MobDoc: Mobile-based Medical Diagnostic Tool

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ABSTRACT
A cost-effective and mobile-based medical diagnostic tool was prototyped in this invention. The tool is an expert system that captures patient’s condition through a rich multimedia-based interface. On the basis of the captured information, the tool suggests a diagnosis and treatment for the patient. The tool is primarily meant to be used by trained healthcare workers in non-emergency situations but patients and their family could also be trained at using it. In case of an emergency, medical data captured by the tool can be transferred to the hospital while the patient is still on the way, so that high-quality medical care is provided speedily upon patient’s arrival. Such a diagnostic tool can be especially useful in remote areas where the healthcare infrastructure is underdeveloped. This prototype was customized for maternal and child healthcare needs. However, it can be extended for addressing other healthcare subdomains as well – for example, geriatric care. An early version of the concept behind this work was previously presented at the national-level of the Microsoft Imagine Cup Contest where it won the People’s Choice Award. A patent on MobDoc is pending.

If developed further, the key benefits of the tool would be: (1) medical help when and where needed (2) field triage to ensure timely emergency intervention (3) connecting patients and healthcare providers (4) supporting and training midwives and other community healthcare workers in assessing the patient (5) collection of information on emerging medical epidemic situations for regional response. One feature of the tool is that it can be adapted to different languages (e.g., English, Spanish, and Chinese) and cultures depending upon the geographical location. Hence, it helps in transcending some of the social, cultural, language, geographic, and technological barriers. Another unique feature of the tool is a multimedia-based training module for training the community healthcare workers in using the tool and providing help to the patients. The tool can also be useful for data collection and trend analysis. The software design is based upon platform-independent model and hence can be easily extended for different architectures and operating systems.

1. INTRODUCTION
The rural areas in the underdeveloped and developing countries often lack the basic infrastructure (e.g., transportation and electricity). The basic health infrastructure, health care professionals, supplies and equipment are also inadequate and unevenly distributed. Consider the facilities for providing maternal healthcare in these rural areas. Emergency obstetric care is beyond the reach of most of the women in these areas. The nearest delivery room with trained personnel has been up to fifty kilometers away. Both distance and finance wise, these delivery rooms are not easily accessible to most women. According to the UNICEF Statistics, a woman dies from complications in childbirth every minute and 530,000 women die in childbirth every year. Improving maternal health is therefore of prime concern in these areas. Though the United Nations has launched several health programs in some of these rural areas but it is often hard to get high-quality statistics for planning future health care programs. Monitoring the progress and effectiveness of these programs is often a challenge too.

These problems are not due to limitations of the medical diagnostic science. Rather, this is a classic example of the CAKE Challenge noted by the authors wherein the state-of-the-practice lags far behind the state-of-the-art due to Compatibility and Availability of Knowledge and Expertise (CAKE). In the context of medical diagnostics, these four fundamental aspects of the CAKE Challenge are as follows:

- Compatibility: Diagnostic services are limited by barriers that may be social, cultural, legal, linguistic, etc.
- Availability: Diagnostic services are not available due to geographic barriers and lack of technical infrastructure.
- Knowledge: Empirical information and analyses are fragmented and locked in unconnected repositories.
- Expertise: Scarcity of highly-trained medical experts creates a bottleneck for medical decisions.

2. KEY CONCEPTS & MOTIVATION
The CAKE challenges mentioned in Section 1 can be mitigated with the help of software applications like MobDoc. Some basic and key terminology related to the concept of MobDoc is presented below and is followed by the reasoning on its need in the healthcare domain.

- Expert system: A software system that simulates the steps taken by human experts, in a given domain, to solve a domain-specific problem is called an expert system. The domain knowledge is gathered and stored in a repository with the help of domain-experts. On the basis of the domain knowledge and the given data related to the problem, the expert system does reasoning on the basis of the inference rules and suggests a solution to the end-user. Some examples of expert systems in medical domain are MYCIN and DENDRAL developed at the Stanford University in 1970s. More information on these systems can be found at [1].

- Differential diagnosis: The process of weighing the probability of one disease versus that of other diseases possibly accounting for a patient's illness is called differential diagnosis. For example, the differential diagnosis of abdominal pain includes (but is not limited to) gastritis, ulcers, appendicitis, ingestion of foreign bodies, and ectopic pregnancy.

- Expert systems for differential diagnosis: Expert systems can be developed for doing differential diagnosis. Many studies demonstrate improvement of quality of care and reduction of medical errors by using similar software systems, called as Decision Support System (DSS). In the past, DSSs have been designed for specific medical problems such as Schizophrenia [2], Lyme disease [3] or Ventilator Associated...
Pneumonia [4]. Others such as Iliad, QMR and DiagnosisPro [5] were designed to cover all major clinical and diagnostic findings to assist physicians with faster and more accurate diagnosis. However, these DSS tools all still require advanced medical skills, in order to rate the symptoms and choose additional tests to deduce the probabilities of different diagnoses. DSS only supports the decision making process. The human user is required to evaluate all the factors before making a decision. On the other hand, an expert system works on the basis of the knowledge acquired from an expert and applies a set of probability-based rules to arrive at a decision regarding a particular problem. Therefore, they could be suitable for usage by healthcare workers having basic training in healthcare.

Larry Weed, the creator of Problem-Oriented Medical Record (POMR) said that like we need X-rays as extensions of human eye, it is necessary to use electronic extensions of human memory and analytic capacity at the time of action. In one study of physicians in outpatient clinics the subjects of the survey recalled only 50% of patient information, 5 minutes after the appointment. Sixty percent of the physicians surveyed did not know the names of their patients’ drugs, and 20% did not recall the purpose of the patients’ medications. It has been estimated that 180,000 patients are dying each year as a result of medical error. Another source suggests that 1.3 million injuries may occur in the U.S. annually during hospitalization. Although many hospital injuries are unpredictable and unavoidable, 20% to 70% may be preventable. These findings illustrate the limitations of the human memory and underscore the urgent need for alternatives. Expert systems and decision support systems are therefore soon going to become a necessity in the medical field and will significantly improve the quality of health care. In the rural areas, where the health care infrastructure is usually missing, these systems can provide economical health service to masses and can reduce the dependence on the availability of a human expert (that is, an expert doctor). In the cases which are not emergencies, the expert system can have the following benefits over a doctor:

- Has the combined knowledge of many doctors and researchers
- Has no time limit
- Does not suffer from forgetfulness or imprecise recall
- Operates at same high standards every day
- Has no interest in selling any particular treatment
- Can show you the full reasoning behind its findings

The MobDoc will have all of the above mentioned advantages of an expert system along with the features that the user-interface will be extremely graphical and intuitive to use.

3. TECHNICAL DETAILS

The concept of MobDoc is based on a rule-based expert system that is capable of doing differential diagnosis and can be loaded on the mobile devices so that the basic first-aid and primary healthcare services can be provided to the patients even if a doctor is unavailable. The community healthcare workers can be trained to use the mobile application and assist the patients in their locality. To reduce the training time of these healthcare workers, it is important that the application interface supports local languages and dialects. The use of pictures to capture the patient condition can reduce the communication overheads involved in the diagnostic process. This is especially useful in case of emergencies. Screenshots of MobDoc are presented in Figures 1, 2, and 3. It can be noticed from these figures that the text for the questions to be asked for differential diagnosis is supplemented by pictures for quick recognition and understanding of the questions themselves.

![Figure 1. Screenshot of MobDoc – Capturing Patient Data](image1)

![Figure 2. Screenshot of MobDoc - early prototype - questions](image2)
On the basis of the patient-data captured using MobDoc, a diagnosis and the course of treatment for the patient are suggested with a probability rating. The healthcare worker can then consult a doctor if there are multiple options presented by MobDoc as potential diagnosis.

In case of an emergency, the application suggests the healthcare worker to take the patient to the nearest hospital. While the patient is on his/her way to the hospital, the patient data can be sent to the hospital so that high-quality and timely attention is provided to the patient. The mobile devices on which MobDoc will run can be connected to light wireless servers which run on rechargeable batteries for storing patient data. The wireless server can in turn be connected to a central server from where data can be collected for trend analysis and monitoring the progress of healthcare programs in remote locations.

The data gathered using the MobDoc mobile application can be stored in a database or in XML documents. In order to retrieve the patient records, one needs to enter the patient name, age and location through a form in MobDoc. The solution is based upon the assumption that some means of mobile communication or satellite communication is already available in the remote areas so that such information can be retrieved from central servers when needed. On submitting the form, the patient data is returned to the end-user. The stored patient history can also be used to check for drug-drug intervention and allergies when the doctors are prescribing new medicines or changing the medical regimen.

The knowledge acquisition through ongoing usage of the tool, mining of historical data, and data stored in data warehouses will keep the system young, evolving and intelligent. Because the knowledge engineering and data curation process will be a continuous one, involving multiple subject-matter experts, the medical expertise will also evolve by taking advantage of powerful inference capabilities provided by the tool. The knowledgebase will be approved and tested by a body of medical experts to ensure high-quality and timely responses. The system will be developed in compliance with the already existing technical standards in the healthcare domain for the purpose of easy extension and integration with other existing modules and systems (e.g., OpenEMed, OpenEHR, OpenMEDIS).

An early version of MobDoc was prototyped a few years ago with the help of additional colleagues of the authors. The idea was developed further to its present state by the authors and is a work still in progress.

4. REFERENCES