33rd Annual International Conference of the IEEE EMBS
Boston, Massachusetts USA, August 30 - September 3, 2011

Online survey system for image-based clinical guideline studies using the Delphi method

Todd M Harper, Chia-Chi Teng

Abstract—**The increasing use of health information technology (HIT) is due to a rising interest in improving the quality of health care. HIT has the potential to reduce cost and transform services. Proper clinical support systems will contribute to the meaningful use of HIT systems by providing a wide array of data to clinicians for the diagnosis and treatments. Clinical guidelines, created by a consensus of experts, can be put in place to assist physicians in making clinical decisions. Delphi methods are commonly used to create consensus from surveys completed by a team of experts. Image based studies could create guidelines that standardize severity, deformity or other clinical classifications. As these studies were traditionally conducted using paper based media, the cost and time requirement often make the process impractical. Ware proposing a web based system to aid medical researchers in conducting image based Delphi studies for improved clinical guidelines and decision support.**

I. Introduction

THE increasing use of health information technology (HIT) promises to transform services with improved quality and reduced cost [1]. Publicly and privately funded projects are aiming to speed up the adoption and meaningful use of health information technology (HIT) and to protect privacy, enhance security, and improve interoperability. Clinicians, consumers, politicians and insurers all share the common interest in improving the quality of health care [2][3].

Subjective clinical decisions are made daily by physicians based on their personal experiences where patients with similar problems end up receiving different care depending on their location, clinician or hospital. These variations are of interest because of some assumptions that the differences in care stem from inappropriate care [3]. To make proper clinical decisions, health care providers need accurate data, pertinent knowledge and problem-solving skills. Clinical decision support systems are designed to provide pertinent data which generally fall under two categories: statements about the patient and what to do for the patient [4]. While the former includes diagnosis and symptoms directly taken from the patient, the latter focuses on the treatment and/or test procedures contained within clinical guidelines.

Clinical guidelines are an important aspect of the clinical decision support systems provided to improve the quality of care received by patients. They are statements that are systematically developed to assist practitioners in making decision about appropriate treatments and healthcare for patients. [2] Best available evidence should be used in developing these guidelines. Ideally the evidence would be scientific; however expert opinion can be used to fill the gaps in knowledge and literature when scientific evidences are not yet available. To create clinical guidelines based on expert opinion, a scientific method should be used that allows for a consensus.

The Delphi Technique is commonly useful in situations where individual judgments must be expressed in order to address the lack of agreement or gaps in current knowledge. [5] A traditional Delphi study is comprised of multiple iterations of surveys or questionnaires. After each iteration feedback is collected and statements modified which allows the expert to come to a consensus. Several modified versions of the Delphi Technique exist.

Traditional paper based surveys can be time consuming, inefficient and costly. Sending studies out and receiving them back takes time as well as financial resources. Human errors can be introduced as data get transferred from paper to analytical tools leading to incorrect results. Web based technologies can be used to create efficient, cost effective Delphi studies. Surveys can be generated and completed in a fraction of the time as paper based counterparts. The cost per survey can also drop dramatically as adding new users to a survey is simple.

Image based surveys focus on creating a standard for diagnosis. Fisher, *et al.* states often in clinical practice "accurate subjective grading of an individual patient's deformity is more difficult because of the absence of direct comparison. [6]" This statement holds true for severity, deformity, similarity or other classifications. By focusing on image based Delphi studies researchers can create a standard, effectively creating an opportunity for direct comparison in the clinic.

We are designing a system using a Delphi Technique for image based surveys where a consensus of certain type of ranking is to be reached. The objective of this system is to allow researchers and clinicians to create surveys, gather experts and produce results that can be used as clinical guidelines.

II. Background

Examples of using Delphi Technique in medical research can be found in the literature from as early as 1975 when Lindeman used a Delphi Technique to expound on clinical nursing research priorities. In this early study nearly 400 nurses completed four rounds of questionnaires. The questionnaires were paper based and did not focus on image ranking.

T. M. Harper is with the Brigham Young University, Provo, UT 84602 USA (e-mail: toddharp@byu .net).

C. Teng is with the Brigham Young University, Provo, UT 84602 USA (phone: 801-422-1297; fax: 801-422-0490; e-mail: ccteng@byu.edu).

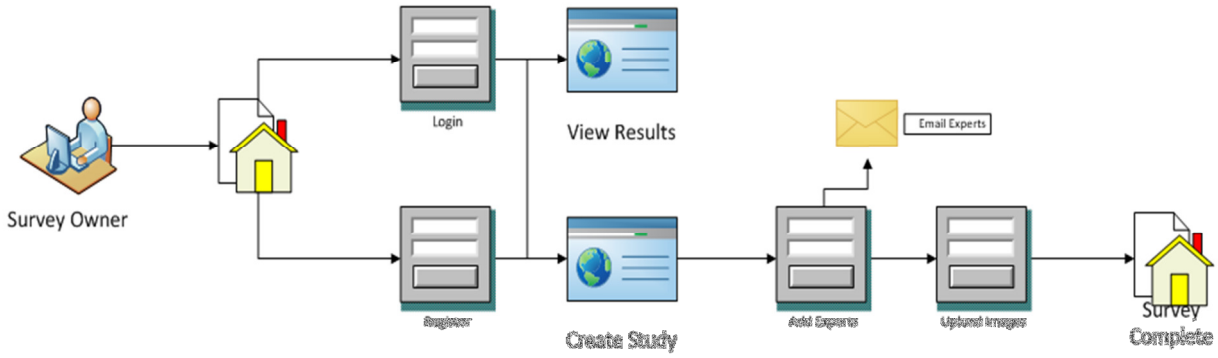

Figure 1. The workflow for a researcher.

In 2008 Fisher, *et al.* published a study that used the Delphi Technique to rate the severity of cleft lip nasal deformities. In this study the researchers hypothesized that experts were able to reliably rank patients according to their deformity and that this ranking is consistent to a set of anthropometric measurements. This study showed that expert ranking is consistent with the measurements. While this study uses an image based Delphi approach the survey was paper based and the statistics were gathered by hand.[6]

Another example of clinical guidelines created from a Delphi study is Linde, *et al.* published in 2005. These researchers used a Delphi study to develop clinical guidelines for lower-limb prostheses. An expert panel was chosen to participate in two survey rounds. The rounds were conducted via the internet. The overall time for this study was 18 months. This study focused on postulates and the expert panel had to reach a consensus, described as near 75% agreement. [8]

In searching the literature for image based Delphi studies only one was found. One possible reason for the lack of literature is the difficulty in carrying out these studies. Images must be printed off with sufficient quality that the experts can make an informed ranking. Once the study is complete transferring the compiled data to a digital form for thorough analysis can cause errors in the data.

An internet based Delphi study engine focusing on image studies will simplify the research process, reduce the time and cost of the study. The images can be as high a resolution as desired to assist experts in the ranking process. Once the images are ranked, statistics can be used to generate the final ranking online or offline. The scale of study can also be dynamically adjusted since the number of experts can be increased or decreased with ease. With an internet based study system, researchers can collaborate with experts from across the globe.

III. System Overview

The proposed system is designed as a web service based on standard internet technologies such as PHP, jQuery and JavaScript programming language, with a SQL database. These open source web technologies allow for full browser compatibility across systems. This website allows researchers to create studies, upload images, identify experts, send invitations, track progress and produce results. Once an expert accepts the invitation to a survey, he can simply follow a link to a webpage where he can rank the images by reordering the images through a drag-and-drop user interface.

The survey work flow is designed as shown in Figure 1. To use the service a user must first log-in or register. Once the user is authenticated, a side panel displays the studies that can be accessed by the user. The user can view the results of past studies or create a new study.

Creating a new study involves two steps, shown in Figure

Figure 2: The workflow depicting an expert taking and completing a survey.

1. First, the study creator must identify participating experts by name and email. He can choose from a list of registered experts by choosing the desired specialty, or manually enter information of known collaborators. These are the experts that will be invited to participate in the study. These experts

are emailed a link to a webpage where they can complete the survey. This process is illustrated in Figure 2. The second step of creating a study is to upload survey images through a web interface which allows multiple images to be upload at one time. Figure 3 shows the web interface for creating a mock survey.

As this is designed for medical research, the use of images is a sensitive issue. As such, once an image is uploaded, it will be anonymized by removing its metadata

expert will submit the order/ranking of the images to a results table. We leveraged the jQuery programming library to facilitate the drag-and-drop functionality.

Throughout the duration of the study simple real-time statistics are provided to the owner of the study. The correlation between the completed rankings is given to establish agreeability between the survey participants. When the study is complete the final correlation is displayed and the researcher can download the raw survey data in a

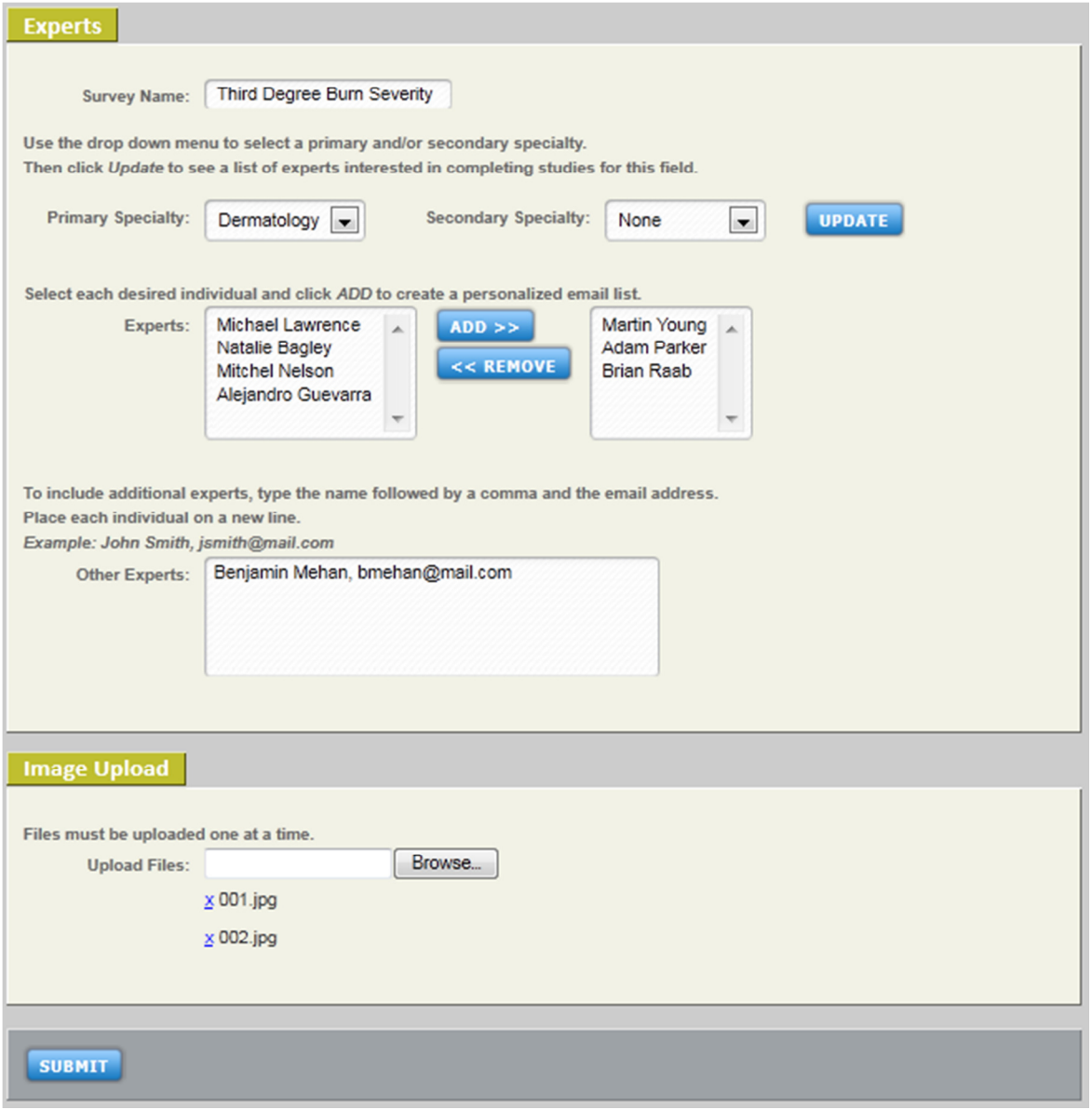

Figure 3: The survey creation form.

such as GPS location, image creator or creation date so that the image cannot be traced back to a specific location and/or subject. It is hoped that the researchers creating the study will have removed this data in compliance with HIPAA laws pertaining to research.

To complete the survey, the participating experts will reorder/rank the images using a drag-and-drop user interface as shown in Figure 4. Once the ordering is complete, the

standard spreadsheet format for further analysis.

The site is powered by a MySQL database that has been normalized. Normalization of the database allows for faster querying as a result of simple primary-key based relations. The database is comprised of seven tables: users, images, experts, studies, results, specialties, userSpecialty. The database schema can be seen in Figure 4

IV. Evaluation

A preliminary validation of this prototype system was conducted through a mock study created online with cleft palate images similar to the Fisher study [6]. Invitations were sent to ten pediatric cranial facial experts. Each participant ranked the severity with the drag-and-drop user interface on the website. The agreeability of the ranking across experts was measured with correlation coefficient also similar to the Fisher study. The online survey system demonstrated comparable agreeability among the experts. The study was completed in less than two weeks with minimal financial cost and staff overhead.

V. Conclusion and Future Work

The creation of this tool allows for more image based Delphi studies to be efficiently conducted for medical research. The results of these studies have the potential to greatly impact patient care as clinical and research guideline. A new clinical case can be compared to the guideline and the appropriate action can be taken for that level of severity.

Future work includes a full beta test with studies in multiple subjects and usability study. Possible additions to the project include integrating a system for text based Delphi studies.

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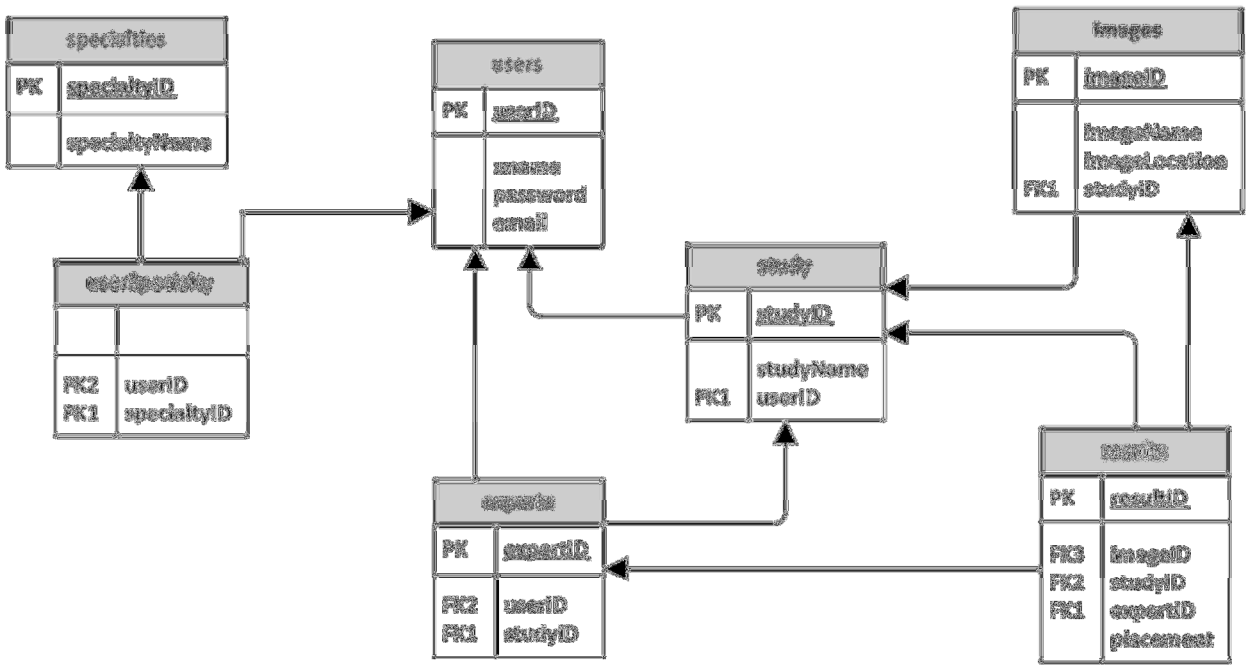

Figure 4: The database schema