

Adapting Mobile Medical Information Search to Low-Resourced Areas

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Abstract: Providing good medical care in low-resourced areas is a challenge faced by many low and middle income countries. Continuously improving mobile communication infrastructure in these areas is however providing the opportunity to improve the access to medical information using mobile phones in these areas. In particular, physicians and community health workers based in low-resourced areas could be the first to gain benefit from this technology. This paper considers the implementation of a medical information search engine accessed on mobile devices for low-resourced areas. The challenges faced in low-resourced areas are covered, and adaptation of mobile medical information search for these areas is discussed. Finally, the impact that this technology can have in low-resourced areas is presented.

Keywords: medical information search, mobile search, low-resourced areas.

1. Introduction

A particular challenge faced by many low and middle income countries is providing good medical care and quality health information to people living in low-resourced areas. The challenge in rural areas is that the population is usually sparsely distributed over a wide area, while health facilities are more concentrated in the areas of higher population. Even in urban townships (underdeveloped living areas on the edge of towns or cities), access to primary healthcare facilities is challenging due to transport costs and user fees. The following are the potential challenges for people living in low-resourced areas:

- **Poor access to information:** Mobile communication infrastructure as well as internet access is available, but the capacity of these services to deliver health information is significantly underused.
- **Sub-optimal medical care:** In isolated areas, people are forced to travel long distances to reach the nearest point where medical care or health advice is available.
- **Low level of education:** This could have an impact on understanding complex medical concepts and terminology. It also has an impact on language capability –

the majority of people are fluent in a local language, but have difficulties with a common language spoken by for example staff in hospitals.

- **Poor training availability:** Training programmes in a suitable format are scarce and generally costly.
- **Low access to high quality health information:** As the priority in these areas is not the health information, the people have no adapted access to quality health information which is part of the care.

Access to medical information could be improved through provision of a search engine accessed from mobile phones. This would enable people to consult background information on health matters themselves. It is however not sufficient to simply provide mobile access to a general search engine such as Google. Even in countries with high levels of access to the internet and high levels of education, searching for medical information using a general search engine is not without its pitfalls. People tend to search for diagnoses on popular web search engines by searching on lists of symptoms, potentially leading to Cyberchondria (the belief that one has a disease because of searching on the internet) [1]. Furthermore, much of the information available on the internet is not trustworthy, e.g. about 70% of the top websites with information on oral cancers gathered by Google and Yahoo searches had serious deficiencies [2]. Lay people might assume that health information on the internet is trustworthy or might not have the ability to evaluate the trustworthiness of large amounts of information delivered by a general search engine.

It is not only lay people that wish to access medical and health information. Various studies have shown that physicians often have unmet information needs when seeing patients [15, 16, 17, 18]. Physicians working in rural areas also have frequent information needs that could be met through mobile medical search engines providing reputable information. Some countries, such as South Africa, have programmes requiring recently graduated physicians to spend at least a year working in a rural area, and these physicians could benefit greatly from such search capabilities. A medical search service for physicians has different requirements to the lay people search service [7]. Physicians wish to see information at a higher level of complexity than lay people, but it should also be directly applicable in their current situation.

2. Objectives

The objectives are to:

- Identify challenges for physicians and community health workers in accessing trustworthy health and medical information in low-resourced settings
- Present potential mobile-based multilingual search technology solutions to overcome some of the challenges identified
- Describe the potential impact of this technological solution
- Propose a model for sustainability of the solution

3. Methodology

The methodology adopted was to first identify the challenges in accessing high-quality health information faced in low-resourced areas, and the current status and use of mobile technology in such areas, based on the experience of the authors and relevant literature. Then specific challenges in adapting mobile multilingual search technology to low-resourced areas were identified, and potential solutions to these challenges were formulated.

4. Technology Description

The lack of medical professionals (doctors and nurses) in low-resourced areas is being countered by the efforts of *Community Health Workers*, who receive training and resources to deliver a large selection of primary healthcare services. Through this *task shifting* from medical professionals to community health workers, more efficient use of available human resources can be made [5]. The value delivered by community health workers is clear – improved public health, less long-distance transport needed of patients to clinics and hospitals, ultimately leading to a more effective and efficient health system. The value of the community health workers is also seen in the recently launched campaign to train one million Community Health Workers in sub-Saharan Africa by 2015 (<http://1millionhealthworkers.org>). Beyond face-to-face courses, the community health workers also receive educational updates through other media, such as instructional radio broadcasts in South Africa. As the majority of communication is by radio, this means that the communication is not interactive (feedback on how well which parts of the broadcast were understood is not available) and not repeatable (once the program is broadcast, the community health worker cannot revise any part of the broadcast at a later time).

It is known that when searching for medical or health information, people generally have the need to query and view search results in their native language [13]. A language barrier is often faced by lay people in low-resourced areas. An example is in rural South Africa where staff members of hospitals generally speak English or Afrikaans whereas patients often have much lower proficiency in these languages, leading to communication difficulties and misunderstandings [4]. A problem with indigenous languages such as Xhosa and Zulu in South Africa is that they are *under-resourced languages* with very few language resources available for training of machine translation or other language processing tools. Finally, as literacy levels are generally lower in low-resourced areas, reading printed information may not be possible for many people.

In 2009, 90% of the world's population lived in areas covered by cellular signal. In 2010, 67.6% of inhabitants in the developing world had mobile subscriptions [22]. With more smartphones in everyone's hands, mobile devices are becoming the connective tissue between citizens and the internet. By the end of 2013, 40% of mobile phone service subscribers worldwide will be using mobile internet [19]. Mobile devices are increasingly used to search for health information. A survey [20] showed that 17% of mobile phone owners have used their phone to look up health or medical information; while 29% of mobile phone owners aged 18–29 have done such searches [20]. The mobile applications will play a major role in promoting healthy living and habits with trustworthy and reliable information online and support in order to modify health risk behaviours such as unbalanced and poor nutrition, tobacco use and lack of physical activity. Physicians also appreciate the possibility to search for medical information from mobile devices, as they may have to do while away from their offices or dealing with cases in varied situations. Figure 1 shows a mobile medical search engine currently under development.

Telemedicine projects are built on the model of professional medical personnel consulting with each other over long distances. However, the technology that is the focus of this paper aims to provide physicians and lay people in low-resourced areas with the capability to access high-quality health and medical information from mobile devices at any time, giving them a powerful tool and hence greater independence in making decisions based on high quality information sources.

Some projects aiming to provide decision support for diagnosis aid are already under development, such as NxOpinion Knowledge Manager (NxKM) [6]. This system also has the capability to send and receive information using basic mobile phones. However, often it

is necessary to go beyond diagnosis aid. People in remote areas wish to obtain targeted medical information, and even participate in social networks.

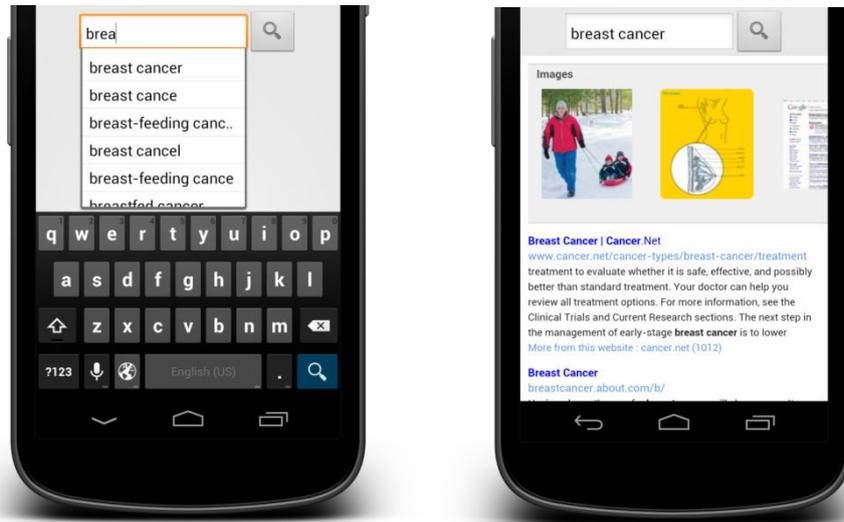


Figure 1. Query with query suggestions and search results on a medical search interface for a mobile device

5. Developments

This section identifies the developments that are necessary in order to overcome the identified challenges. In many parts of Africa, the lack of fixed lines in the telecommunications infrastructure is compensated by good mobile phone coverage, but usually limited to GSM (voice and SMS services). Nevertheless, innovative ways of using these simple technologies to communicate and conduct business have emerged [3]. In the health area, mobile phones are already being used for mHealth, such as for teleconsultation of health professionals with more specialists, and for data collection, such as research studies in geographically dispersed areas, disease surveillance and identification of seasonal priorities and epidemics [22].

Some countries are investing heavily into expanding data services in rural areas. South Africa for example has extensive coverage in rural areas by EDGE services, and is steadily expanding the 3G services. Through the improving level of service and the reduction in price of smartphones (the simplest smartphones already cost less than €150), the number of people in rural areas having access to smartphones will increase. Physicians in rural areas will likely be the first to use smartphones, and through e.g. social responsibility programmes of telecommunication providers, it is feasible to begin providing community health workers with smartphones.

Neil Pakenham-Walsh [23] stated that the real challenge is “around content and retrieval: to ensure that the [...] community health workers are actually able to access and use reliable, appropriate content, in the right language, in the right format, at the right time, to empower them to deliver the best possible care for different clinical situations with available resources; and that they are able to distinguish such content easily from the competing and increasing pressure of misinformation and commercially biased information.”

A recent survey of translators for African languages [21] showed that 67.85% of African language speakers prefer to receive health-related materials as a combination of spoken and written information, while 17.86% prefer receiving health information in spoken form only and 14.29% in written form only, which underlines the requirement for providing a combination of written and spoken material in the training of community health workers, which is possible on smartphones. A well-designed search system has the capacity

to allow the community health workers: 1) to access and listen to material broadcast by radio at a later stage, by giving a query-by-speech and obtaining access to the relevant sections of the broadcast, 2) to look up further information beyond what was broadcast on the radio, but also to look up information if faced with a new situation. Physicians will be able to take advantage of access to quality medical information provided by such a search system, although the documents provided can be of higher detail and complexity.

In order to adapt the search technology to low-resourced areas, a number of challenges need to be overcome:

Poor signal strength or low data transfer rate: Due to these factors, one cannot use the standard search engine model of returning multiple pages of ranked results, as it will be exceedingly time-consuming to scan through multiple pages of results and download multiple documents. A number of refinements to the search engine are necessary, which could include:

- Extensive assistance with query reformulation carried out before the search is launched in order to obtain specific queries that return a short list of high precision search results.
- Ability to obtain automatically generated summaries of documents at multiple granularities (corresponding to multiple lengths), so that the relevance of a document can be judged at multiple steps before the full document is downloaded.

Lower education levels: As lay people often cannot judge the trustworthiness and reliability of results obtained, the search engine will have to implement a stringent control of the results. This can be done through the use of an indicator of quality, such as the HONCode [14], but it will also be necessary to enhance this manual process with automated estimation of the trustworthiness and reliability of web pages [8]. It will also be necessary to specifically target search results based on the level of education of the user, with physicians receiving information at a higher technical level than a lay person.

Poor medical infrastructure: As well as being targeted to the level of education of the searcher, the information found should be targeted to local conditions and local infrastructure. A medical guideline containing advice that a patient should undergo an MRI scan may be less useful in a low-resourced area. In order to achieve the targeting of information to local conditions, ranking functions for search results will have to take into account information about the geographic applicability of the information given in the returned documents.

Low resourced languages: In addition to the regions being poorly resourced, the spoken languages are usually also under-resourced in terms of language resources such as vocabularies, corpora and thesauri. For this reason, particular attention will have to be focussed on creating the necessary cross-lingual information access, machine translation of results and query-by-speech technologies for these languages. Much work has already been done on machine translation for under-resourced languages [10], in which it is attempted to use e.g. texts that are not perfect translations of each other (non-parallel corpora) to train machine translation systems. However, it would also be useful to develop algorithms that make use of user interaction to improve language resources, for example, finding the best translation for a query by providing documents corresponding to a number of potential translations and recording the document selected by the user.

Poor levels of literacy: As many end users are expected to have poor literacy levels, it will be necessary to create a speech interface for querying and presentation of search results. The balance between client-based and server-based speech recognition is currently in a state of flux. For the majority of speech recognition services, almost all the computation is done on the server – the language models employed for such services can be

several GB in size, and the computational load has traditionally been beyond the capabilities of hand-held devices. However, both of those constraints are being removed as Moore's law does its work. Thus, the providers of speech-recognition services are all investing in client-based solutions as well. In the implementation of such a project, two opposing dynamics will have to be considered: as the use of high-performance smartphones becomes commonplace, client-based recognition becomes increasingly viable; however, the replacement of low-speed wireless connectivity by higher-speed networks is also a rapid process, thus obviating the need for such client-based solutions in many cases.

In order to ensure that the developed technology meets the requirements of the end users, it will be necessary to plan and execute extensive user-centred evaluations with the end users at all levels [9], and to continuously adapt the technology based on the results of multiple rounds of user-centred evaluations.

6. Results

The advantages in providing a multilingual mobile search system accessing high quality medical information to community health workers and physicians working in low-resourced areas have been identified and listed. For meeting the needs of the community health workers, the system should provide understandable information in both spoken and written form, with the possibility to search through query-by-speech. For physicians, the information provided should be more detailed, while the speech aspects are not required.

Based on the challenges identified in implementing such a system in low-resourced areas, technology that needs to be further developed has been identified. This includes: search engines returning more specific answers than a long list of links to result pages, improved algorithms for estimating the trustworthiness and readability level of medical information, better localisation of retrieved medical information so that it fits to local conditions and requirements, improved machine translation for the medical domain for under-resourced languages and a query-by-speech capability that works with under-resourced languages and lower bandwidth.

7. Business Benefits

Implementing the technologies proposed above would lead to the achievement of a significantly greater healthcare impact for the same amount of health expenditure. This expanded value proposition will include:

- **Improvement in the service offered:** Community health workers will have a more interactive service available as they will be able to repeat any part of a radio broadcast at will, and will also have access to a search engine allowing them to look up further information as needed. Furthermore, physicians based in rural areas will have access to medical information targeted at their level of education and adapted to the local conditions. This should enable the physicians to provide better medical care more effectively, by satisfying their information needs more rapidly.
- **Improvement in the interaction:** It will be possible for the service provider to get feedback from the community health workers through search log files. This will contain e.g. which parts of broadcasts were most repeated and which search terms were entered most often. This will contribute to a better adaptation of the educational material to the needs of the community health workers.
- **Capacity building:** At present, the training of a community health worker is time-consuming and expensive, as training is conducted face-to-face and hence requires extensive travelling. The technology proposed in this paper will increase the ability of community health workers to educate their colleagues, thus reducing the extent of centralised education needed and resulting in empowered end users.

- **Wider and more effective distribution of healthcare information:** The proposed system will be able to provide people with low health literacy a solution to be more involved in their health and accessing healthcare. Through the innovations such as multilingual support of under-resourced languages and speech interfaces through mobile devices, the hurdle to accessing the information will be significantly lowered.

8. Conclusions

Access to comprehensive and targeted medical information in low-resourced areas can have a large impact on the level of medical care in these areas. This paper discussed the challenges of and requirements for implementing a medical information search engine accessed on mobile devices for these areas. Due to rapid improvements in the mobile communications infrastructure in many low-resourced areas, the use of smartphones to access this information is becoming feasible. Two groups of end users have been identified as being the first to benefit from this technology: rural physicians and community health workers. The information presented by the search engine must be adapted to the level of education of the end user and to the specific requirements of their environment. It is important to be able to present information in local languages, which requires innovative work on improving the language resources available for under-resourced languages. Presentation of the information in audio form and query-by-speech is also important to counter potentially low levels of literacy.

Many of the basic technologies needed to solve the above challenges are already under development. Examples include the Khresmoi project (<http://khresmoi.eu>) in Europe, which is developing a search system for medical information including semantic search, machine translation and automated estimation of the trustworthiness and readability of medical documents [11]. The VOICES project (<http://www.mvoices.eu/>) has seen substantial progress in the development of speech technologies for under-resourced languages, as well as their application in environments where limited literacy is prevalent — the problem is not entirely solved, but the applicability of these technologies has been made abundantly clear. The IBM Watson Question-Answering technology is also being applied to healthcare [12]. Much work has already been invested in creating medical search engines and accessing them from mobile devices. Creating a well-adapted medical search engine for low-resourced regions can be done by building on and adapting existing work.

Making the mobile search technology proposed in this paper a reality will require a 2 year development effort with the participation of experts in search technology, mobile search and speech interfaces, as well as an organisation that develops health educational materials and provides education to community health workers, and optimally a mobile communications provider. During this period, extensive consultation, requirement elicitation and user testing will have to be undertaken with end users to ensure that the developed system meets their needs. Community health workers are already accustomed to obtaining their information from a particular organisation, so presenting the mobile search system as an additional resource provided by this organisation should encourage them to adopt it (provided that the user-centred design phase has been successful and the service provided is beneficial). Convincing physicians to use the proposed search service will require that the service provides clear benefits to them, most likely in terms of time saved due to more rapid access to pertinent medical information. A model for the sustainability of the service is also foreseen. Ideally, the benefits provided by the service will result in a significant reduction in medical expenses of a country's health system. This service can therefore be funded by a government or an NGO. For example, in South Africa, the government is currently in a pilot phase to introduce a National Health Insurance. This technological solution would be timely in solving the problem of providing country-wide

customised training and access to health resources for health workers on all professional levels.

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