Multidisciplinary Research in e-Health: Challenges and Thoughts

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Abstract: This paper attempts to shed some light on challenges encountered when researching e-Health, along with some thoughts on addressing them. The nature of e-Health requires putting together groups of multidisciplinary researchers. This complex, yet exciting, work environment presents several challenges that should be addressed in order to enhance e-Health studies. Issues regarding the system design and acceptance create challenges of their own and are discussed. Further challenges present themselves in aspects related to the data used for e-Health, some specific problems in this domain are related to obtaining labeled data for study, privacy issues, and dataset size. The paper also discusses the analysis of data and whether traditional expert experience is used or machine learning and data mining methods are preferred. While there is no claim to solve all the challenges raised, several directions on how to mitigate them and encourage research, in the fascinating area of e-Health, are suggested.

1 INTRODUCTION

This paper presents a viewpoint on the challenges faced while researching e-Health. It describes experiences had while researching health related systems in a multidisciplinary environment. The aim of the paper is to create discussion and provoke thought on the challenges researchers face in these domains, and hopefully by this shed light on directions to be taken for future studies.

Different types of e-Health systems exist, such as decision support systems, see (Kawamoto et al., 2005; Shibl et al., 2013) for a vast survey. Other systems are aimed at monitoring and rehabilitation such as (Seo et al., 2015; Zhang et al., 2015; Micallef et al., 2016) or bridging the distance between the patients to medical assistance (Nam et al., 2014; Mitchell et al., 2011; Demaerschalk et al., 2012). While some systems are specific to a condition (Richardson et al., 2008; Weymann et al., 2016; Bourouis et al., 2014; Artikis et al., 2012; Richardson et al., 2019), others try to present a holistic diagnosis based on various information such as combining various electronic medical records (El-Sappagh and El-Masri, 2014) or adding sensor analysis (Richardson et al., 2019; Peleg et al., 2017).

In many areas of research, studies are often performed in very controlled domains, and within specific disciplines. In contrast, e-Health requires the expertise of researchers from multiple areas. The combined nature of these studies presents many of the initial challenges faced by researchers in e-Health.

The paper describes some of the challenges that arise from the multidisciplinary nature of the studies, and point to some of the key aspects creating the complex environment. Some discussion on this can also be found in (Grönqvist et al., 2017; Pagliari, 2007). Perhaps, the first issue that the parties encounter is the different background knowledge of the various participants. This is often followed by differences in the technical terminology used and might also surface in the form of differences in research methods and platforms for publication. All of these issues must be addressed and handled in order for studies of this nature to succeed while keeping all collaborating parties active and contributing.

Unfortunately, even when research teams succeed in developing e-Health systems, many remain unused. Sometimes the systems simply don't do what they were meant to do and are therefore rejected. But, even functional systems are often unused. Sometimes it is the practitioners refusing to adopt the new technology, other times it is the patients. The paper points to the main reasons that systems are not accepted by practitioners or patients.

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As most e-Health systems use data sources of various kinds, the paper introduces some of the key issues in these domains. The first and most important is obtaining data for study, since without data e-Health systems are hard to realize. Another key issue is the privacy of the data which is extra sensitive because of the type of data used. Other challenges relate to obtaining labeled data, the dataset size and the size of the research groups involved. Some discussion on issues regarding the use of data in e-Health can be also be found in (Kuo et al., 2014).

The question of what type of analysis to perform on the data that is used for modeling the system, or throughout system use raises another set of challenges. Sometimes expert experience is used in the system and the question becomes who is an expert and how to update the system along with growing knowledge. Other alternatives are using statistical analysis or perhaps most common today is the integration of machine learning and data mining methods into e-Health systems. Challenges regarding how to preform this integration are discussed.

Finally, some thoughts on how to contribute to future studies on e-Health are proposed, including thoughts on education, and relevant research platforms.

2 MULTIDISCIPLINARY RESEARCH CHALLENGES

The first and perhaps most important challenge that arises when discussing e-Health is who are the collaborating researchers? In the past it was probably the technology community that thought of applying known technology and algorithms to the health domain, as these methods were unknown to the medical community. However, as technology developed and has become a part of everyday life, there is perhaps a shift to initiation coming from the health field (Pagliari, 2007).

Systems developed by engineers without medical support are possibly lacking from the health perspective. These systems were often developed with very limited knowledge regarding the health domain that the technology/algorithm was supposedly designed towards. The was often an underlying assumption that the 'fine details' could be ironed out in the future in the industry. Unfortunately, for many problems this is not the case, making many studies inapplicable to real world problems. Furthermore, the 'fine details' are often what make the problem interesting from an academic perspective as well. These aspects of the problem at hand are sometimes incentives to the development of new methods algorithms and technologies.

In contrast to systems initiated by engineers, practitioners are often unaware of available technology or how to apply it to their problems. Sometimes practitioners lack the understanding of how technology may be able to assist them and their patients. Other times a notion of unrealistic 'science fiction' ideas may exist.

Therefore, there is no doubt that e-Health requires multidisciplinary study that combines knowledge and methods from various fields. (Heeks, 2006; Pagliari, 2007; Van Velsen et al., 2013). These may be computer scientists, engineers, doctors and other health practitioners etc. The joined study becomes a spiral process where each discipline shares knowledge with collaborators, enriching them, and enabling them to proceed to the next level of understanding. In turn, this often raises deeper issues in each domain, resulting in further knowledge been shared between domain experts. This process repeats itself in an iterative fashion.

While it is clear that multidisciplinary research is necessary for e-Health, it also creates great challenges. Different research areas are sometimes worlds apart and coming together is often a complicated task. Some of the challenges encountered in multidisciplinary study are gaps in:

- Background knowledge
- Terminology
- Research methods and publication

Perhaps, the first problem researchers encounter when addressing multidisciplinary studies is obtaining enough knowledge in the domains outside their area of expertise. Some degree of understanding of what tools and methods exist in other domains is critical to providing a joint solution to a problem. While the expert from each domain is assumed to have sufficient background and understanding of his area, a discussion on a joint solution requires learning about research performed outside the area of expertise.

This brings on the second challenge - terminology. Different areas have different sets of terminology conventions. Sometimes learning a new set of terms is as "simple" as learning new definitions. Often, similar terms are used to describe different concepts across areas. This makes understanding each other even more confusing. The process of learning about other domains and terms is a continuous process that more often than not continues throughout the whole research process. Further discussion on terminology is also addressed in (Pagliari, 2007)

Aside from understanding each others language and concepts, conventions regarding research meth-

ods and later publication vary across fields and disciplines. Medical scientists use different study setups to computer scientists. Experimental setups may differ as do conventions of reporting research studies. The value of publication in conferences vs. journals often becoming another obstacle to overcome. The question of where to publish is sometimes confusing, some ”pure” venues consider multidisciplinary studies to be inferior to other studies and while multidisciplinary platforms are increasing they are still less common than platforms for specified disciplines.

Despite the aforementioned challenges, many researchers understand the importance of performing research across domains, and even enjoy the challenges as they enable expansion of knowledge and enable exploring new solutions to interesting problems. This leads to more and more research platforms becoming available, and perhaps even to some changes in thoughts on how to educate the next generation of researchers.

3 SYSTEM DESIGN AND ACCEPTANCE

System design proves to be one of the great challenges in designing and studying e-Health systems. The surplus of health related applications and systems is unbelievable and growing, approximating 40,000 apps in 2013 (Boulos et al., 2014) and 165,000 in 2015 (Terry, 2015). The diversity of conditions that are covered ranges from everyday diet apps (Recio-Rodriguez et al., 2016) to critical oncology apps (de Bruin et al., 2015) and touches on psychiatric symptoms (Place et al., 2017). Many systems require the users to actively interact with the application in order to achieve medical feedback, for example (Seo et al., 2015; Zhang et al., 2015; Nam et al., 2014), while others attempt to provide meaningful information, without requiring user actions for data collection and input (Richardson et al., 2019).

However, many of these diverse and interesting applications are never used. Some of the factors such as slow adaptation of the traditional healthcare community, the lack of integration with electronic health records etc. can be found in (Crockett and Eliason, 2016; Terry, 2015). The main challenges regarding system development are:

- Design
- Acceptance by practitioners
- Acceptance by patients

As with the development of any system, proper design is important. When it comes to e-Health this may be even more important. Defining the aim of the system, the targeted users, what the scope is, what aspects of the system are critical and what should be left out etc. Liability issues regarding the system must be addressed. The issue of false alerts verses missing out on a diagnosis or treatment need to be considered. To improve on regular system design models (Van Velsen et al., 2013) suggest a formalization for e-Health system design and are recommended for further reading.

Challenges regarding acceptance can be split into two categories. The first is practitioner acceptance. One of the main parameters found to affect acceptance was whether the system interfered with the regular work-flow (Shibl et al., 2013). Systems that interrupted with regular workflow were often rejected. Surprisingly, ease of use was considered less important. Practitioners also favor systems that display information automatically over search based systems (Kawamoto et al., 2005), see (Shibl et al., 2013; Kawamoto et al., 2005) for more details.

The second acceptance challenge relates to the acceptance by patients. Adoption of health apps is sometimes compounded by factors such as confusion regarding which app to use. Introducing systems to ageing communities sometimes creates extra challenges. Perhaps the most significant is the relative reluctance of older people to adopt new technology. While one must beware of generalization, as some mature adults are extremely comfortable with these technologies, others are not. The reluctance to adopt new technologies is often complicated by accessibly issues such as text size, and button size, or even by cognitive functioning require to use the system. All these parameters and more, must be considered for system design.

Despite these challenges, establishing patient self-monitoring with tools such as mobile apps is important for improving patient health (Dobkin and Dorsch, 2011; Writing et al., 2016).

4 DATA RELATED CHALLENGES

In the domain of e-Health most studies require data for designing the system, validating it or testing it. The types of data used and the ways in which they are used is diverse. For example, data might be obtained from patients and then used to study medical conditions. Systems that use machine learning often use the data to build their classification models. Sometimes data is used to evaluate e-Health tools. Some key issues regarding the type of data are:

- Obtaining data for study
- Privacy

- Labeled data
- Dataset size

Obtaining data for health studies can be a nontrivial issue. In order to collect data one needs to have access to a group of subjects with a certain underlying health issue. These subjects must agree and commit to data collection. Patients are often hesitant about sharing their personal data and even after agreement to contribute, often fail to cooperate over the lengthy time periods that are often needed for data collection.

For obvious reasons data concerning the health of patients must be kept under strict privacy conditions. Issues regarding privacy are often the key reasons to medical data being unobtainable to researchers.

To complicate matters further, it is very difficult to obtain labeled data. Labeled data is critical to many machine learning algorithms. In health domains labeled data is usually the tagging of the condition being studied. But, while unlabeled data is comparatively easy to obtain, labeling the data usually requires manual labeling by trained practitioners. this makes labeled data much harder to collect, since the labeling process is time consuming and thus expensive. On top of this, since labeling is performed by human experts it may be disputable or inexact. This might result in disputable results regarding modeling or testing that are based on the labeling.

There is the question of the dataset size. While the world is abuzz with "Big Data" and some medical data is obtainable in large quantities, it is often difficult to use these datasets for studies. The requirements regarding controlled studies that require data obtained under specific conditions and/or the need for labeled data make obtaining large datasets very difficult. A contributing factor is sometimes the research group size. Big health organizations and research groups, often have the upper hand regarding access to data as opposed to smaller groups. This often results in studies using comparatively small datasets for research, limiting the choice of tools for data mining, and perhaps even sometimes inhibiting the validity of the studies.

5 ANALYSIS CHALLENGES

While some e-Health systems are simply computerized listings with search capabilities, that are important in themselves, it is common for systems to use some analysis. The analysis is sometimes a set of rules defined by practitioners. However, it is becoming increasingly common, and perhaps almost mandatory to include some kind of automated analysis from fields such as machine learning. Some possible analysis methods are:

- Expert experience
- Statistical analysis
- Machine learning

Expert (Practitioners) experience may be present in different ways. If the system is a Decision Support System, then the expert considers the output from the system and them combines it with his prior knowledge. Alternatively, systems sometimes integrate expert knowledge (perhaps from multiple experts) within the system decision process. In this the case there is a vulnerability to differences in opinions between practitioners. A broad survey of Clinical Decision Support Systems along with a detailed discussion explaining the need for such systems can be found in (Castaneda et al., 2015).

Standard statistical analysis is often of great use to building health systems, and evaluating data such as in (Rosenblum et al., 2003; Rosenblum, 2006). However it is guided by the analysts assumptions on the interesting features in the data.

Using methods from machine learning is becoming increasingly common for example: (Artikis et al., 2012; Richardson et al., 2019; Richardson et al., 2019) and has great potential. The challenges of using a machine learning component are vast. The first, as mentioned earlier, is obtaining data for building machine learning models with. The size of the dataset greatly impacts the choice of the chosen algorithm. While neural nets are becoming the most common way to analyze data, they require large sets of labeled data, these are often unavailable for health domains.

Another challenge that is especially important in health domains is the question of explainability. Explainability refers to the ability of the user (practitioner/patient) to understand how the system works, or makes decisions (Rosenfeld and Richardson, 2019). It seems that in health domains this requirement is even stronger than in some other domains. The reason may be the reluctance of practitioners to trust systems where they do not fully understand the thought process. A survey of how explainable different types of algorithms are appears in (Rosenfeld and Richardson, 2019) and is of possible interest to readers addressing this challenge.

6 LOOKING FORWARD

This paper is by no means a complete list of all challenges that might be encountered while touching on e-Health. Rather, it raises discussion on some of these

challenges. This wouldn't be complete without some thoughts regarding what might be done in the future in order to help resolve these challenges or at least assist e-Health researchers in addressing them.

One of the most significant ways to address the complexity of multidisciplinary work is to introduce it at earlier stages of academic education. The undergraduate level might be the right time to begin this process. Encouraging courses taught by lecturers from several discipline might be a good step. Even better is to encourage projects that require cooperation between students from different disciplines. This would give the students, tomorrows researchers, the experience that they need in handling multidisciplinary discussions and cooperation techniques.

Building platforms for multidisciplinary study such as that described by (Grönqvist et al., 2017) will enable both understanding of these challenges and hopefully also possible solutions. Together with platforms for the presentation of multidisciplinary studies, such as conferences and journals. These platforms are already becoming more common, and will enable the discussion of studies in these areas within the relevant framework in a fashion that is presentable to researchers with a variety of backgrounds.

Regarding the availability of data with the restrictions discussed, this is a sensitive issue, as data is difficult to obtain and often sensitive to freely distribute. Defining standards for depersonalizing data along with the support of data repositories might prove beneficial. Other ideas remain for further investigation.

Perhaps the most important point to consider when looking forward is that despite the challenges mentioned and perhaps because of them, Studying e-Health is a very rewarding task. The excitement derived from learning new methods, terms and domains provides interest to researchers from all areas. The need to mold and refine familiar research methods in order to bridge the gaps between areas, enables the development of new and perhaps improved techniques. Challenges are what make research interesting, and will hopefully continue to advance the science in this domain and others.

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