DocTouch

Tianyi Yao, Stephen Xia, Momona Yamagami
Final Report
ELEC 419

April 22, 2015
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1. Introduction

DocTouch is a novel platform to better assess post-surgical wound recovery and track surgical sites for signs of infection. It utilizes a mobile application combined with a phone stand to facilitate remote monitoring of the post-surgical wounds using video media.

With increasing quality of healthcare and better technology, the mean length of stay at a hospital after surgery has been decreasing over the years worldwide. As such, it is much more difficult for doctors to follow up and ensure that the patient does not have surgical site infections, or SSIs. Current interventions include phone calls made to the patient, routine checkups, and questionnaires, but all methods take time for both the patient and the doctor. Additionally, they assume that the patient can tell whether their wound is infected or not. However, research shows that patients do not have the ability to determine whether their wound is infected or not. Studies show that out of all the people that say they have an infection, only 30% actually do, meaning inefficient use of time for both the doctor and the patient.

By providing patients with an application through which they can complete a questionnaire about their wellbeing as well as take a video of themselves pressing around the post-surgical wound, DocTouch will allow the doctor to make the final conclusion about whether the wound needs further attention or not and remotely track the wound healing process.

2. Customer Discovery Process

Before we decided upon what constitutes our minimum viable product (MVP), we first made hypotheses or assumptions as to what our potential customers value and what they are willing to do for their values. Since our objective is to provide an effective way for patients who had undergone surgeries to provide data on their surgical sites to doctors and surgeons, we must make assumptions about both parties, since both parties will be using the system we create. Our initial hypothesis include the following:

- Patients are willing to install and use a medically approved software application that would let them communicate with their doctors, rather than seeing them directly
- Sending 3-D images of wounds is a sufficient substitute for in-person doctor check-ups
- If doctors have access to 3-D images of wounds, they can better assess the condition of their patients' wounds

To validate our hypotheses and assumptions, we conducted a series of interviews before and during the product development phase.

Our first assumption pertains to patients who will use our system. In order to validate this hypothesis, we interviewed five Rice University students who have undergone surgery to learn more about the surgery process they went through. Additionally some of the interviewees, at their own discretion, shared the experiences of any close relatives who have had surgery. All of the interviewees stated that they would prefer using a software application that would allow them to remotely communicate with their doctors than going to see them for in-person checkups as long as there was nothing abnormal about their surgical sites. Going in for checkups is both costly and inconvenient for
patients. These results validate our first assumption. However, the Rice University students brought up a few points of consideration.

First, there is the issue of wound dressings. Most patients had dressings over their wounds, which makes taking any kind of media such as pictures or videos of the wound impossible. Doctors will want to receive information on their patients’ wounds on a regular basis, which can be problematic if there is no window of opportunity for patients to capture media. The problem can be averted if we look at the fact that the bandages on wet or fresh wounds have to be changed on a regular basis, every one to two days. Before applying a new bandage, patients can take and send the necessary media to their doctors.

Second, many surgeries occur in areas of the body that are difficult to capture using phone cameras because the area is well concealed, such as the inside of the mouth, or because there exists better techniques for evaluating surgeries on that region of the body, such as the eyes. Since there are alternative methods for these procedures, we decided to limit the application of our device to surgeries excluding the types of surgeries listed above.

Third, we asked patients to describe the types of questions their doctors asked them while they were recovering and what they thought their doctors were looking for to assess their condition. Every response we received was different, ranging from diet to range of motion, implying that the types of information doctors ask from patients vary greatly depending on the type of surgery. Our final system must try to accommodate for this variability.

Our second and third assumptions pertains to doctors and medical professionals who will use our system. In order to verify these assumptions, we spoke with doctors and surgeons in the Texas Medical Center.

The first medical professional we spoke with was pediatric surgeon Dr. Kevin Lally. Dr. Lally stated that if he cannot determine the condition of the wound from one image, he calls the patient in for an in-person examination, as one photograph from above the wound is usually sufficient to determine whether the wound is infected or not, and multiple angles that a 3-D image would provide are not required for an initial remote assessment. As such, we found that our second and third hypotheses pertaining to medical professionals needed to be revised heavily.

However, Dr. Lally and the other three surgeons we spoke with throughout the semester emphasized touching points around the wound to assess the condition of the wound. By applying external pressure to the wound, they then observe indicators such as temperature, drainage, swolleness, and tenderness around the wound. From this insight, we reformulated our assumptions to the following.

- Patients are willing to install and use a medically approved software application that would let them communicate with their doctors, rather than seeing them directly.
- Doctors heavily rely on touching and applying pressure to assess the condition of wounds. Subsequently, both patients and medical doctors have validated these assumptions. These points formed the basis of our minimum viable product.
3. The Minimum Viable Product (MVP)

The features and functionalities of our Minimal Viable Product (MVP) are based on the hypotheses validated by interviews and literatures. The DocTouch platform consists of an Android compatible mobile application coupled with a Web App. The reason why we chose the Android platform over the IOS is because Android is a relatively more stable operating system, and software for Android can be more easily distributed. We chose a cross-platform Web App for doctors to view patients’ video session in any web browser because during the interview process, a few doctors, especially Dr. Suliburk, mentioned that they prefer using desktops in their offices to check patient-related documents, as desktops normally have larger screens and they are more accessible than a smartphone for doctors at hospitals.

Our decision to use video taking as our medium to communicate the conditions of the wounds to doctors was based on literature review on 2D images, as well as interviews conducted with the medical professionals. Research shows that assessments of the condition of the wound based on a photo poorly correlates with an actual in-person check-up, with an r value of only 0.54². In addition, Dr. Suliburk, one of the doctors that we interviewed noted that 2D images do not contain sufficient information of the wound and shaky cameras rendered such images almost unusable. Therefore, we decided to take videos of the surgical sites which could contain information of the wound from multiple angles, in addition to audio information from the patients using our application.

Moreover, all the medical professionals we interviewed confirmed that physically touching the wound is of utmost importance in the process of wound infection detection. Since our platform promotes the concept of remote wound monitoring, we came up of a way to “replace” the doctors’ touch with self-assessment by patients. More specifically, patients will use the DocTouch mobile application to take a video of themselves touching multiple points around the wound and send the video session to their respective doctors for examination.

Additionally, patients’ wounds will only be exposed when their dressing is changed once a day. As the DocTouch platform requires the patients to take a video of themselves pressing the area around the wounds, the video-taking activity can only take place during the time when bandages are changed. Therefore, instead of using real-time video session which would require the doctors to be available during the time of dressing change, the DocTouch mobile application automatically saves the video session to the cloud and allowing doctors to view the videos at any time they want, thus making the video-taking and viewing process even more convenient for both doctors and patients.

Furthermore, a few studies have shown that there is correlation between pain level and wound healing progress. More specifically, nociceptive pain indicates tissue damage and such symptom should prompt doctors to perform further examination⁵,⁶,⁷. As such, by having the patients touch pressure points around the wound, the pain level experienced by these patients as recorded on audio should give a good indication to doctors as to whether the wound requires further attention.

To minimize the effect of poor video quality due to shaking cameras, we built a phone stand so they can use both hands to press areas around the wound. The stand is foldable, and allows the patient
to use the better quality back camera while still viewing the front screen to take better quality videos (figure 1).

![Image](image-url)

**Figure 1:** Picture of stand (left) and picture of recording session using back camera (right)

Additionally the types of information that doctors ask from patients vary significantly from surgery to surgery. As such, we found it necessary to include a questionnaire, to be filled out by patients, into the application. The questionnaire can be customized by medical professionals, depending on the type of surgery that was performed on the patient. An example of the questionnaire feature is displayed below (figure 2).

![Image](image-url)

**Figure 2:** Patient Questionnaire
4. Technical details of the MVP
The overall system diagram of the DocTouch platform is shown below (figure 3).

![Diagram](image.png)

**Figure 3**: Basic structure of the DocTouch software platform
As shown in the system diagram, the DocTouch platform consists of a central cloud server and two client sides, namely, an Android mobile application for both patients and doctors, and a Web App designed specifically for doctors.

For the DocTouch Android mobile application, patients and doctors can sign up for a new account by entering their desired username and password (figure 4).

![Figure 4: Login/register page](image)

As some features of the application are only accessible to medical professionals, we created a separate login system for patients and doctors. After they register successfully, they can log in to their respective accounts. After patients log in with their valid credentials, they will be taken to the video taking screen automatically. On the same screen, there is basic instruction asking the patients to press five points around their wounds. For example, if a patient would like to start the video session, they can press the “Take Video” or “Record” button and the video recording will begin (figure 5). During the recording, whenever the patient presses the area around the wound, they are required to indicate the pain level by saying out loud a number between zero and ten where ten refers to the maximum level of pain. After the video session ends, the patient will be able to review the video in the DocTouch folder on their smartphone and they can choose to upload the video session to the server by pressing the “Send” button if they are satisfied with the video quality.
Now if the doctor of the patient logs into their Medical Professional account either from the Android mobile application or the Web App, the video session will be automatically downloaded to the doctor’s phone or computer (figure 6). Afterwards, the doctor can examine the wound conditions based on the information provided by the video. If the doctor finds the touching points are not ideal, they can pause the video at any time, take a screenshot of that particular frame, and move the screenshot to the drawing canvas (figure 7). On the drawing canvas, the doctor can indicate the ideal touching points for the next video session by mark a few dots on the screenshot and send the image back to the patient.

For the DocTouch MVP, the cloud server is mainly utilized to store the video sessions taken by the patients and the feedback images sent by doctors.
5. Results

We validated our MVP in two parts - first with patients and determining whether they will use our application as a substitute to going in for checkups post surgery, and second with doctors and determining whether a video provides sufficient data to determine whether the wound is infected or not.

We obtained mixed reviews from the patients. Generally, it seemed that most of the patients liked the idea of our product, and thought it would be helpful to use when they are too busy to stop by the doctor’s office. One patient mentioned that because he has time as a graduate student, he doesn’t mind going to the doctor’s office periodically, but could see the potential benefits of the device for users with busier schedules. They also wanted a sleeker interface, and wanted explicit instructions telling them how to touch the area around their wound. In addition, patients liked the idea of using a stand to take a video of the wound, but wanted it to be foldable so it will be easier to store and transport, which we implemented in our most recent round of prototyping.

The doctor feedback we received was more positive, and they thought that focusing on post-surgical wounds was an excellent idea considering how surgeons get paid as opposed to other medical professionals. In addition, we took a video of a patient, who recently underwent surgery, touching pressure points around his wound. We showed the video to a doctor, who told us that because of the large volume of data that a video contains, it was fairly easy for him to determine whether the patient had an infection or not. He also suggested creating another phone stand for abdominal and chest surgery, as our current device is designed specifically for limbs. Another idea that he mentioned that we would like to implement in the future is first taking a video of an uninjured section of the skin to compare it against the injured skin, to determine the relative redness of the skin.
6. Future works

The overall system diagram with new features that will be implemented in the next few months is shown below (figure 8).

Figure 8: DocTouch extended software platform
Based on our interviews with surgeons, we have found that skin bounce rate, blood flow rate, and skin temperature are crucial indicators of wound healing progress. Therefore, we will implement various algorithms to compute these evaluation metrics in the cloud and send the data to doctors for analysis.

Furthermore, because of the asynchronous nature of the DocTouch platform, the doctors might not choose to view the video sessions right after the patients take them. This could pose a potential problem as the doctors might miss the best time to provide treatment if the video indicates that the wound is infected but doctors wait too long before they view the video. To mitigate this potential issue, we will construct an artificial neural network (ANN) in the cloud server. Using all the data available, including the skin bounce rate, the blood flow rate, and the color of the area surrounding the wound, the ANN can perform a preliminary examination on the wound. If the ANN detects clear signs of infection, the system will automatically send an email alert to the doctor and remind the doctor to examine this particular video session promptly.
7. References:


