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Data Collection with iPhone Web Apps

Efficiently Collecting Patient Data Using Mobile Devices

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***Abstract*—The use of mobile and ubiquitous computing devices is advantageous for collecting and sharing patient data at the bedside or in hospital waiting areas. iPhone web applications — or web apps — combine the power of Internet based solutions with the simplicity of multi-touch and gesture technology, all one portable device. Since many data collection platforms have moved to an online paradigm (or are in the process of doing so), a web app is an ideal solution. In this work, we show the advantages of using a web app for patient data collection, as an imaging engine, and for patient feedback and survey systems. This can be achieved by taking advantage of simple functions available on the iPhone OS when using an online collection platform.**

Keywords-iPhone; patient data collection; imaging engine; electronic health record; patient feedback systems

I. INTRODUCTION

Traditional portable systems (tablets or laptop systems) have been cumbersome and difficult for patients to use due to their large size, clumsy interfaces and limited battery life. Device costs were also quite expensive and difficult to replace and maintain. The use of ubiquitous computing devices (especially smart mobile phone technology) for collecting data is better suited in a high tech hospital environment.

Only a handful of hospitals have migrated or adopted the use of mobile systems (and applications). Such systems would increase efficiency and reduce errors for a multitude of applications. One popular system – which was only introduced in 2007 – is Apple Inc's iPhone (and iPod touch). This smart phone has garnered great public consumer support, making it an extremely widespread mainstream device. (1) Taking advantage of this popularity and user understanding, helps to create more streamlined workflows that can incorporate the patient directly within a hospital or clinical setting. Some of these will be outlined below.

A. Medical Applications for the iPhone

There are a growing number of medical applications tailored for the iPhone with Apple Inc suggesting over 700 as of January 2010. (5;10;11) Some of the available applications border on data collection tools with features such as self-report and sharing information with a consulting physician. Various medical professionals are now using the iPhone to access patient electronic records, laboratory test result values, medication information and reference systems (such as contra-indications), charge capture decision-support tools and medical calculators. (7) Below we describe some applications.

FitnessBuilder, pioneered by PumpOne, is a physical therapy tool that allows a physical therapist and the client to communicate during therapy. This application allows the therapist to assign exercises, and patients to report how much of the exercise routine they have completed. The physical therapist is then able to monitor the progress of the patient. (12)

AsthmaMD is a self-management application with features such as a diary, graphing ability, and medication logs. This application encourages the interaction of physician and patient by sharing charts and information as well as sharing the user's information for research purposes. (15)

Hopkins Antibiotic Guide is an application for the management and diagnosis of syndromes and pathogens with a reference guide on antibiotics, as well as a section for comments by the author. (5)

There are also a growing number of reference apps for the iPhone. Epocrates is an extensive drug database for information on dosage, interactions, laboratory tests, adverse reactions, pharmacological information, profiles on clinical news and conference highlights. (5;13) Attesting to the popularity of this application is the claim that 100,000 physicians use this application via their iPhone.(14) Similar applications are Medilyzer, (a drug reference application with information about side effects and dosage) and Procedures Consult (a medical reference application, providing educational material to students and professionals). The reference applications generally include animation, illustrations, and video. (15)

Programs that assist decision making have become quite prolific. KidneyCalc is an application that guides decisions about dosage for patients with renal dysfunction. (15) Handbook of Signs and Symptoms is a decision-tool application whereby medical staff can identify signs and symptoms and discover the most probable cause. (15) Differential Diagnosis i-pocket is a similar product with over

800 sings, symptoms and abnormal findings. (15) MedMath and MedCalc are both medical calculator applications that include commonly used medical equations. (5)

One of the primary functions of an iPhone was the ability to Podcast presentations, hence broadcasts of medical presentations or conference content can also be uploaded to any iPhone device. (5)

B. Health Projects using iPhone Technology

The Doylestown Hospital project wanted to improve clinic workflow. In turn they gave physicians access to the hospital electronic medical records database using the iPhone to facilitate this. (8) A primary reason the project called for iPhone usage is that after initial installation, the device automatically wirelessly synchs with the hospital server. (7) iPhones allowed physicians to access information necessary for patient care such as laboratory results and vital signs while enabling them to explain surgical procedures through imaging capabilities. (8)

George Washington University Hospital developed a project aimed at improving cardiology patient care which enabled physicians to access EKG images from their iPhone. This simplified the physician's on-call routine decreasing the burden on emergency room staff. This rapid access to patient data led to improving turn-around times for patients. (7)

Utilising the iPhone as a platform for anatomical education was found to be successful in multiple educational centres since sources (such as imaging data and educational videos) were effortlessly transferred to and easily accessible by the iPhone. (1)

Memorial Hermann Healthcare System is currently drafting systems that envision physicians using their iPhone as a medical reference tool and to view patient information in a secure manner – with remote wipe facilities and passcode protection. (9) This particular hospital currently makes use of the AirStrip OB application in order to monitor labour with delivery room data such as contraction patterns. (9)

II. METHODOLOGY

We conducted this research with an aim to propose the use of an iPhone application within the healthcare sector. Several applications for the iPhone have been created in order to test such mechanisms on real world systems for various clinics. The application specified in this work, was designed for use in an atheroscerlotic patient clinic (SPARC) that relies on a MySQL backend database and a PHP front end web platform. Each specific section of the iPhone application will be described here.

A. Patient Demographics Acquisition

One of the foundations of any health record is patient demographics. It represents the core data for any medical institution. Accurate demographics equates to eventual accurate statistical analysis. In traditional systems, a triage nurse (or assistant) collects baseline foundation data manually. In other words, either the patient or the nurse fills out forms by hand – which are eventually transcribed or coded to an electronic database housing all patient records. These traditional systems introduce a redundancy to the entry mechanism which leads to various quality control issues. These include: errors in filling out initial handwritten forms, errors unintentionally transcribed to the database during coding, etc. Furthermore this process requires two separate steps, manual collection and electronic transcription, in order to populate the database; hence twice the amount of time and resources are used by the clinic.

In order to alleviate such issues, a mobile web application (web app) was designed for use with the clinic's database. This web app was designed for the iPhone to take advantage of the interface features offered – such as gesture support. The acquisition tool allows for demographic data to be directly imported into the database, which could be done by either patient or nurse onsite. Furthermore, validation (which was implemented using JavaScript) was applied to each field ensuring that data was not missed or incorrectly filled. Such techniques allowed for further increases in quality control ensuring accurate patient record entry.

Figure 1(a) depicts a screenshot of the patient demographics acquisition system. For this web app, detailed history was required by the client. The web app takes advantage of all the user interface enhancements of the iPhone along with soft keyboard features for data input.

B. Imaging Platform

An imaging platform was created in this web app since the use of imaging data (whether CT, Ultrasound, MRI, etc) associated with a patient's record was required. This is used in two ways:

1. The first allows the clinician to analyze a complete patient record, including all associated test results in order to verify findings. Gesture-supported tools such as magnify and reorient allows the clinician to highlight and focus on various aspects of the patient images.
2. The second allows the clinician to illustrate a patient's condition and would help them cope with their illness. Ultrasounds were imaged in the proposed iPhone application such that multiple views (for instance bifurcation, internal carotid, four-chamber, apex, etc) were available for the user to select and magnify.

Figure 1(b) depicts an example of a four-chamber view echocardiogram. This image can be selected and manipulated by the user using simple hand gestures (tapping, pinching, etc) as defined by the iPhone's interface.

This platform is easily extended to include multimodal datasets and simple registration and segmentation algorithms. These are only limited by the processing power of the iPhone – as such algorithm efficiency is critical to ensuring these tools would be used.

C. Patient Surveys and Learning Tools

Feedback mechanisms from patients provide valuable information that can be stored and queried on the database. Once collected, this section of the web app can also be used to train and teach patients about various issues regarding the

effects of their medications and counter indications if stopped. Furthermore, it can be used to collect and track patient knowledge, their medication compliance, satisfaction and health related quality of life.

The gesture supported interface allows for ease of data entry of these surveys, which can be filled out while the patient is waiting for the clinician. Several devices can be reserved for patient waiting rooms which can collect feedback and educate the patient about their illness simultaneously. They can also be used to inform the patient that the clinician is ready to see them. Furthermore, patients can provide their email address, which would allow the system to send educational material to the patient following their visit.

Figure 1(c) depicts an example of a patient survey and feedback form. Patient lifestyle habits allowed the clinic to make more accurate decisions on diagnosis and future outcomes. These feedback systems provided a means for the clinic to improve their workflow and operations center.

III. Advantages of the Platform

Many advantages have already been mentioned as to using smart mobile systems (direct entry, portable, relatively inexpensive, remote wipe features, etc), however many specific reasons exist for utilizing Apple Inc's iPhone platform:

- The iPhone allows for adaptation and flexibility at each level of its operating system. (2)
- The iPhone can be easily sterilised for use with patients by means of a standard alcohol wipes. (3) This can prevent the possible spread of microbes or other germs present within the hospital environment.
- With specific functions such as an accelerometer and microphone, multimodal data can be collected or captured. (4)
  - Given the motion sensors embedded in the iPhone, it could allow for the possibility of monitoring a person's agility and movement (possibly monitoring various movement based disorders).
  - Accelerometers may aid in mental health i.e. many disorders are accompanied by physical signs and symptoms (physical movement as well as activity levels) such as frenetic motions which aid in diagnosis of a mental condition. (4)
- Data that can be potentially mined from the iPhone could provide rich, dynamic information in a second-by-second account of the patient's experience. (4) Although this is an intervention, the patient may consider this as part of their daily routine as the device is not overly intrusive and is enjoyable to use.
- The iPhone as a data collection tool could help monitor the patient's response to a given treatment (be it medication compliance or based on behaviour change). (4)
- The touch-screen and gesture support allows for easy and familiar user interaction, as well as panning images with a finger tip - essentially interacting with the phone. (1;5) This is particularly relevant where older patients are concerned. The touch facility requires less agility then using a point and click device.
- The built in GPS could provide, with patient consent, tracking of patient location and geographical patterns that could be useful in diet and nutrition initiatives. (4)
- The wireless and 3G capabilities allow for easy and seamless access to the internet. (1;6)

A. *User Interface and Mainstream Proliferation*

Touch screen interfaces have traditionally suffered from cramped layouts and poor displays. This has led them to rely on soft pens for navigation. The iPhone user interface relies primarily on finger based navigation, and a minimalist layout paradigm. In other words, screens must be kept simple and focused, relating only to the operations desired.

Application features are structured at a very high level. This ensures that application abide by the standards outlined by the provided libraries. These standards provide, hierarchical levels that are easily retractable, which allow for switching between main functionality without losing your position, editing of information while maintaining context, etc. The simple and intuitive layout of the interface allows for natural understanding of programs running on the iPhone, which allows users to take full advantage of the application without a learning curve.

The rapid adoption rate and popularity of the iPhone (and iPhone OS devices) have made the use of such systems advantageous, as most clinicians and patients have access to them and are familiar to use such systems. This makes them ideal for small clinic use that sees a high throughput of patients. For instance a clinic could purchase several iPod Touch devices (instead of iPhones) for a relatively inexpensive amount – and they would not require mobile phone plans. These devices can communicate with the database via a wireless network or Bluetooth connection rather than a mobile data plan.

B. *Rapid Development Model*

Apple Inc. has provided several tutorials and an extremely comprehensive literature set on its iPhone development platform. Furthermore, examples and drag-and-drop interfaces for creating web apps (or fully flanked iPhone applications) facilitate rapid development times. Each section of the iPhone application designed took minimal development time since current PHP pages were simply adapted to the mobile screen size and various gesture features were added.

Since iPhone development is carried out using xCode (Apple Inc's integrated development environment) and involves similar methods and library calls as writing standard Mac OS X applications, there was virtually no learning curve for our current developers. Those that had no prior experience with Objective-C (the language used for Mac OS X development), followed Apple Inc's online tutorials and were creating example programs extremely quickly. The relatively low learning curve for development created great excitement and drove rapid development times.

(a) *(b)* *(c)*

Figure 1. iPhone web app screenshots. *(a)* Detailed patient demographics acquisition platform, *(b)* Imaging platform, *(c)* Patient survey and feedback platform.

C. Security

In general, when dealing with any patient record or information, all data must be secured and housed behind a hospital firewall system. One of the main objectives in using a web app was to build a system without breaking this imperative. The use of web apps provided this functionality, since any data would be accessed through the secure site already established by the current database.

Current PHP pages that were retooled for the iPhone leveraged the same security protocols on the original website accessing patient data. Furthermore, all of the actions taken by any user of the web app was logged and stored on the database. Hence any malicious attempts to circumvent security or corrupt data are quickly detected and access is revoked (reinstating the original data if changes that did occur become trivial).

IV. CONCLUSIONS

In order to improve efficiency in collecting patient data, tablet systems or lightweight client computers have been adopted by various clinics for use in patient waiting rooms. These systems have been found to improve workflow, increase the accuracy of data acquisition systems, and streamline patient feedback mechanisms. The use of ubiquitous mobile devices (such as iPhone OS technology, which further supports future platforms – such as the iPad) allows to further improve such practices. The proliferation of these mainstream devices has encouraged a strong paradigm shift in the consumer space which encourages their adoption in an ever growing e-health world.

We have shown that it is possible to use of iPhones for collecting patient data, displaying various imaging modalities, and collecting feedback is advantageous when used in a clinical setting. Our future research will involve pilot work with patients evaluating the applications in order to improve adherence to lifestyle, diet and medication use changes. We aim to do this through a cross-over trial where patients are initially given traditional care interventions followed by the use of our iPhone application. We will also conduct focus groups with our patients to ensure that we are responsive to their needs and preferences in future development.

The web app created for this project will be extended to be used in other clinical centres which would aim to improve their respective workflows and data collection systems. There are implications to both individual health (where the application can be personalized based on patient preferences and needs) as well as at the population level (where these devices can be used to reach different age cohorts). Although cardiovascular disease is very prevalent, the emerging diseases such as childhood obesity and type 2 diabetes in these patients is equally

compelling and requires new media to engage patients. We believe the iPhone provides a unique opportunity achieve this.

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