Knowledge-Based Decision Support Systems and the Improvement of Healthcare Practices in Developing Nations

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ABSTRACT

During the first portion of this current research project we present an approach to implementing a dynamic, stable information system and medical diagnosis decision support system, with a main focus on cardiovascular diseases. This system integrates pre-existing open source projects such as a OpenMRS, and in-house projects like the Ontology generator, as well as a simple business rule engine and knowledge-base. Using industry standards such as a OWL, JAVA, and XML we are able to establish a scalable model as well for future innovations and additions. The methodology behind these decisions will be discussed and presented.

INTRODUCTION

Low healthcare quality and medical malpractice in developing nations can be caused by many factors, such as economic hardship and crude living conditions. One large factor is also physician's outdated literature and tools. While outside countries donate resources, such as clinics, tools, and medical books, as an attempt to correct this reoccurring issue, often these donated items are not current.

The Butterfly Medical Foundation took it upon them to aid in the correction of this healthcare weakness in developing nations. Though currently Butterfly Medical Foundation is working closely with India specifically, the goal is to spread their services throughout the world, where it is needed most.

In this undergraduate research project I was charged with creating solutions in bringing more current medical information and diagnosis tools to these developing nations. I was brought into Butterfly Medical as both Lead Developer and Software Team Leader, with sole purpose of researching what tools, skills, and individuals would be required for a project of this complexity, along with managing programming and healthcare information management intern, and aid in the development and implementation of the solution software for the given goal. The project itself is large in its nature and will be continuously evolving, though the end product will by dynamic allowing easies of implementation of theses exponentially growing future related functionality and overall capabilities. This will be done through comprehensive research and carefully implemented of each module tools.

The end overall development product goal would be to implement a system that floats flawlessly tracks clinical records for patients in developing nations, then based on the input of these records and inputted patient form information, suggest treatments, tests to perform, and medical text reading for the doctor. This goal will be achieved by implementing an open source, web-based medical articles library, electronic medical records system, and digital decision support system that incorporates a business engine as well as a data-driven, machine-readable knowledge base. All components must have a stable, detailed medical ontology, which will serve as the foundation of each of the above mentioned components.

MEDICAL ONTOLOGY

An ontology can be simply though of as a semantic web representing relationships, properties, and concepts between a given domain of knowledge. For this project in particular, the ontology will be medical based and construct a

semantic web on various diseases and disorders. The ontology is the rock of this project and essential for the implementation of each of the primary components. The ontology is constructed from inputted physician data and as well as being derived from the medical articles library. The ontology will provide a type of reference dictionary for each project component to be based upon. [1]

While the context within the ontology can and will be updated in the future by individuals of the Butterfly Medical Foundation, the creations of a more dynamic approach was determined to be essential for the future and completion of this project. While a complete ontology would be best derived from a mixture of human knowledge input and in depth dynamic generation, time is of essence for part one of this reach project. Due to time limitations the chose was made to create a basic in-house ontology generator.

The in-house ontology generator, Medical Ontology Information Engine (MOIE) was created using the standard scripting language of Perl. MOIE is a command-line, text-based application that will take a user inputted disease/disorder, look up the Wikipedia page for the disease/disorder, and then parse essential ontology information into a file. [3] The decision to use Wikipedia pages as the source of the current ontology structure was based upon the ease of use and readiness of information within the Wikipedia engine, as well as research pre-existing on this very concept. [3] The ontology will be stored in an information file that will be XML (Extensive Markup Language) formatted. This will allow for ease of translation into a stand alone ontology manager such as Protégé, which uses OWL language. OWL is a variation of XML which will undoubtingly help in later translation of data.

BUTTEFRLY MEDICAL LIBRARY

One goal of the Butterfly Medical Foundation has been to aid in creating greater medical resources and knowledge availability to developing nations. One step that has been made to achieve this goal has been to initialize a Wikipedia page for the Butterfly Medical Foundation. This will allow members of the medical community to contribute via articles and decisions to the spread of knowledge.

The Medical Library will not only be used as an information resource for medical practitioners to read and discuss, but also as an aid in the final project of the digital diagnosis support system. The goal being to provide article and discussion links once a diagnosis has been made, to allow the physician and patient to further understand the possible disease/disorder.

Physicians can also fill comfort that they are gaining knowledge for well informed individuals, as our article publication process is concise and secure. An article must be submitted by a physician through a custom designed Butterfly Medical page. The article will then be passed to beginning a three step validation process. This process involves having several qualified physicians review the article and send feedback to the original author. Once the article has been edited to its final approved state, it is then submitted to the Butterfly Medical Library, at which point it will be publicly viewable.

ELECTRONIC MEDICAL RECORDS SYSTEM

The ability to efficiently obtain patient information, and store the data in a uniform fashion is another issue crippling developing countries and increasing medical malpractice. Many tools have been implemented to help improve this issue; one in particular that will be focused upon is OpenMRS. OpenMRS is an open-source java/tomcat based application, created for the primary purpose of acting as an electronic medical records system. It's solidly built, and various features aided in our decision to use this tool and build upon it for the Butterfly Medical project. Being open source, we at Butterfly Medical are able to build JAVA-Based

modules to mold OpenMRS to fit our specific needs. OpenMRS offers the ability to remotely run the application based on an apache/tomcat server. Most of the heavy functionality is server-side, which is a quality that peeked interest with us, primarily for the fact that the countries we are focusing on might not have the best Internet connection, so taking calculations off client-side and placing them into server-side procedures were essential to the success of our project.

The ease of OpenMRS module implementation was increased by the use of the supplied development plug-in for the widely used JAVA Integrated Development Environment Eclipse. Within the plug-in a developer can test and deploy custom-modules to the tomcat OpenMRS server environment. Due to the time constraints of the current part of this project, we chose to focus on one specific sector diseases that affected all regions of the world, Cardiovascular Diseases. While we were able to begin our Cardiovascular Disease OpenMRS module based of the pre-existing HIV module, much had to be changed and/or added to the module. The module must be able to tolerate processing of test results by way of the Decision Support System (DDS) that constantly runs on the server; we will discuss the DDS in more detail later. The module also had to provide a simplistic user interface geared towards multi-cultural use. Our hope to use this module as an underlying layer of our even more simplistic user interface web application. This web application is written in PHP5, and has familiar web 2.0 aesthetics to its design, which will ensure users will have the most optimal use and ease of understanding as possible on our system. This means that the majority of the web application consists of drop-down menus, check boxes, and radio buttons, with very limited free text entry. This was a design decision in an affect to element free-text searches on multi-lingual records.

DECISION SUPPORT SYSTEM

All components discussed to this point have lead to the core of the Butterfly Medical, which is the Decision Support System (DDS). This component will draw in data from all other components and apply logical rules and business rules to calculate disorder/disease diagnosis and probabilities, as well as suggestions for possible treatment paths and informative articles. There are several subcomponents that comprise the DDS, which then in turn interact with the other components; User Interface, Medical Library and Electronic Medical Records System. *(see figure 1.0 – Butterfly Medical Project Model 2010)*

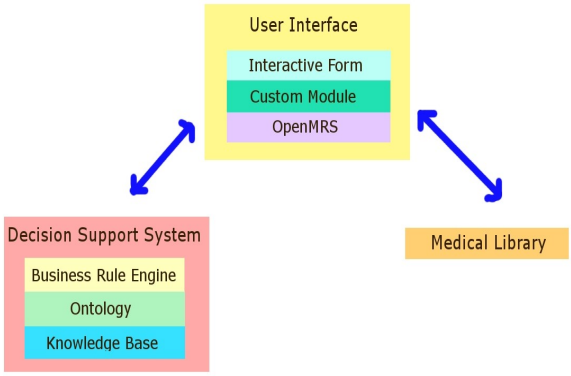

Figure 1.1

The ground component that is an essential part of the DDS is the Knowledge-Base system. After researching different structures and types of knowledge base systems, it was determined that a machine-readable, data-driven knowledge base would be the most efficient choice for the Butterfly Medical Project. Due to the degree of logic and intelligence required as part of this project, this system contains the features needed to run the DDS. A machine-readable knowledge-base stores the knowledge in a form that is ideal for machine processing. In most cases this allows for easier automated deductive reasoning to be applied. The data that populates this knowledge base will be a set of rules to describe the data in logically consistently.
To construct the machine-readable knowledge base and to enable the store rules to be both consistent and logical the first step must be to implement an ontology that will be used to define the the structure of the data that will be stored in the knowledge base. It is essential that this ontology contains definitions of the types of

entities that are to be recorded as well as the relationship that exists amongst these entities. [5]

Once the ontology is implemented the use of classical deduction can be used accompanied by first-order logic operators, conjunction – disjunction – implication – negation, to build information and reason through the knowledge stored. For the knowledge base an amount of artificial intelligence must also be implemented,thus creating a semantic web to easily automate diagnosis by the DDS. [5]

The logic need for a component of this stature requires strict consistency, and to ensure this occurs a Business Rules engine must be properly implemented. This engine will consist of multiple components, such as properties and rules that will be derived from the comprised ontology. The business rules engine will use the relationships and context of the ontology to evaluate user input from both the user interface and the OpenMRS and generate conclusions based on set rules. These rules will be constructed using First-Order Propositional Logic and the Ontology, and programmatically implemented via server-side services. This will require the implementation of a stable machine learning based on a Bayesian Belief Network. (BBN) This will allow for efficient statistical analysis and a search queries with combining user input with the knowledge-base and ontology.

CONCLUSION

As the Butterfly Medical Foundation grows and the start of the second part of the project begins. This will portion of the project will exclusively focus on the complete implementation and completion of each component concluded by the research done for part one of the project. The challenges that lie ahead involve the implementation of a fully functional Decision Support System, and all its subcomponents. However, through the use of the documentation and research findings completed by the conclusion of the first part of the project, the structure and implementation of the future components are more feasible. The end project will result in not only a great understanding of the dynamics of a multi-component health system, but a forward step in the right direction to accomplish the greater end goal, spreading better healthcare knowledge and resource to developing countries.

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