University of Cape Town

Department of Computer Science

Project Proposal:

A Knowledge-Based System for Medical Advice Provision

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Table of Contents

1 Project Description

Many rural communities have extremely limited access to medical advice. This is due to shortage of medical experts and medical facilities such as clinics. People travel long distances to clinics or medical facilities. This results in slow service hence patients end up waiting longer hours without being given attention. For these reasons, there is a need for a medical advisor system, a system that is easily accessed and used by different users (sophisticated or novice).

The aim of this project is to develop a prototype knowledge-based system for the provision of medical advice on diabetes or any similar medical condition. A knowledge-based system is an intelligent computer program which captures the knowledge of a human expert and uses this knowledge to solve a real-world problem in real time [1].

The knowledge-based system can be built to give advice to all commonly found conditions; and if the medical condition is not found the system will recommend another type of expert. Furthermore, a knowledge-based system can play a significant role in cases where experts are not readily available. The purpose of this project is to analyze the role that these systems can play in improving the aforementioned situation. The knowledge-based system to be developed in this project is a medical advisor system that will give advice to patients concerning their current medical conditions.

Our knowledge-based expert systems will consist of the following modules:

- **Working memory** that will store all the information provided by the user such as historical data and current symptoms or signs.
- The **knowledge-base** includes a set of IF-THEN rules and a collection of information for both the user and the medical human expert. (IF-THEN rules are type of rules that relates some of the known information contained in the IF to other information; this information can then be concluded in the THEN part.)
- **Inference engine** is an analogy of human reasoning to help address the medical condition based on the information from the user and the human expert.
- A **user interface** which allows users to tell the expert system what their signs or symptoms are and receive a friendly, understandable and accurate medical advice which they can trust.

2 Project Statement

Medical expert systems were very popular during 1970s and early 1980s [2, 3]. However people stopped using them because they did not trust them as much as necessary. Another obstacle was that the computers of those years had limited processing power. A large knowledge base requires a fast processor and a large amount of memory. However computers have become more compact and considerably faster, therefore this project aims to improve on existing approaches taking advantage of new technologies. We believe that there is a need for a medical advisor system especially for people in rural areas, where there is a lack of medical experts.

Thus our system will benefit people in rural communities saving them long trips to far-way clinics. It will absolutely speed up the services in cases where doctors are not present but medical assistants are left in charge. The system will also assist doctors in mining through a large amount of patient data which would not be practical to do manually. The system will help the expert in linking information pertaining to multiple patients in derive patterns (e.g. in an epidemic). The expert system can regularly update its knowledge base with new discoveries that are published.

The main aim of this project is to design accurate medical advisor systems with a user interface that is easy to use. Our medical advisor system will provide a user with a natural language-based interface, with which a user can answer a series of long queries about his or her current medical condition. The expert system will act with the same logic as a human expert, and the interface will display understandable and usable output. The role of the medical advisor system in this case is to assist the doctor to come to a decision, but the decision is still the doctor's. The user at home who is not assisted by a medical practitioner in using our medical advisor should only receive advice such as what to eat, how much to exercise, or to be tested for a specific condition (e.g. eat more fruits and vegetable, exercise thirty minutes a day, go and have your blood sugar tested).

The graphical-based interface will exploit the fact that people are generally disposed to problem solving spatially. Users will be able to locate on an avatar where they are experiencing symptoms and what the symptoms entail. Natural language will allow rural users with low computer skills to be able to use the system naturally and without any training whatsoever. This project is in two parts, the first part of the project is to create a medical advisor system and the second part of this project is to create an interactive system for users with low literacy level. The system will provide a speech-based interface and a spatial graphical-based interface. The speech-based interface is included for those who would want to speak to their phone naturally. The spatial interface is included since people are disposed to solving problems spatially [4].

The following research questions will be addressed:

- Is it viable to make a usable, reliable, accessible and accurate medical knowledge based system for rural areas?
- Can a mobile platform efficiently run an expert system and interface in real time?
- How can we create an easy to learn (or more user friendly) interface for people who have low computer literacy?
- Can an interface/expert system be made that rural users will trust?
- How can we make use of the technology available to improve medical advisor systems?
- How can an effective medical advisor system be built taking advantage of modern technology, to improve on existing techniques?

3 Procedures and Methods

A prototype will need to be developed in order to demonstrate feasibility of the system. The system is divided into two components namely: the medical advisor system and the user interface. This will include the system design, user interface design and development of the entire system. The development of the knowledge-based system will be done using an existing open source tool, such as CLIPS or JESS. The development of the speech-based interface will be done using Android SDK and Java Nedbeans. This system does not aim to replace the consulting of a real human expert hence the system cannot prescribe drugs or diagnose complicated or rare conditions. Instead, the system will advise the user to see a professional, and will even advise what professional to see. The system aims to give advice on common problems thus relieving professionals from these problems and saving rural users many hours going to see an expert.

Research shows that in rural communities, a mobile platform is the biggest way to access the Internet [5]. For this reason, therefore people in rural communities are quite exposed to mobile devices and the usage of mobile devices is very well developed. This project will take advantage of this fact in developing a mobile medical application. This would both save the user the time and cost of seeing an expert, as well as save the expert (often a volunteer) valuable time. Most android phones will be able to run this software thus all android 2.1 versions and above will be compatible.

When interacting with a natural language system, users make the assumption that the system has conversational abilities such as ellipsis. Also the speech recognition needs to understand a wide variety of accents. We define accents as a dialogue system that uses a limited subset of the language, which makes accents less of a challenge. Tests will be designed to see if a user can get

the correct output and the user will then rate the output. Test users will be given a set of conditions and asked to input this into the system to see if they will get the correct output.
The test users will not be given the name of a symptom, only a description. Interface experts will also be asked to evaluate what can be improved with the interface. The performance of the system will be measured by user tests, to see if users can achieve an acceptable accuracy level with condition recognition, and appropriate advice.

The system is a medical advisor system, with a natural language user interface and a graphical user interface. The system will be installed on desktop computer in a clinic. Users who have capable Android phones will also be able to access it at home and interact with it using speech. The system will advice users, based on the information they provide about the symptoms they are displaying. The system will simulate the problem solving of a real medical expert. In cases where medicine is needed or severe cases, the system will recommend that a medical expert be seen, and will even recommend which medical expert to see. Data on medical diagnosis will come from actual experts, or at least medical students.

The expert system needs to be able to simulate a human expert, so human medical experts will need to be consulted in its creation. The interfaces will have to communicate with the back-end expert system; the interfaces will create multiple interface tags such as Boolean values which will be provided to the back-end.

Our knowledge-based system will consist of four modules namely: the working memory, the knowledge base, the inference engine and user interface.

3.1 The working memory

Working memory is an input to the system which includes case facts about the user such as medical history, current symptoms and inferred or answered questions [4]. This information is used to evaluate antecedents in the knowledge base.

3.2 The knowledge base

The knowledge base is a heart of an expert system [5]; it includes specific knowledge on a given subject such as medicine that makes a human a true expert in that subject [2]. It takes the collection of relevant knowledge that is stored in a computer and organizes the information in such a way that it can be used for inferences. This is generally in the form of IF-THEN rules [6] that make use of various tests to rule in or out a diagnosis. These tests are scheduled based on suspicion of disease [4]. This project aims to implement a knowledge base that will store all relevant information and procedures that will help to solve the problem.

The following questions arise with regard to creating a knowledge base:

- Which objects will be defined?
- What are the relationships between the objects?
- How will the rules be formulated?

3.3 Inference Engine

An inference engine is a reasoning process of artificial intelligence or an analogy of human reasoning. Its role is to work with the available information from both the user and the system to derive new information or solution to the problem [7]. It can be presented in a form of a table with fields corresponding to the clinical condition findings. This project aims to implement a spatial database to present the information.

3.4 User Interface

The user interface is an intermediary that allows communication between the user and a computer. It takes input to the system such as symptoms or signs, and presents output to the user such as diagnosis results, summary of case facts or recommendation or treatment [8].

This project will look at the following questions:

- How should the questions be asked?
- What information should be presented graphically?
- How to make the system more user-friendly and easy to learn?
- How to avoid erroneous input?

Our user interface will consist of the speech-based and graphical-based interface.

3.4.1 Speech-based interface

A speech-based interface is an interface that users can interact with using natural language. It uses the Microphone of the phone device to record speech and this speech will then be converted to text which will be passed and sent to expert the system back end to process. The back end will pass the user input on to the inference engine which will perform a diagnosis. The output of the inference engine will be converted into a natural language response before being presented to the patient. The interface will try to make the 'thinking' of the expert system apparent as well as the output understandable in-order to increase the trust of the users. The speech interface will be built using the Android SDK for speech and language recognition.

3.4.2 Graphical-based interface

The Graphical interface is an interface that users will be able to interact with by simply touching the avatar on the screen. The user will be able to point out where the symptoms are, and what type of symptom they are. Patients may not know what is wrong with them, may be able to point out the where the problem is and what the problem looks like, and this will be exploited.

4 Ethical, Professional and Legal Issues

The system will only be used for research purposes and will not be used to diagnose actual patients. The main purpose of the system is to give medical advice and to recommend qualified doctors for any diagnosis required by the patient. Therefore there are no ethical issues involved concerning harming victims. The information that we will obtain from the human expert will be kept confidential and we will sign permission forms if necessary. User testing will be required for both the knowledge-base and interfaces (both speech-based and graphical user interface), to answer most of our major research questions such as usability and therefore external users will be needed to test the system. Therefore ethics clearance will be sought for all human participants.

All data recorded during user tests will be kept confidential and the user will be notified of any changes to the agreement.

In case of misdiagnosis of an issue, a disclaimer will be placed in the program stating that the designers and UCT do not take any responsibility for rash actions taken by users without consulting proper medical experts. We will develop our system using Android software but no legal clearance is needed because Android freely supports developers to develop in this platform.

5 Related Work

Several techniques have been implemented for medical advice provision. However most of the existing techniques are limited to diagnose a specific medical condition such as blood infections or heart conditions [5, 9].

5.1 Knowledge-based system

5.1.1 MYCIN

MYCIN is a medical diagnosis expert system designed to advice physicians on findings and diagnoses in the area of blood infections [7]. MYCIN was designed to identify most likely infectious diseases based on the patient's medical data provided and suggests a prescription or recommends treatment [10]. Other medical expert systems were implemented based on MYCIN such as PUFF and ONCOCIN [11], focusing on the limitations and improving its performance. Most of the existing expert systems were mostly focusing on the technology, for this reason most of them are less user friendly. Now with the current advances in technology, we believe that a huge improvement can be made to these systems. The rules used can also be improved. Expert systems were not well-known to many people back then because people were not confident in using them but now that technology has advanced and most people are familiar and comfortable with it [12]. MYCIN originally used an interface where most of the interaction with the user was question based with the physician answering "Yes" and "No". A natural language interface could have greatly improved MYCIN [13].

5.1.2 Interface

SOPHIE is an expert system dealing with electronic circuits. A Natural language interface was created for SOPHIE. This allowed students to interact with the system in natural (text) language and at the end of the development of the interface, it was able to respond to 90% of the queries accurately, and most queries were processed in about 150ms [14]. The ChEM expert system used a graphical "hyper-map" interface to the expert system, and was able to efficiently map 40% of problems graphically [15].

6 Anticipated Outcomes

6.1 System

Once the project is complete we expect to have produced a fully functional medical advisor system which produces accurate results and medical recommendations. The system should be able to clearly highlight all relevant and noticeable information to the user. The system should be able to reveal the level of information based on the user. We expect to have produced an effective speech-based mobile interface which will be able to recognize different accents. The system will be easy to use and with all key features available to the user.

Major design challenges:

- Accurate speech recognition
- Accurate conversation parsing
- Limited bandwidth usage

6.2 Expected impact

If our system becomes a success we expect to relieve professional medical experts from giving medical advice on simple cases. To provide users with a convenient system and to help them avoid long trips to clinics for easy managed problems.

6.3 Key success factors

The key success factor will be different for each section but both parts should be robust and flexible:

6.3.1 Knowledge-based system

The success factor for the knowledge-based system will be measured by the accuracy of the results and its ability to do a quick medical advice. The system should be able to recommend understandable and accurate treatment and it should be able to provide real-time performance.

6.3.2 Interface

The success factor of the interfaces is that the users can input symptoms without difficulty. The Interfaces should also be able to communicate with the user in a natural, friendly and understandable manner.

7 Project Plan

7.1 Risks Analysis

#	Risk	Probability	Impact	Mitigation (Plan)
1	Group member becomes unavailable	Low	This will results in missing milestones and delay project completion	The project is divided in such a way that each member's work stands alone.
2	Equipments becomes unavailable	Low	This will delay project completion	Make appointment earlier
3	Data Loss	Medium	This will results in missing deadlines	Have multiple backup of every work modified each day.
4	Unable to reach the project milestones	Medium	This will delay the project completion and will affect the next tasks. The project might results in a failure	Have weekly meeting to keep track on how far we are, this is to make sure that everyone is aware of the deadline
6	Unable to get a professional physician or medical expert	Medium	This will results in inaccurate results	We will rely on the internet and published books and journals for medical information
7	Misdiagnosis-Legal	Medium	This project is for research purposes only	Disclaimers will be placed in the program

7.2 Timeline, including Gantt chart

See appendix A for Gantt chart

7.3 Resources required

7.3.1 Software

The software requires is as follows:

- Android SDK
- Open source tools such as CLIPS or JESS

7.3.2 Hardware

The hardware required is as follows:

- Android device
- Computer

7.3.3 Users

Users required for testing

7.3.4 Professional physician

- Physician required for professional medical background or diagnosis methodology (If not available in the internet)
- Or medical student

7.4 Deliverables and Milestones

#	Milestones	Date
1	Literature Synthesis	14 May 2012
2	Project Proposal draft	14 May 2012
3	Project Proposal	21 May 2012
4	Project Proposal Presentation	24 May 2012
5	Revised Proposal finalized	11 June 2012
6	Project Web Presence	12 June 2012
7	Initial Feasibility Demonstration	25-29 July 2012
8	Background/Theory Chapter	29 July 2012
9	Design Chapter	29 August 2012
10	First Implementation	29 August 2012
11	Final Prototype	19 September 2012
12	Final Implementation	28 September 2012
13	Complete Report Outline	03 October 2012
14	Complete Report outline	10 October 2012
15	Final Project Report Draft	24 October 2012
16	Project Report	31 October 2012
17	Poster	03 November 2012
18	Web Page Completion	07 November 2012
19	Project Demonstration	08 November 2012
20	Reflection Paper	11 November 2012
21	Final Project Presentation	18 November 2012
22	Final Project	23 November 2012

7.5 Work allocation

This project is divided into two parts, the knowledge-based system and the speech-based interface for Android. Kulani will be working on the implementation of a prototype knowledge-based system that includes the text-based interface for the provision of a medical advisor, focusing more on the back end of the system. While Kevin works on the graphical user interface and the speech user interface.

8 References

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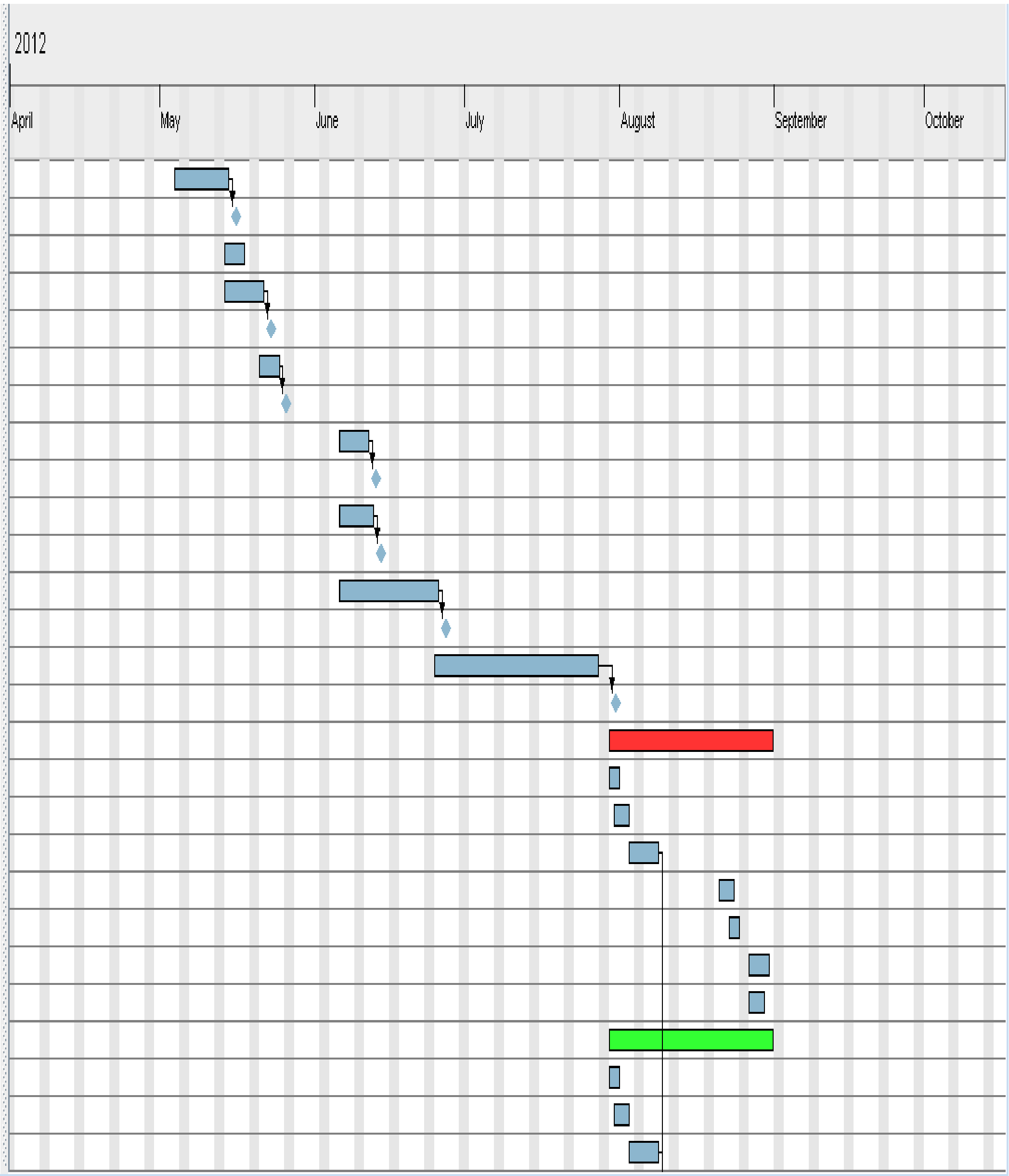
9 Appendix A

Name	Begin date	End date
Literature Synthesis	5/4/12	5/14/12
Literature Synthesis	5/15/12	5/15/12
Project Proposal draft	5/14/12	5/17/12
Project Proposal	5/14/12	5/21/12
Project Proposal	5/22/12	5/22/12
Project Proposal Present...	5/21/12	5/24/12
Project Proposal Present...	5/25/12	5/25/12
Revised Proposal finalized	6/6/12	6/11/12
Revised Proposal finalized	6/12/12	6/12/12
Project Web Presence	6/6/12	6/12/12
Project Web Presence	6/13/12	6/13/12
Initial Feasibility Demonst...	6/6/12	6/25/12
Initial Feasibility Demonst...	6/26/12	6/26/12
Background/Theory Chap...	6/25/12	7/27/12
Background/Theory Chap...	7/30/12	7/30/12
Knowlage base medical ...	7/30/12	8/31/12
Research/brain storming	7/30/12	7/31/12
planning	7/31/12	8/2/12
Design Chapter	8/3/12	8/8/12
experiments	8/21/12	8/23/12
performance test	8/23/12	8/24/12
user testing	8/27/12	8/30/12
write up	8/27/12	8/29/12
Interfaces	7/30/12	8/31/12
Research/brain storming	7/30/12	7/31/12
planning	7/31/12	8/2/12
Design Chapter	8/3/12	8/8/12



Name	Begin date	End date
performance test	8/23/12	8/24/12
user testing	8/27/12	8/30/12
write up	8/27/12	8/30/12
Design charter	8/9/12	8/9/12
First implementation	7/30/12	9/19/12
First implementation	9/20/12	9/20/12
Final prototype	9/19/12	9/28/12
Copy_Final prototype	10/1/12	10/1/12
Final testing	10/1/12	10/3/12
Complete report outline	10/4/12	10/10/12
Complete report outline	10/11/12	10/11/12
Final project report draft	10/10/12	10/24/12
Final project report draft	10/25/12	10/25/12
Project report	8/29/12	10/31/12
Project report	11/1/12	11/2/12
Poster	11/1/12	11/2/12
Copy_Poster	11/5/12	11/5/12
Web page completion	11/5/12	11/7/12
Web page completion	11/8/12	11/8/12
Project demonstration	11/1/12	11/8/12
Project demonstration	11/9/12	11/9/12
Refection Paper	11/8/12	11/9/12
Refection Paper	11/12/12	11/12/12
final project presentation	11/12/12	11/16/12
final project presentation	11/19/12	11/19/12
final project	11/19/12	11/22/12
final project	11/23/12	11/23/12