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Original Article

Pocket pathologist: A mobile application for rapid diagnostic surgical pathology consultation

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Abstract

Introduction: Telepathology allows the digital transmission of images for rapid access to pathology experts. Recent technologic advances in smartphones have allowed them to be used to acquire and transmit digital images of the glass slide, representing cost savings and efficiency gains over traditional forms of telepathology. We report our experience with developing an iPhone application (App - Pocket Pathologist) to facilitate rapid diagnostic pathology teleconsultation utilizing a smartphone. **Materials and Methods:** A secure, web-based portal (http://pathconsult.upmc.com/) was created to facilitate remote transmission of digital images for teleconsultation. The App augments functionality of the web-based portal and allows the user to quickly and easily upload digital images for teleconsultation. Image quality of smartphone cameras was evaluated by capturing images using different adapters that directly attach phones to a microscope ocular lens. **Results:** The App was launched in August 2013. The App facilitated easy submission of cases for teleconsultation by limiting the number of data entry fields for users and enabling uploading of images from their smartphone's gallery wirelessly. Smartphone cameras properly attached to a microscope create static digital images of similar quality to a commercial digital microscope camera. **Conclusion:** Smartphones have great potential to support telepathology because they are portable, provide ubiquitous internet connectivity, contain excellent digital cameras, and can be easily attached to a microscope. The Pocket Pathologist App represents a significant reduction in the cost of creating digital images and submitting them for teleconsultation. The iPhone App provides an easy solution for global users to submit digital pathology images to pathology experts for consultation.

Key words: Application, cell phone, consultation, digital pathology, iPhone, smartphone, telepathology

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INTRODUCTION

The traditional method for consultation in anatomic pathology relied on the physical transport of glass slides or tissue blocks. This method is often lengthy, logistically difficult, and may have legal considerations when originating institutions lose control of the tissue. Telepathology however, can transmit digital pathology images of the glass

slides via telecommunication links for remote interpretation (telediagnosis) and/or consultation (teleconsultation). The benefit of adopting telepathology is rapid access to pathology experts, and hence improved patient care.

Various modes of telepathology have been employed including the use of static images, video microscopy, robotic microscopy, and most recently, whole slide imaging (WSI). One of the major drawbacks to the widespread adoption of telepathology has been the prohibitive cost of purchasing and maintaining digital imaging equipment. Digital cameras mounted to microscopes can be expensive (e.g. $2,000-6,000). WSI scanning systems are even more expensive (e.g. $30,000-300,000). Recent technological advances have led to the widespread and rapid adoption of clinical photography and sharing of digital images using smartphones in diverse medical fields. Medical applications for smartphones and tablets are changing the practice of medicine.[1] The use of smartphones also presents a new opportunity for digital pathology consultation,[2] especially in the developing world and rural areas.[3] Given the ubiquitous use of comparatively inexpensive smartphones, and the advent of adapters that enable smartphones to be attached to microscopes to take photographs,[4,5] a mobile solution using cellular phones presents a feasible solution to solve the restrictions of traditional telepathology.

The aim of this technical note is to share our experience with developing an iPhone application (App) to facilitate rapid diagnostic telepathology consultation.

MATERIALS AND METHODS

Website Development

Technical details about the web-based tool our group created to support digital pathology consultations has been previously reported.[6,7] This digital pathology consultation portal (http://pathconsult.upmc.com/) was designed primarily to facilitate second opinion consults using whole slide images. However, static images can also be uploaded via this portal. In addition to images, the portal also permits pertinent accompanying clinical information to be securely uploaded. The tool was designed to accept a limited number of data fields in order to facilitate rapid submission of cases. It allows the customer to enter a full patient background, attach patient reports if needed, upload static and/or whole slide image files, submit insurance reimbursement information, and select a specific consulting pathologist or subspecialty pathology division from which to obtain a consultation. Using this tool, consultants at our institution are able to view digital images using a Java applet and have the ability to incorporate their diagnostic reports into this web-based application.

Application Development

The iPhone App was designed to provide the same user experience as the web portal, while functioning as a standalone program. The development of the App required teamwork among pathologists and information technology professionals. Members of the development team involved are shown in Table 1. The iPhone App was developed using the SCRUM software development process. Rally software was used to track progress through each 2-week sprint. The application was developed over the course of four sprints (8 weeks). Application Lifecycle Management software was employed for quality assurance testing and tracking.

It was critical to allow the iPhone App to interface with the existing database structure currently used for the mobile and browser-based web portal [Figure 1]. A secure Rest API was developed in .Net to allow the iPhone App to communicate with the Microsoft SQL Server database. All data were encrypted in transit over

Table 1: List of project team with associated responsibilities

Role	Responsibility	Team members
Product Manager	Managing product backlog and working with stakeholders to define minimal viable product per release	1
Product Analyst	Defining product requirements and assessing value	1
Project Manager	Tracking overall progress and coordinating events	1
User Experience Designer	Optimizing user experience through user interface and user interaction with the information system	1
Software Engineer	Development of the product	2
Quality Assurance Analyst	Product validation and verification	2
Architect	Technical and informational design	1
Pathologist	Define clinical needs, workflow, and user testing	4

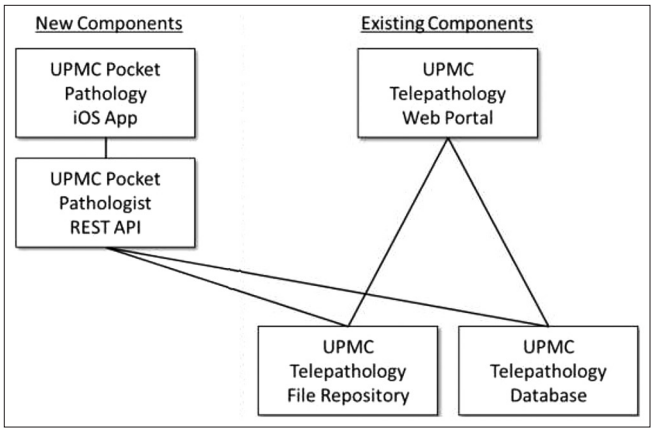

Figure 1: High-level architectural design of the mobile telepathology application

https and at rest to eliminate the risk of electronic protected health information (ePHI) exposure. The intent was not to store ePHI on the smartphone device to mitigate privacy risk. Photographs could be stored encrypted within the application memory, but without any ePHI.

An agile software development process [Figure 2] was used to develop the final product [Figure 3]. The goal of the agile process was to rapidly deliver a releasable product at every development iteration. The high-level flow began with aggregating all user feedback and product requirements into the "Product Backlog". At the beginning of every development iteration (sprint), the Product Backlog was "groomed" for the most valuable or desired features. Any features that the team estimated to take longer than the 2 week sprint were subdivided so that the feature was attainable within the sprint window. The resulting "sprint backlog" contained only the top features that our team had capacity to deliver. At the end of each sprint, a "sprint review" occurred where the end users and product owners accepted or rejected the feature sets based on completeness towards the intended goal. Our sprints were grouped into quarterly release cycles.

A member of the team acted as SCRUM master throughout the entire release. This SCRUM master was charged with managing the daily SCRUM standup meetings and worked to identify and resolve barriers. All team member roles and responsibilities are described in Table 1.

RESULTS

In April 2013 we completed development of a native iPhone App called "UPMC Pocket Pathologist" [Figure 4] to facilitate rapid second-opinion digital pathology consultations. The application was launched on August 7, 2013 in the Apple iTunes store. Paired with an ocular attachment for capturing digital images using a smartphone camera from a light microscope, the submitting pathologist/institution was able to submit a full digital consultation request directly from an iPhone with just a few taps on the smartphone. The first digital submission from China consisting of 18 static images was received 12 days after launch [Figure 5].

DISCUSSION

The aim of the iPhone application was to provide an easy solution for global users to submit digital pathology

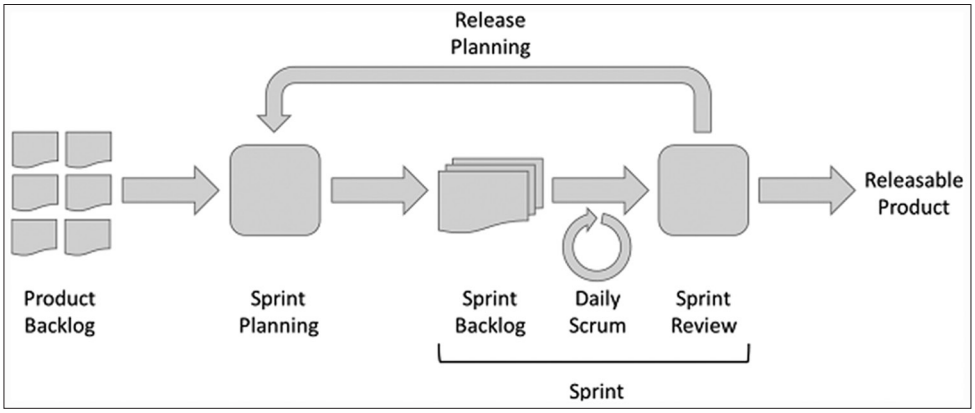

Figure 2: Simplified agile development process employed

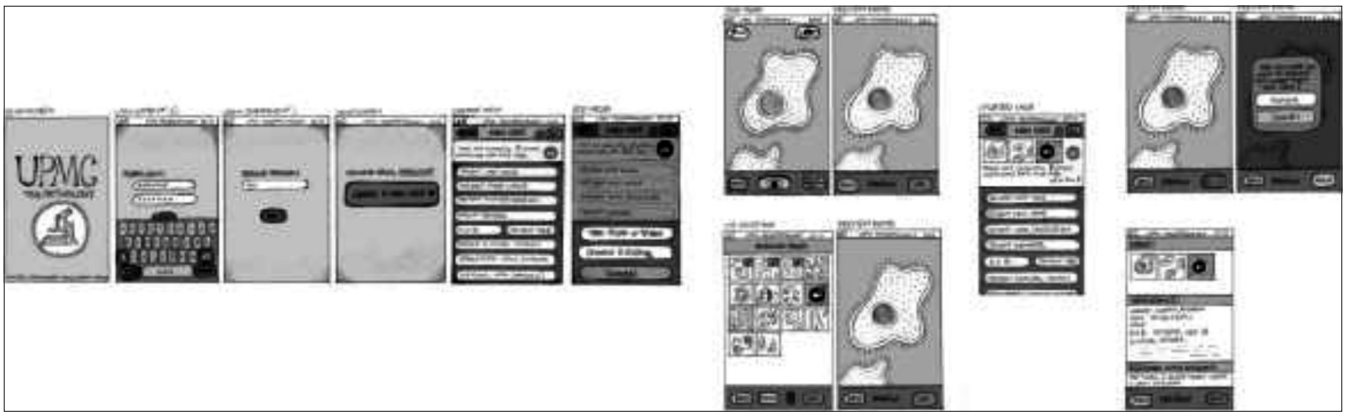

Figure 3: UPMC pocket pathologist wireframes created during App development

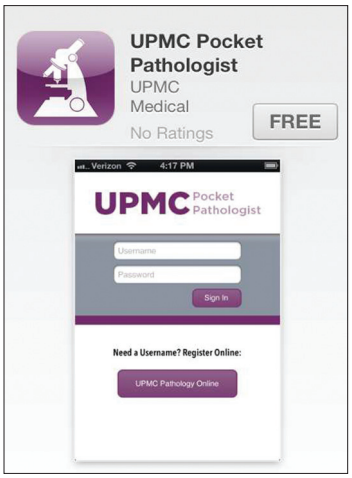

Figure 4: UPMC pocket pathologist available in the iOS App store

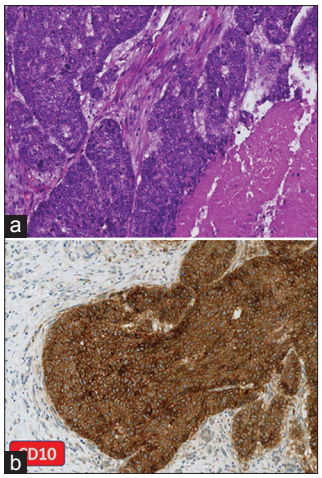

Figure 5: Examples of static pathology images submitted using the smartphone application for digital consultation. (a) Pancreatic carcinoma (hematoxylin and eosin (H&E)). (b) CD10 positive tumor (immunohistochemical stain)

images to pathology experts at our institution for consultation. Our web-based telepathology portal was modified to support HTML5, a protocol widely supported in smartphone devices such as iPhones or Android-based devices. However, a mobile website, no matter how well-designed, does not offer the same user experience, flexibility, and elegance of a dedicated mobile App. Of note, Facebook and LinkedIn have abandoned hybrid HTML5 approaches for mobile devices due to a variety of technical reasons including immature development tools and inefficient memory utilization among other reasons.[8,9] Developers in general accordingly seek HTML5 approaches due to the allure of cross-platform portability,[10] but mobile browsers tend to lag native application capabilities.

The UPMC Pocket Pathologist App represents a significant reduction in the cost of creating digital images and submitting them for teleconsultation. The static images our institution received via smartphone for teleconsultation were of adequate quantity and quality for our consultants to render a diagnosis. Building on our existing web-based telepathology platform allowed for rapid development and deployment of this native mobile application. The file upload and data entry process was streamlined to create a user-friendly interface, allowing the originating pathologist to complete it in just a few minutes. This tool represents a considerable hardware cost saving when compared to currently available digital imaging technology. As a result, this mobile solution makes digital pathology teleconsultation a viable option for all pathologists, when previously it was only tenable for large healthcare institutions. In Europe, Drs Livia Bellini and Eduardo Missoni have been utilizing mobile technologies to spread diagnostic assistance into the developing world particularly in Africa starting in 2008.[5,11] With the ever-increasing use of mobile medical Apps greater attention will need to be paid to their accuracy,[11] standards,[12] and emerging regulatory rules.[13-14]

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