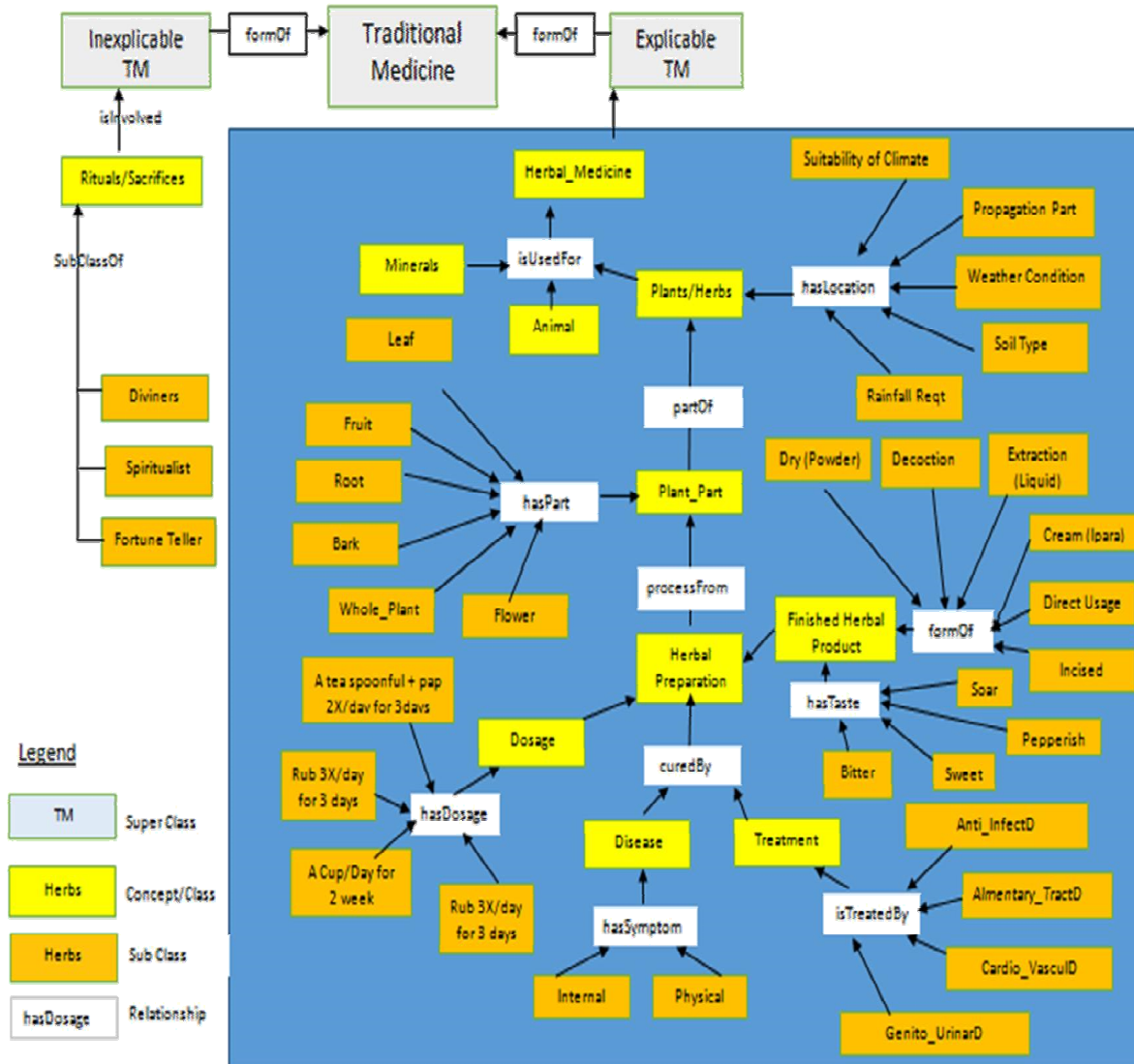

Figure 2: A Proposed Conceptual Model for Yoruba Traditional Medicine Ontology

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:

M(x) denotes x is a Mistletoe

H(x) denotes x is herbal therapy,

This statement can be symbolized as;

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

Due to the universal quantifier, the variable x in the logical formula ranges over all domain objects and its reading is *everything that is a plant is also a herbal therapy.* Other parts of the network can be further restricted using logical formulas, as shown in the following example;

Herbal Therapy cures Disease

$$\forall x, y : (cures(y, x) \rightarrow HerbalTherapy(x) \cap Disease(y))$$
$$\forall x : \exists y : (Disease(y) \rightarrow HerbalTherapy(x) \cap cures(y, x))$$

Reasoning about Knowledge

The basic operations a knowledge-based system can perform on its knowledge base are typically denoted by;

1. The tell-operation which adds a new statement to the knowledge base and
2.   The ask-operation is used to query what is known (Russel and Norvig, 2003).

As an example, consider the following knowledge base with sentences in predicate logic.

predicate logic.

$KB = person(mister(x)), prescribes(mister(x), herb(z)),$
$Disease(Cancer(y)), cures(mistletoe(z), cancer(y),$

$$\forall x, y, z : (Cancer(y) \cap prescribes(x, z) \cap cures(z, y) \rightarrow treatedBy(y, z)),$$
$$\forall x, y : (treatedBy(y, x) \rightarrow practitioner(x) \cap cancer(y)),$$
$$\forall x : (Person(x) \rightarrow \neg herb(z))$$

The knowledge-base (KB) explicitly states that *"MisterX is a practitioner who diagnoses and prescribes mistletoe to cure cancer affecting patient"*, that *"diagnoses and prescription are employed to cure cancer"*, that *"the treatment relation holds between practitioner herbal therapy"* and that *"persons are different from herb"*. If we ask the question

"Is cancer treatedBy practitioner?" by saying

$$ask(KB, treatedBy(cancer(y), practitioner(x)))$$

the answer will be YES. The knowledge-base KB entails the fact that *"cancery is treated by Misterx"*, that is, $KB \vDash treatedBy(cancer(y), Mister(x))$. This follows from its general knowledge about the domain. A further consequence is that "Misterx is a practitioner", that is, $KB \vDash Practitioner(Misterx)$, which is reflected by a positive answer to the question,

$$ask(KB, practitioner(Misterx)).$$

Another important notion related to entailment is that of consistency or satisfiability. Intuitively, a knowledge base is consistent or satisfiable if it does not contain contradictory facts. If we would add the fact that "Mistletoe is a person" to the above knowledge-base by saying;

$$tell(KB, Person(Mistletoe(z))),$$

It would become insatisfiable because persons are said to be different from herbs. In general, an insatisfiable knowledge-base is not very useful, since in logical formalisms it would entail any arbitrary fact. The ask-operation would always return a positive result independent from its parameters, which is clearly not desirable for a knowledge-based system. The inference procedures implemented in computational reasoners aim at realizing the entailment relation between logical statements (Russel and Norvig, 2003). They derive implicit statements from a given knowledge-base or check whether a particular statement is entailed by a knowledge-base.

3.1.4 Implementation Phase: Ontology Visualisation and Query

The semi-formal version of the ontology is formally represented in one of Semantic Web Language with ontology editing platforms. In order to implement the ontology, we chose Protege 4.3 because of the fact that it is extensible and provides plug-and-play environment that makes it a exible base for rapid prototyping and application development (Knublauch et. al., 2005). YTMO classes, object properties and data properties were created. To compare the ontology implementation with its conceptualisation, graphics using the OWL-Viz and Ontoviz plug-ins were generated. OWL-Viz enables the class hierarchies in OWL ontology to be viewed, allowing comparison of the asserted class hierarchy and the inferred class hierarchy.

In this defined classes can be distinguished and inconsistent concepts are highlighted in red. Figures 3 and 4 show the domain ontology taxonomy and the ontology visualisation.

3.2 Consistency Checking

Ontology consistency checking is very important as it identifies the duplicating instances or instances that are clustered according to their sources in the same ontology which may decrease the usefulness of the ontology. Figures 5 and 6 show the implementations. In order to check such inconsistencies we used Protege[9]. Before using Protege, we carefully checked our ontology for any modelling inconsistencies such as wrongly associated concepts or inconsistent data property definition, relationship and property labeling. After this, we perform reasoning in Protege by utilizing a Description Logic Reasoner. One can use different reasoning tools, such as Racer, Pellet and FACT++ (to check the consistency of an OWL ontology and a set of data descriptions along with ending implicit subclass relationships induced by the declaration in the ontology) to perform intelligent reasoning on OWL ontologies. These reasoning tools can help in assessing the overall consistency of the ontology. We used FACT++ to evaluate our ontology due to its relatively easy interface with Protege. Similarly, in the case of a query, first of all, the query will be sent to.
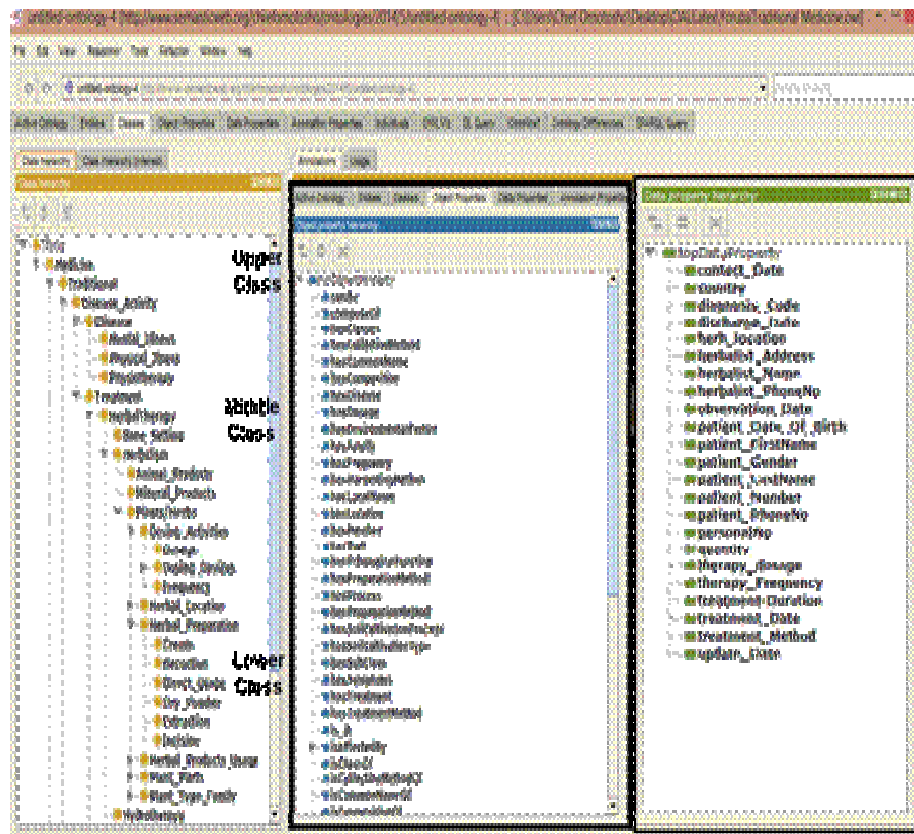

Figure 3: Yoruba Traditional Medicine concepts, object properties and data properties.
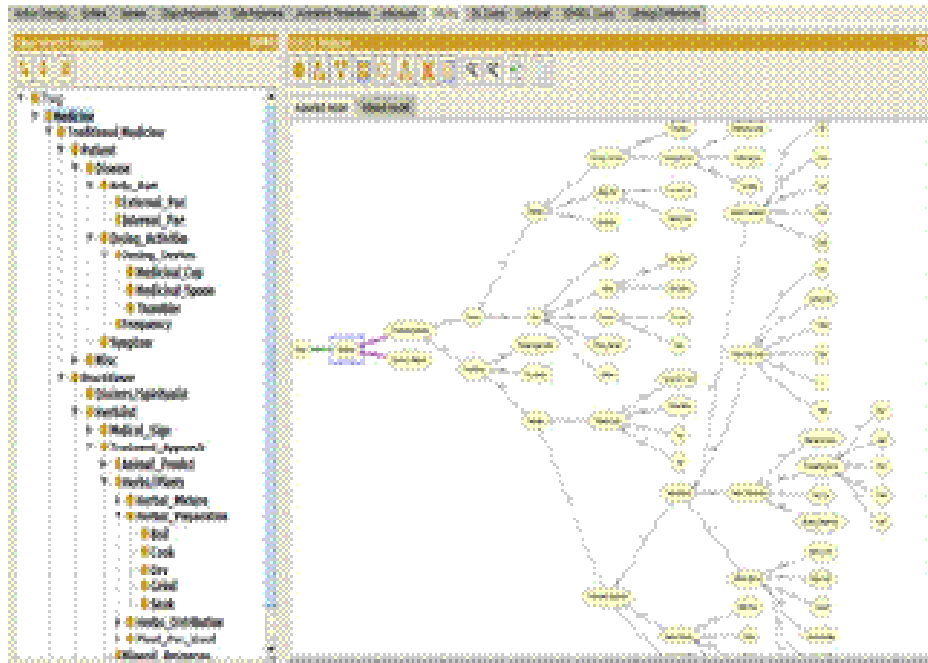
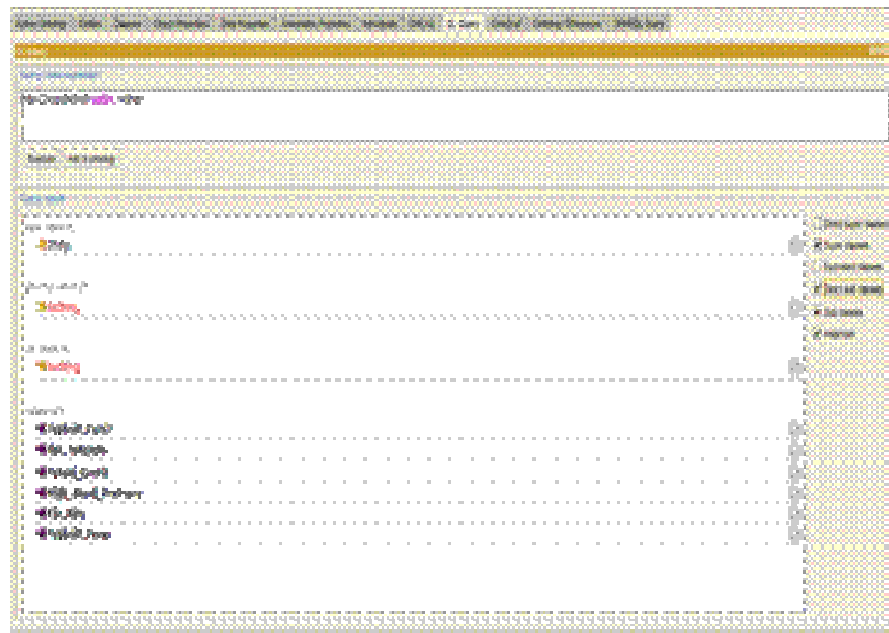**Figure 4: Yoruba Traditional Medicine concepts and Owlviz.**

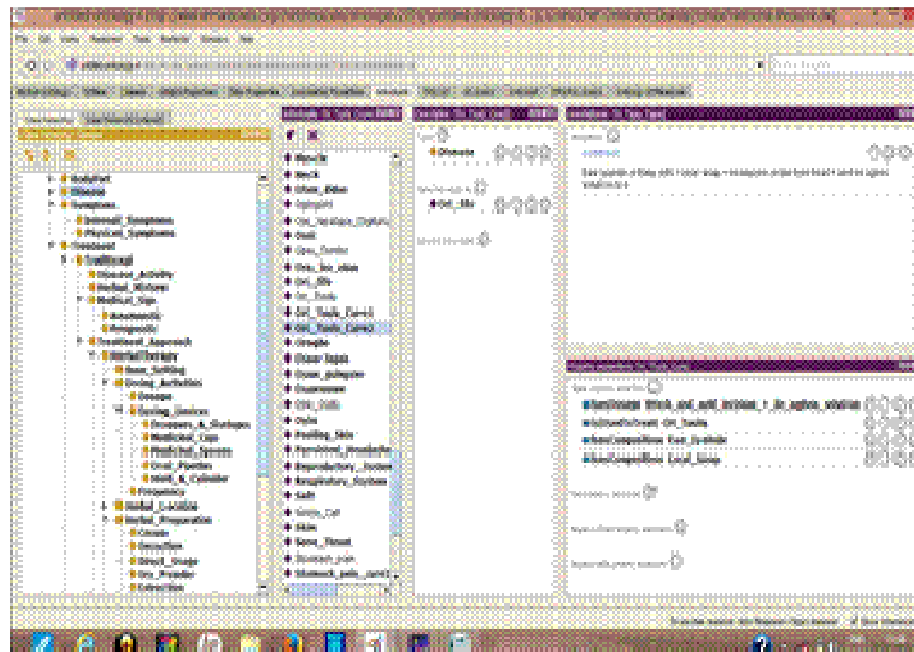**Figure 5: Query about Diseases having Composition `Water'**

Figure 6: YTMO Instances

Figure 7: Yoruba Traditional Medicine Diagnosis Page.

The ontology reasoner to check its consistency against the ontology rules; if no inconsistencies are found, only then will the query be processed, otherwise an error message will be returned to the requester. In order to verify the accuracy of the ontology, DL query was used to test for the satisfiability of the ontology. Overall, the checking indicates that our approach is consistent and can offer annotation suggestions for computer-assisted ontology development which requires less human effort.

4. RESULTS AND DISCUSSION

In demonstration of how the ontological framework functions, a number of screen shots were taken from the application developed and the functionality is discussed in this section. The home page interface comprise of other graphical user interfaces GUI which is an interface between the user and the database. It is where the user can query the database for the desire information about herbs working for an ailment . One of the important buttons in the home page is the data entry button. When selected it invokes the Data entry interface for the herbal data in the database, with its individual botanical hierarchy names or botanical taxonomy such as the Family, Gen-era/Genus, Specie(s), and Common Name, Yoruba Name, the herbal cures and all other necessary information as shown in Figure 7. The system can extract herbal remedy for a specific illness. An example of this is shown in Figure 8. which shows two alternative herbal remedy for `Typhoid'. The Yoruba name for the herb is shown for the herb in order to make it easy

Figure 8: Yoruba Traditional Medicine Prescription Page.

For the indigenous user to apply knowledge from the ontology to care giving. This solution thus provides a formal platform for the local (Yoruba) user to provide primary and secondary healthcare from a knowledge-based system. This is the main trust of this work.

5. CONCLUSION AND FUTURE RESEARCH DIRECTION

In this paper we have demonstrated the technical aspects and features of the ontology construction. Particularly, this approach has been used to de ne a domain ontology for YTM, which could be extended by task ontologies and used by different medical applications. The YTMO so developed will assist in the development of the Decision Support System for Yoruba herbal medicine as well as to preserve , share and discover new herbal medicine knowledge among the communities of practice. Also it serves as a vital tool in promoting and accommodating the growing demands of the economic sector in herbal medicine. To make knowledge of YTM more easily accessible in the future, there are plans to conduct a study to strengthen the treatment supporting functions and link them with other services that utilise ontology. Furthermore, a study to construct a system that can help practicing practitioners by including traditional medical knowledge in the ontology is also necessary.

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