Knowledge-based Service for African Traditional Herbal Medicine: A Hybrid Approach

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Abstract: Globally, the acceptance and use of herbal and traditional medicine is on the rise. Africa, especially Ghana, has its populace resorting to African Traditional Herbal Medicine (ATHMed) for their healthcare needs due to its potency and accessibility. However, the practice involving its preparation and administration has come into question. Even more daunting is the poor and inadequate documentation covering the preservation and retrieval of knowledge on ATHMed for long-term use, resulting in invaluable healthcare knowledge being lost. Consequently, there is the need to adopt strategies to help curtail the loss of such healthcare knowledge, for the benefit of ATHMed stakeholders in healthcare delivery, industry and academia. This paper proposes a hybrid-based computational knowledge framework for the preservation and retrieval of traditional herbal medicine. By the hybrid approach, the framework proposes the use of machine learning and ontology-based techniques. While reviewing literature to reflect the existing challenges, this paper discusses current technologies suited to approach them. This results in a framework that embodies an ontology driven knowledge-based system operating on a semantically annotated corpus that delivers a contextual search pattern, geared towards a formalized, explicit preservation and retrieval mechanism for safeguarding ATHMed knowledge.

1 INTRODUCTION

The idea of providing treatment to ailments or diseases has, over the years, seen various methods being applied, with each having to show its own potency and often attributed to a specific region or country. The case of Ghana is not different as the use of such methods is either orthodox or traditional. Before the introduction of orthodox medicine, many a Ghanaian took to the use of traditional herbal treatments, of all sorts, to help cure all forms of diseases. Still, the use of African traditional herbal medicine (ATHMed) is widespread in Ghana, as an estimated 70% of the population obtain healthcare through traditional healers (Amoah et al., 2014), especially with rural communities. Interestingly, preference for traditional medicine is on the rise worldwide (Frass et al., 2012; Zhang, 2004). The preparation of ATHMed is often in various forms with ingredients (herbs) and methods which are usually in the keep of the practitioners.

Predominantly and habitually, this knowledge, as classified by Nonaka and Takeuchi (1995), is tacit, which does not suit the view of long-term use and preservation of such valuable knowledge. Tacit knowledge comprises of the skills, ideas and experiences people possess, which are hard to access and transfer (Chugh, 2018, p. 2), in this case the ATHMed practitioners in Ghana. There are many cases where in an attempt to remain relevant, herbal practitioners (traditional healers and herbalist) pass on the knowledge to only their close allies or families. This often leads to the likelihood of such knowledge being either lost or failing to be developed over time (Amoah et al., 2014). In the case where the knowledge is not shared at all, the practitioner eventually dies with the knowledge. Furthermore, due to the absence of proper documentation on the choice selection of ingredients, methods of drug preparation and administration, some ATHMed patrons often doubt the efficacy of these medications. There have been reported instances of "misinformation and abuse

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of traditional health knowledge" (Yeboah, 2000: p. 208) which poses negative consequences to the health of ATHMed patrons. With these concerns, this study seeks to develop a framework for preserving and retrieving knowledge in traditional herbal medicine.

Throughout history, attempts and varying approaches have been developed and implemented in order to safeguard, as well as, disseminate knowledge. This is to ensure posterity and present benefit from works, acts, processes, information and all relevant data that will help improve or maintain personal to organizational development needs. Knowledge is regarded as key to any organization's present and future growth, and competitive advantage especially in the 21st century (Xue, 2017; Davenport and Prusak, 1998), with its basis being often formed by, but not limited to, data and information.

To help salvage and standardize such practices in the area of ATHMed, the United Nations Millennium Development Goals and the World Health Organization (WHO) has recognise the need to promote and support the development of traditional herbal medicine by launching the Traditional Medicine Strategy 2014–2023 (WHA62.13)[1]. Key amongst its strategic objectives is "to build the knowledge base for active management of Traditional, complementary and integrative medicine through appropriate national policies". In view of this advocacy, these researchers propose a novel model and knowledge-based framework using computational ontologies and machine learning to help in the preservation and retrieval of traditional herbal medicines. In this paper, we have suggested a framework fit for use in Medical Institutions of Higher Education (IHE) and herbal businesses where the knowledge of herbal medicine, sourced from "deep smart" knowledge bearers, is imparted to students who are, potentially, future herbal doctors.

2 BACKGROUND

2.1 Traditional Herbal Medicine

According to the World Health Organization (WHO), traditional medicine deals with "knowledge, skill, and practices based on the theories, beliefs, and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness" (WHO, 2018, p. 1). Herbal medicines also encompass "herbs, herbal materials, herbal preparations and finished herbal products that contain as active ingredients parts of plants, or other plant materials, or combinations" (WHO, 2018, p. 1).

The Government of Ghana realising such a need has setup the Centre for Scientific Research into Plant Medicine to lead the way in the preparation and standardization of herbal medicine in Ghana (Amoah et al., 2014). In recent times, attempts are being made by Universities in Ghana to train pharmacists in the area of indigenous African herbal medicine treatment. Two universities, Kwame Nkrumah University of Science and Technology and University of Ghana, are currently offering degree programmes at the undergraduate level and training programs in an attempt to assist in formalizing the training of professionals in herbal medicine. However, their focus has mainly been to help curb the challenge related to the Ghanaian traditional herbal medicine practitioner's accurate measurement of ingredients for drug preparation with issues on quality. The universities also strive to provide strategies for long-term preservation, appropriate forms of administration, and administering right dosage of such herbal drugs. For instance, the University of Ghana[2] in 2016 organized a 2-day face-to-face training programme for manufacturers of herbal products/food supplements, focusing on the improvement of safety and efficacy, evaluation of raw materials, toxicological assessment, quality and standardization in Ghana. These interventions seek to harness the potential of herbal medicine, providing orthodox and scientific approaches to standardizing and safeguarding the knowledge associated with it, and the practices in applying medication. This attempt also assists in documenting and preserving practices and medications associated with African traditional herbal medicines (ATHMed) which hitherto was in the domain of the practitioner. Failure to undertake such interventions would in the end lead to loss of this indigenous yet efficient medicinal approach (Boadu and Asase, 2017).

To address the problem, a computer-aided approach is suggested. The applications of information technologies have been experienced in many fields of study and are described to be a viable, sustainable mechanism for long-term storage (preservation) and information sharing (retrieval)

[1] http://www.who.int/traditional-complementary-integrative-medicine/en/

[2] https://www.ug.edu.gh/announcements/2-day-training-programme-manufacturers-herbal-productsfood-supplements

resident in the domain of knowledge management. To this end, a knowledge-based framework for preserving and retrieving ATHMed in the service pharmaceutical sector and assistive of formal learning in Medical Institutions of Higher Education is proposed. The framework provides a roadmap on describing some key elements such as choice of medicinal plants, relationship between them and the associated diseases they seek to cure. This would provide the base for preserving the knowledge of traditional herbal medicine practitioners (formal and informal), thus, the engineering of an African Traditional Herbal Medicine ontology. This is geared towards assisting in the efficient classification and annotation of the knowledge of treatment in traditional herbal medicine, in order to build the relevant contextual relationship between ATHMed remedies and their associated cures. The fulcrum of designing such a retrieval mechanism is to enable efficient access to the knowledge base (KB). A software artefact developed based on the framework is needed to test the adequacy and viability of the KB. By this approach, the knowledge preservation of ATHMed will aid in providing a formalized, explicit repository for future pharmaceutical needs and formal training.

2.2 Related Works in Knowledge-base Archival

Since the 1990s, with the advent of computers, knowledge management (KM) has been implemented through software solutions. This is especially in the employee training, based on well documented norms, practices and personal know-how (tacit knowledge) of other internal employees, so that sharing and safeguarding knowledge can be efficiently done (Davenport and Völpel, 2001; El Morr, 2010).

Extant literature has revealed that, preservation of data and knowledge has been the focus of many organizations since the integration of procedures to manage and improve information assets has become critical for competitive growth in the 21st century (Xue, 2017). However, the preservation of knowledge, especially tacit, is hard to transfer and difficult to preserve (Mazour, 2006). By implication, there is the need for a more robust, explicit and systematic approach to capturing, classifying and sharing such knowledge. The involvement of computerization and various electronic-based strategies also provide additional power to monitor and manage electronic information (Davidavičienė and Raudeliūnienė, 2010).

Ashkenas (2013) advocates that to sustain, adequately formalize, explicitly define and ensure continuity of institutional knowledge, information technology, thus computational approaches, should be adopted. In agreement, Panahi, Watson and Partridge (2012) espouse that using computational approaches are more effective and efficient than verbal/oral or face-to-face approaches. As knowledge sharing, which hinges on efficient knowledge preservation (KP), particularly tacit knowledge, is paramount and unavoidable (Sarkiunaite and Kriksciuniene, 2005), this paper proposes a hybrid approach to KB implementation for ATHMed, based on prior approaches adopted in other related fields. Efficient and accurate retrieval of knowledge is heavily dependent on how it is stored, herein, preservation. The relevance and critical role of knowledge preservation cannot be downplayed as it drives the very essence of continuous learning and improvement for posterity (Faust, 2007).

Knowledge preservation can be viewed as "a process for maintaining knowledge important to an organization's mission that stores knowledge/information over time and provides the possibility of recall for the future" (Mazour, 2006: p. 2). Probst et al., (2006) also argue that the processes of KP are covered in three stages: *select*, *store*, *actualize*. In an extensive review undertaken by Antonova et al., (2006) on technology solutions for KM, the researchers explored numerous approaches employed within the domain. Antonova et al., (2006) detail notable technological solutions in managing knowledge by classifying them based on the key KM processes encompassing: *'generation'*, *'storing, codification and representation'*, *'transformation and use'* and *'transfer, sharing, retrieval, access and search'*. This paper discusses KP and retrieval, focusing on storage, codification and representation of knowledge (Antonova et al., 2006), considering KP as a purposeful, articulate, and explicit activity that involves the safeguarding of knowledge, especially tacit knowledge, for efficient storage, retrieval, use and dissemination.

Over the years, there has been a study migration from merely employing information system strategies that mainly focused on transaction processing, process controls and assisting in decision making, to the efficient capturing and dissemination of interrelated knowledge. This shift has become a vital component to many an organization's operations. This focus seeks to guarantee the future success and sustenance of organizations, using relevant, progressive and adaptive computational approaches. Mazour (2006) emphasizes that documentation, hitherto preservation, is a “good means” to “articulate knowledge” and though knowledge (tacit) preservation and retrieval involves extensive effort, its benefit is undeniably vast.

Based on the classification proposed by Probst et al. (2006) for tacit knowledge preservation processes, Davidaviciene and Raudeliuniene (2010), in an extended work, identified ICT tools that implement the KP process. The implementation is carried out through capturing systems (*expert systems, chat groups, wikis, blogs, podcasting, best practices and lessons learned databases, computer based communication, computer based simulation*) and sharing systems (*team collaboration tools, wikis, blogs, podcasting, web-based access to data, databases, best practice databases, lessons learned systems and expertise locator systems*) (Davidaviciene and Raudeliuniene, 2010).

Antonova et al., (2006) catalogued technological solutions for storage of knowledge assets into databases, knowledge bases, data warehouses and knowledge warehouses, data marts and data repositories. With regards to knowledge codification and representation, case-based reasoning systems, rule-based approaches, frame and semantic nets as well as formal logical, production and procedural model approaches are engaged (Antonova et al., 2006). Antonova et al. (2006) further postulate that for retrieval to be easily facilitated, knowledge organization technologies which include directories, taxonomies and repository indexes must be adopted. This suggests the adoption of ontology-based design specifications. In addition to these technologies for knowledge storage and representation, topic and skill maps, and controlled vocabularies, structured as data dictionaries can be applied (Antonova et al., 2006).

Presently, research leans towards contextual semantic preservation of knowledge assets using semantic enabling technologies such as XML. The use of XML has aided the provision of interrelated pattern search in a platform-independent environment, as evident in the web environment. Other studies have indicated the integration of natural language processing (NLP) techniques to provide linguistic semantic analysis and pattern related search and retrieval of knowledge (Tomai and Spanaki, 2005). Additionally, machine learning techniques for intuitive extraction of knowledge is being adopted.

As earlier espoused, KB development related literature indicates focus towards intuitive, robust, platform-independent, metadata dependent, semantically driven, contextual domain-based knowledge modelling, reasoning, preservation and extraction systems. A number of these computational approaches have been explored and adopted over the years.

In their study, Li, et al., (2003) investigated the feasibility of adopting an ontology-based approach to supporting KM activities in the metal industry in Taiwan. The researchers argue that, though this approach is an “adequate methodology” for domain specific KM, it is rather involving and time-consuming. To this end, an ontology-based KMS was modelled, using KAON for building the ontology and Java 2 Enterprise Edition (J2EE) for the system in a web-based environment.

Similarly, Tomai and Spanaki (2005) adopted the use of ontologies to propose a framework for modelling robust geographic concepts. However, they utilized NLP approaches for linguistic semantic analysis of the knowledge in the KB. To enable data be appropriately tagged, in context, the metadata handling and description language, Web Ontology Language (OWL) full was used. This enabled the application of W3C specification tools, thus supporting Extensible Markup Language (XML)/XML Schema and Resource Definition Framework (RDF)/RDF Schema. A web-based environment for user interaction with the KB was also adopted, built on the .ASP format, and tested in an intranet.

Lin, et al., (2013) also addressed the challenge of tackling environmental protection concerns in the product development process, through an eco-design approach, using a Life Cycle Assessment (LCA) strategy. The researchers presented an ontology-based process-oriented framework as the underpinning strategy to address the problem, with Protégé as the tool for building the ontology. A reasoning engine was formed to establish an ontology-based knowledge decision support system by transforming the knowledge acquired into a linguistic information, fit for OWL and Semantic Web Rule Language (SWRL), using the Java Expert System Shell (Jess).

In the aerospace industry domain, Sanya and Shehab (2014) propose a novel approach towards the development of a KB engineering framework for implementing platform-independent knowledge-enabled product design systems. With the aim of achieving long-term preservation of knowledge on engineering, their framework targeted a cost-effective, reasonable, model-driven architecture, also using an ontology-based approach that renders a semantic and portable knowledge structuring system. OWL and SWRL were used to model the KB system, Java for the CAD interface and Jess was used for the inference engine.

Song et al., (2016) explored a 3-tier system architectural framework for KB systems' management of manufacturing process knowledge. The researchers proposed an effective reusable management approach to implementing their KB system, via a systematic methodology for constructing the KB, indicating the key role of ontology development through an iterative process.

According to Shang et al., (2017), by employing a vulnerability-centric ontology-based KB framework strategy, cyber security knowledge existing in some independent KBs and on the internet, in text form, was efficiently integrated. This enabled the extraction of cyber security knowledge using both rule-based and machine learning information extraction techniques.

From the literature reviewed, in addressing KM needs, a systematic approach is to be adopted. The approach should be dynamic, contextual, ontology-based, AI-oriented, platform independent and semantic in nature. This forms the basis of the design and development approach adopted for this research.

3 METHODOLGY

This research is an ongoing study that adopts a design science research process. In this section, we provide the overview of the DSR process and the framework for the implementation of the system.

3.1 Design Science Research

As part of this project, the development of the knowledge-based system follows a design science research (DSR) process. Peffers et al. (2006) DSR is adopted as shown in Figure 1. DSR is one of the two major paradigms in Information System research (Hevner et al., 2004; Mramba et al., 2016) and is a solution-oriented methodology that focuses on the design and investigation of IT artefacts (Peffer et al., 2006; Hevner et al., 2004). DSR seeks the systematic and purposeful development of a solution (artefact) based on a rigorous scientific process. It provides a strategic mental model for empirical and theory research building for contextual understanding, evaluation and reproducibility of a study. The artefact may take the form of a construct, model, method, or an instantiation such as hardware or software (Hevner et al., 2004).

For an Information Systems' project such as this study, Peffer et al., (2006) propose six common design process elements that cover DSR methodology in a nominal sequence: *Problem Identification and Motivation, Objectives of a Solution, Design and Development, Demonstration, Evaluation and Communication.* This study takes a problem-centered focus as its entry point. Consequently, the DSR methodology is well suited for this research as our aim is to develop an artefact that provides a formal computational solution for safeguarding ATHMed knowledge (Peffers et al., 2006). Subject to this approach, stakeholders for this project will be involved throughout the developmental stages as shown in Figure 1. The idea is to co-create the intended system with the stakeholders' involvement.

This paper forms part of the initial phase of the DSR framework. Based on the DSR's initial phase, this study identifies the gap in the knowledge preservation and retrieval (KPR) practices within the ATHMed domain. From literature, it is evident that the KPR practices are inadequate with its repercussion having been discussed in earlier sections. The motivation therefore is to propose a framework to assist in addressing the phenomenon. This will require clearly defined requirements to help obtain relevant information and guidelines needed for identifying key concepts towards the KBS development.

Of the requirements specified through active stakeholders' consultation, the artefact will be designed and developed towards meeting the set objectives. Four components of the artefact will be materialized to provide a contextually fit and rigorous solution. The artefacts are interdependent covering an ATHMed Framework to guide the development process, a formalized ontology, a corpus and a KBS. The prototyping strategy shall be used to enable stepwise involvement of stakeholders. As a proof of concept, the KBS will undergo rigorous testing with training data to demonstrate its ability and adequacy to meet the objective for which the system was designed for.

Subsequently, the output, efficiency and overall performance of the artefact will be measured through another stage of rigorous testing by stakeholders and patrons of ATHMed. This will help in assessing the veracity and efficacy of the KB and how usable the KBS is. The feedback obtained will affirm system adequacy and viability, as well as usability and user satisfaction.

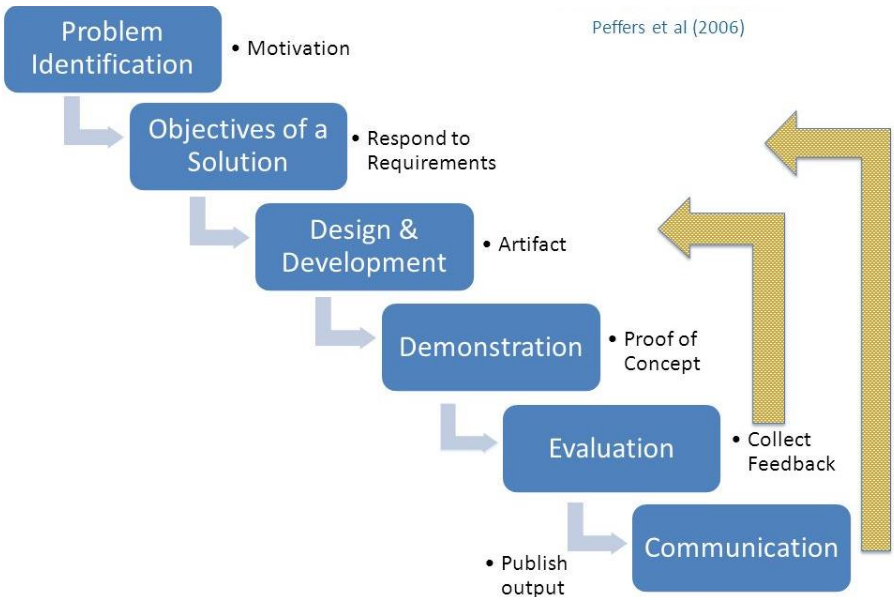

Figure 1: Design process with design science framework (Adopted from Peffers et al., 2006).

3.2 Knowledge-based Framework for Traditional Herbal Medicine

To contribute to the building of a formally defined body of knowledge in the domain of ATHMed practice and training in Medical IHE, a conceptual framework (model) is proposed. As such, defining a semantic-oriented, lexically functional, syntactic structure in a machine-readable and machine-understandable language is the focus of this proposed framework. The framework seeks to adopt and incorporate two major Artificial Intelligence (AI) techniques – machine learning (ML) and ontology– to provide a progressively adaptive environment to implement an intuitive KBS. Additionally, the retrieval mechanism for users' interaction is facilitated using web and mobile technologies. The proposed knowledge-based framework has three components as shown in Figure 2: *data layer, logic layer* and *application layer*. The system will be designed by following the Model-View-Control (MVC) software architecture. The Data Layer implements the Model component, the Logic Layer actualizes the Control component and the View component is considered in the Application Layer.

3.2.1 The Data Layer

The data layer is comprised of the data (knowledge) acquisition sub-component, which captures the knowledge, and knowledge base, which stores the knowledge obtained from the domain experts.

Data Processing

As earlier indicated, with the DSR, stakeholders in the medical fraternity are involve in the actual implementation. Therefore, the initial data (ATHMed corpus) obtained from interacting with the stakeholders (ATHMed practitioners and academia) is to be pre-processed for easy annotation. This processing is based on the elements relevant for ingredient selection and processing, mode of preparation and associated treatment (administration) method. Through expert (experts from academia, research institutions and registered herbal clinics) annotation, a predefine annotation scheme for the ATHMed data shall be arrived at. This will enable the attainment of a good agreement score on what element goes where, to obtain a concisely annotated data for training a ML classifier. This will lead to a gold standard being obtained, from the initial test data, via a supervised machine learning technique.

During storage, which implements the preservation phase, the data after pre-processing, is run through a classifier for categorization into specific non-static association and accurate identification of the knowledge using a suitable ML classifier. Throughout classification process, each data value (or key words) will be tagged to enable efficient association of term and concepts, via part-of-speech tagging through lemmatization.

Literature in medical research involving the use of ML suggests a diversity of techniques being applied. Jiang et al., (2017) conducted a survey of AI application in healthcare. The researchers observed that Support Vector Machine (SVM) and Artificial Neural Networks (ANNs) were often used. In a related study on biomedical disease detection, Niharika and Kaushik (2018) concluded that different ML classifiers should be considered to build a unified hybrid framework. By this, to obtain optimal results, they recommend the use of SVM, extreme learning with variations of various swarm techniques. Similarly, Bayesian Networks (BNs), ANNs and SVM were identified as methods most frequently applied in the THMed domain (Arji et al., 2018).

Consequently, to determine which ML algorithm is most suited for the ATHMed classifier, an optimal performance test shall be undertaken. This test shall involve the use of notable machine learning software, example WEKA. Based on the results, ML that demonstrate superiority in classifying ATHMed data will be chosen for the implementation.

Additionally, a robust algorithm to improve classification of the ATHMed data shall be considered. This is to directly influence the performance of ontology model, through a novel indexing approach, to facilitate quick retrieval.

The Ontology Model

The proposed knowledge base (KB) design is based on an ontology, for extensibility and reusability. As such, at the ontology construction phase, the proposed ontology model is to be defined through the process of organizing the ATHMed knowledge in categories, type classification into classes, hierarchical structuring of associated instances and properties, with appropriate axioms, rules, restrictions and interrelations. The ontology model is to be evaluated to verify functional specifications thereby ensuring consistency, reliability, accuracy and extensibility. A further validation, involving verification and evaluation tests for reliability (Preece, 1994) is required to ascertain the performance capacity of the KBS. This is to measure the quality of the ontology by ensuring adequate coverage of the knowledge within the ATHMed domain. The testing strategy for the KB is tailored to conform to software development test approaches.

The ontology-based approach is predominantly novel yet extensive for knowledge engineering. It facilitates appropriate representation, maintenance and dissemination of knowledge, and thus relevant in applying this approach in the ATHMed domain. The proposed knowledge capturing/acquisition component is targeted at being modelled based on a standard medicine preparation template design focus, under the guide of a domain expert (in academia) and verified by experts (both academia and practitioners).

This shall require the use of knowledge and metadata representation tools. An ontology authoring tool such as Protégé shall be used for building the ontology. XML and XML Schema is suitable for defining the metadata description, structure and storage, with RDF for describing related knowledge resources prevalent on the web for interrelation definition. OWL Descriptive Logic (DL) shall be used for defining the ontology structure and necessary semantics, and SPARQL to querying the ontology-based knowledge-base. A classification of key elements and concepts, with their interrelationships shall be explored, defined and annotated. Appropriate axioms shall be used to implement the guidelines for building the ontology.

Through this approach, the proposed knowledge-based system is certain in providing knowledge users and ATHMed stakeholders with a computer-aided solution that supports semantic capabilities. This will facilitate relevant, contextual preservation and retrieval of results from the knowledge base, through a simplified search mechanism using a web portal or mobile app.

3.2.2 The Logical Layer

This layer, as the middle layer, interacts with the data layer where the knowledge is preserved and the application layer, where requests from users are submitted via queries. Thus, the reasoning module is executed via the logic layer, tagged as the Information Extraction Component (IE). The IE is implemented via two sub-components: *Machine Learning Extractor* and *Semantic Reasoner*.

Machine Learning Extractor

The information extraction component shall be used as the means to extract or retrieve information from the knowledge base. The IE constructed using two sub-approaches involving a machine learning based (ML-based) extraction algorithm and an inference engine. The ML extractor will be designed to complement the ontology, that possess features of the ATHMed knowledge-based ontology, taking critical considerations to class types, their relationships, instances, connotations and semantics. The ML extractor interacts with the inference engine built to deduce new knowledge, thus from the data and information present in the knowledge base (KB) to ensure accurate prediction and determination of appropriate treatment, association to ailment, preparation methods and other relevant inferences.

Semantic Reasoner

The proposed knowledge-based system's semantic reasoner acts as the inference engine. The inference engine structure is expected to work on the Java-based framework, Apache Jena. ML techniques mainly to improve efficiency of predictability, deduction accuracy and an extensible deeper learning approach shall be considered. This shall support making of inferences whiles deducing new knowledge in a contextual form. This requires that the ML algorithm (classifier) chosen must be trained, firstly on some rule-based approach before a well-structured corpus for ATHMed is defined and extended with the algorithm.

3.2.3 The Application Layer

As earlier mentioned, the application layer is the view component, thus presentation layer for accessing the KBS. In the wake of enhanced and fluid ways of communication, there is the need to make access to knowledge easy and quick, supported in an interconnected, platform independent environment. This requires employing technologies that are ubiquitous and support use, anywhere and at anytime with ease. Web-based and mobile technologies have shown potential to be adaptive to such an environment. The proposed KBS is targeted at providing users with a graphical front-end: web-based interface designed with J2EE technology and a mobile interface using Android technology. Users will pass queries through simple to expressive statements which are treated as natural language expressions. NLP techniques and tools are efficient to support such manipulation. This requires that all queries be analysed lexically, and semantically compared against the KB through the information extraction (IE) component. This is to facilitate the extraction of relevant knowledge in the form required for adequate interpretation and understanding to the user. To this end, representation of the extracted knowledge must be textual and visual where required. Same interface shall be used to provide new knowledge to the KB.

For optimal performance, thus reliability and accuracy of the proposed KB, systematic engagement of domain experts in designing and validating every stage of the KBS is required. Below is a conceptual design of the proposed ATHMed KB framework.

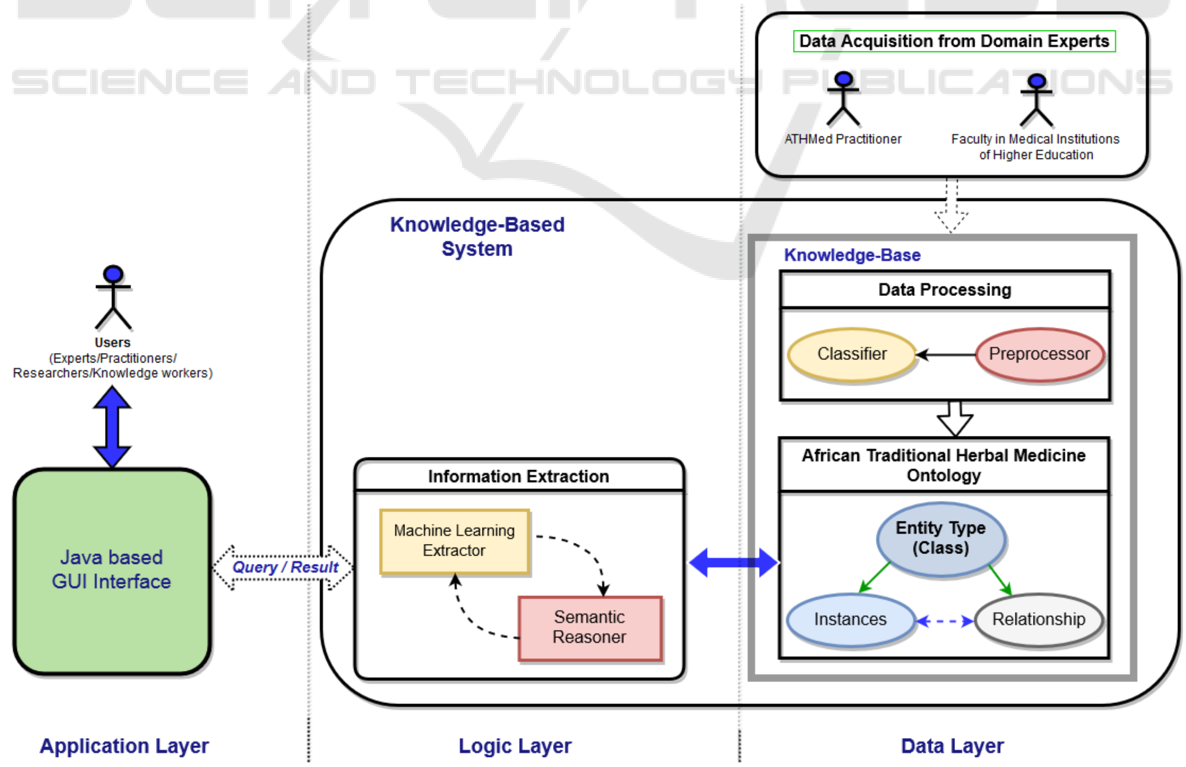

Figure 2: The Proposed knowledge-based framework for Achieving African traditional herbal medicine.

4 DISCUSSION

Developing countries have about 80% of their populace depending on THMed, with reports of rising global demands, for their health needs (WHO, 2018; Frass et al., 2012; Zhang, 2004). This is due to THMed's ease of use, natural form, often minimal side effects, availability, affordability and ease of preparation. Poorna, Mymoon and Hariharan (2014) reported cases of countries pursuing knowledge preservation and retrieval practices on traditional knowledge, thus THMed. Their findings, indicate strategic, meticulous efforts to safeguard THMed knowledge, have yielded distinctive yet collaboratively immense benefits. This result was attained through an all-inclusive effort spanning the health, academic and industry divide. Interestingly, all 6 countries that were observed to be making strives by implementing THMed documentation initiatives were from developing nations. This reiterates the importance of THMed to developing nations, and African countries in particular.

In essence, the impact of pursuing such THMed knowledge preservation and retrieval leads to key benefits to countries especially in Africa. There are obvious implications of healthcare benefits. It provides economic benefits whiles promoting preservation of indigenous cultural heritage (Boadu and Asase, 2017; van Andel et al., 2015). It provides avenues for securing patents to THMed knowledge (Zhang, 2004) and protecting such knowledge against misuse (Poorna, et al., 2014). These benefits were witnessed amongst the 6 countries that were observed by Poorna, Mymoon and Hariharan (2014). This was possible through proper codification and documentation (Poorna, Mymoon and Hariharan, 2014), a requisite strongly advocated for, to facilitate preservation (Faust, 2007; Mazour, 2006). This means that for THMed knowledge to be preserved, a consistent and purposeful effort is required. In addition, it is necessary that all such knowledge captured are interlinked or semantically correlated, to enable efficient search and retrieval, in order to promote new discoveries in related medicines and treatments.

Despite extant literature indicating growing interest in herbal medicine usage, especially in developing countries, most of these practices are either not well preserved nor documented. The evidence and dangers of THMed knowledge not being properly and adequately transferred from one bearer to another, to continue the medicinal practice is well documented in literature. Instances of this nature were observed by Adekannbi, et al., (2014). The researchers indicate that, though some practitioners of THMed willingly share their knowledge with their assistants, they choose to purposefully, deliberately and prudently transfer such knowledge, comfortably with their own relations. Notably, albeit some African countries are attempting to safeguard THMed knowledge, it is predominantly oral and being leisurely done using some form of recording (Maluleka and Ngulube, 2018; Adekannbi, et al., 2014; Yeboah, 2000). Consequently, a knowledge bearer may teach in part resulting in half-baked practitioners administering poor medical practices which are likely to cause more harm than good, as evidenced in some reports (Yeboah, 2000).

To help salvage the situation, deliberate calls and attempts have been made, by academia and research institutions worldwide, to help formalize and train THMed professionals. As custodians, these professionals will not only guide the processes and procedures to the preparation, preservation and administration of THMed, but also ensure the knowledge is not lost (WHO, 2018; Boadu and Asase, 2017; Amoah et al., 2014; Poorna, et al., 2014). Additionally, this effort is to assist in safeguarding such vital knowledge which can be extracted and refined for further commercialization in the service industry. Key to benefiting from this are researchers and academia, in general, via extending studies into the viability of such medicines and the development of appropriate curricula in the training of qualified herbal medicinal practitioners and healthcare professionals who will ensure continuity and formalization of THMed practices in Higher Learning Institutions. The resulting output from academia will feed the pharmaceutical industry with the requisite knowledge on THMed. Causally, it will provide opportunities for job creation while sustaining economies of countries that depend predominantly on THMed for providing healthcare to their indigenes. Ultimately, the effort will assist in improving socio-economic livelihoods and sustaining biological resources at the same time. The overall effect shall be to the advantage of the general populace with regards to the provision of relevant information on what choice of THMed medication to resort to in servicing their medical needs. The study conducted by Poorna, et al., (2014) supports these claims. In their study, it was revealed that countries that pursued preservation of THMed knowledge benefited not only to safeguard such knowledge, but also inherently promoted saving and securing patent to these national assets.

The provision of improved, timely, accessible and affordable healthcare through the offering of alternative healthcare practices based on a formalized THMed knowledge-based Framework is the underlining motivation proposed in this paper. The expected impact will not only be for developing countries like Ghana, but all regions that value and access healthcare through THMed.

The proposed framework is geared towards managing African traditional herbal medicine (ATHMed) knowledge, focusing on its relevance in the Ghanaian pharmaceutical service sector and the medical institutions of higher education context, seeking to deepen research at the national and global level, as advocated by Xu et al. (2008). The framework falls in the domain of KM processes covering technologies, related tools, appropriate methods and general KM involving frameworks. Furthermore, the proposed framework seeks to add to the KM body of knowledge, by contributing to the delivery and improvement of quality healthcare (El Morr and Subercaze, 2010). This, we hope, will extend knowledge in ATHMed and contribute in answering the call for preserving such indigenous medicinal practices (WHO, 2018).

5 CONCLUSION AND FUTURE WORK

The premise and prospects of this work is based on the articulation of formalized processes that are expected to yield a structured computer science approach to assist in preserving and retrieving relevant data and information on African Traditional Herbal Medicine, progressively, efficiently and sustainably, using novel approaches.

A hybrid approach of adopting machine learning techniques and an ontology framework is presented. This is geared towards addressing issues related to developing an efficient knowledge-based system (KBS), that provides a formal, explicit preservation and retrieval mechanism of ATHMed leading to a well-defined body of ATHMed knowledge.

This paper is considerably a working paper, requiring further empirical studies to concretize and affirm the veracity and viability of the framework. In this regard, further research will focus on the design of an ontology, based on ATHMed. Trailing this will be the exploration of strategies to facilitate quick and adept cataloging of data through an innovative search pattern that employs a novel indexing approach to storage and data retrieval, applicable to classifying semantic data, thus an annotated corpus. Furthermore, research into the adoption of machine learning techniques tailored to suit annotated ATHMed knowledge to provide a semantically-aware, contextual knowledge base shall be pursued. The research then culminates with an implementation of the framework proposed and validation of the ATHMed KBS.

REFERENCES

Adekannbi, J., Olatokun, W. M., Ajiferuke, I., 2014. Preserving traditional medical knowledge through modes of transmission: A post-positivist enquiry. *South African Journal of Inform Management*, *16*(1), pp.1-9.

Alavi, M., Leidner, D. E., 2001. Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS quarterly*, Vol. 25 (*1*), pp. 107-136.

Amoah, S. K., Sandjo, L. P., Bazzo, M. L., Leite, S. N., Biavatti, M. W., 2014. Herbalists, traditional healers and pharmacists: a view of the tuberculosis in Ghana. *Brazilian Journal of Pharmacognosy*, 89-95.

Antonova, A., Gourova, E. and Nikolov, R., 2006, July. Review of technology solutions for knowledge management. In *2006 2nd IET International Conference on Intelligent Environments-IE 06* (Vol. 2, pp. 39-44). IET.

Arji, G., Safdari, R., Rezaeizadeh, H., Abbassian, A., Mokhtaran, M., Ayati, M. H., 2019. A systematic literature review and classification of knowledge discovery in traditional medicine. *Computer methods and programs in biomedicine*, *168*, pp.39-57.

Ashkenas, R., 2013. How to preserve institutional knowledge. *Harvard Business Review*.

Boadu, A. A., Asase, A., 2017. Documentation of herbal medicines used for the treatment and management of human diseases by some communities in southern Ghana. *Evidence-Based Complementary and Alternative Medicine*, *2017*.

Bolisani, E., Bratianu, C., 2018. The Elusive Definition of Knowledge. In *Emergent Knowledge Strategies* (pp. 1-22). Springer, Cham. DOI: https://doi.org/10.1007/978-3-319-60657-6_1

Carrillo, F. J., 2006. From transitional to radical knowledge-based development. *Journal of Knowledge Management*, *10*(5), 3-5. DOI: https://doi.org/10.1108/13673270610691125

Chugh, R., 2018. Tacit Knowledge Transfer in Australian Universities: Exploring the Barriers and Enablers. In MATEC Web of Conferences (Vol. 210, p. 04054). EDP Sciences. DOI: https://doi.org/10.1051/matecconf/201821004054

Davenport, T. H., Prusak, L., 1998. *Working knowledge: How organizations manage what they know*. Harvard Business Press.

Davenport, T. H., Völpel, S. C., 2001. The rise of knowledge towards attention management. *Journal of knowledge management*, *5*(3), 212-222.

Davidavičienė, V., Raudeliūnienė, J., 2010. ICT in tacit knowledge preservation. In *Proceedings of the 6th*

International Scientific Conference "Business and Management 2010", Selected Papers (pp. 436–442).

El Morr, C., Subercaze, J., 2010. Knowledge management in healthcare. In *Handbook of research on developments in e-health and telemedicine: Technological and social perspectives* (pp. 490-510). IGI Global.

Faust, B., 2007. Implementation of tacit knowledge preservation and transfer methods. In *International Conference on Knowledge Management in Nuclear Facilities* (pp. 18-21).

Frass, M., Strassl, R. P., Friehs, H., Müllner, M., Kundi, M., Kaye, A. D., 2012. Use and acceptance of complementary and alternative medicine among the general population and medical personnel: a systematic review. *The Ochsner Journal*, *12*(1), 45-56.

Girard, J., Girard, J., 2015. Defining knowledge management: Toward an applied compendium. *Online Journal of Applied Knowledge Manag.*, *3*(1), 1-20.

Hevner, A. R., March, S. T., Park, J., Ram, S., 2004. Design science in information systems research. *MIS quarterly, 28*(1), 75-105.

Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., Wang, Y., Dong, Q., Shen, H., Wang, Y., 2017. Artificial intelligence in healthcare: past, present and future. *Stroke and vascular neurology*, *2*(4), pp.230-243.

Li, S. T., Hsieh, H. C., Sun, I. W., 2003. An Ontology-based Knowledge Management System for the Metal Industry. In *WWW (Alternate Paper Tracks)*.

Lin, J. S., Hsu, W. L., Chang, J. H., 2013. An ontology-based product development framework considering eco-design. In *Proceedings of the International Multi Conference of Engineers and Computer Scientists*.

Maluleka, J. R., Ngulube, P., 2018. The preservation of knowledge of traditional healing in the Limpopo province of South Africa. *Inform. Dev, 34*(5), 515-525.

Mazour, T., 2006. Knowledge preservation and transfer: issues and terminology. *Proceedings of School of Nuclear Knowledge Management*, pp.18-22.

Mramba, N., Apiola, M., Kolog, E.A. and Sutinen, E., 2016. Technology for street traders in Tanzania: a design science research approach. *African Journal of Science, Techn, Innovation and Development*, *8*(1), pp.121-133.

Nonaka, I., Takeuchi, H., 1995. *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford university press.

Niharika, Kaushik, B. N., 2018. Machine Learning in Biomedical Mining for Disease Detection. *Journal of Artificial Intelligence, 11: 39-47.*

Panahi, S., Watson, J., Partridge, H., 2012. Social media and tacit knowledge sharing: Developing a conceptual model. *World academy of science, engineering and technology*, (64), pp.1095-1102.

Peffers, K., Tuunanen, T., Rothenberger, M. A. Chatterjee, S., 2006. A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), Winter 2007-8, 45-78.

Poorna, R., Mymoon, M., Hariharan, A., 2014. Preservation and protection of traditional knowledge – diverse documentation initiatives across the globe. *Current Science, 107*(8):1240–1246.

Preece, A., 1994. Validation of knowledge-based systems: The state-of-the-art in north america. *Journal of communication and cognition-Artificial intelligence, 11*, 381-413.

Probst, G., Raub, S., Romhardt, K., 2006. Ziniu vadyba: sekmes komponentai [Managing Knowledge: Building Blocks for Success]. Vilnius: Knygiai. 352 p. ISBN 9955-443-26-X

Sanya, I. O., Shehab, E. M., 2014. An ontology framework for developing platform-independent knowledge-based engineering systems in the aerospace industry. *International Journal of Production Research*, *52*(20), 6192-6215.

Sarkiunaite, I. D., Kriksciuniene. 2005. Impacts of information technologies to tacit knowledge sharing: Empirical approach. *Informacijos mokslai*, pp. 69-79.

Shang, H., Jiang, R., Li, A., Wang, W., 2017. A Framework to Construct Knowledge Base for Cyber Security. In *Data Science in Cyberspace (DSC), 2017 IEEE Second International Conference on* (pp. 242-248). IEEE.

Tomai, E., Spanaki, M., 2005. From ontology design to ontology implementation: A web tool for building geographic ontologies.

Song, H., Wang, H., Liu, T., Zhang, Q., Gao, B., 2016. The Design and Development of Manufacturing Process Knowledge Base System Based on Ontology. In *International Conference on Cooperative Design, Visualization and Eng.* (pp. 9-16). Springer, Cham.

Van Andel, T. R., Croft, S., van Loon, E. E., Quiroz, D., Towns, A. M., Raes, N., 2015. Prioritizing West African medicinal plants for conservation and sustainable extraction studies based on market surveys and species distribution models. *Biological Conservation, 181*, 173–181.

World Health Organization, 2018. *Traditional, complementary and integrative medicine*. [online] Available at: http://www.who.int/traditional-complementary-integrative-medicine/about/en/ [Accessed 18 Feb, 2018]

Zhang, X., 2004. Traditional Medicine: Its Importance and Protection. Protecting and Promoting Traditional Knowledge: Systems, National Experiences and International Dimensions. Part, 1, 3-6. Available at: https://unctad.org/en/docs/ditcted10_en.pdf#page=23.

Xu, J., Sankaran, G., Sankaran, S., Clarke, D., 2008. Knowledge management in twenty-first century: Literature review and future research directions. *The Intern. Technology Management Review*, *1*(2), 16-24.

Xue, C. T. S., 2017. A Literature Review on Knowledge Management in Organizations. *Research in Business and Management*, *4*(1), pp.30-41.

Yeboah, T., 2000. Improving the provision of traditional health knowledge for rural communities in Ghana. *Health Information & Libraries Journal, 17*(4), 203-208.