Utilizing Multi-Touch Technologies in Medical Rehabilitation: A Therapeutic Capstone Project

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Abstract - It has been reported that capstone course projects can be made more engaging by working with external clients, incorporating new technologies, and creating a socially relevant product. Researchers have reported the potential for valuable assistive therapy by incorporating multi-touch technology in neuromuscular and cognitive rehabilitation.

In this paper the author discusses a capstone project that includes the development of a suite of therapeutic activities, with monitoring and reporting capabilities, which were designed and developed for medical rehabilitation. The activities were suggested by practicing therapists and developed on the Microsoft Surface multi-touch device. At project completion, the system will be delivered to a local rehabilitation center and we are hopeful that it can be used to provide valuable assistive therapy.

Keywords: capstone course, senior design project, multi-touch technologies, medical rehabilitation

1 Introduction

Capstone courses in computer science traditionally include such requirements as: 1) an extensive software design, implementation, and testing effort, often over an entire academic year; 2) development in a team environment, thus requiring students to use project planning and management skills; 3) numerous opportunities for the demonstration of oral and written communication – both in documentation and public project presentations; and 4) reviews and critical evaluation – both of the product and individuals.

Identifying the “ideal” capstone project for a senior class that meets these requirements and is both instructional and engaging is a challenge. Instructors of the capstone courses at other universities report several characteristics of senior projects that can be included to better engage the students. This includes such things as working with external clients [4,5,8], working on socially relevant projects [2,7], and working on projects that allow students to explore emerging technologies [7,8]. In our recent capstone course projects we have tried to include all of these characteristics.

This paper describes what we feel to be an exemplary capstone project using a multi-touch, multi-user device – the Microsoft Surface. Students were given the opportunity to work on a project that required learning a new technology, developing a very relevant medical rehabilitation application, and rolling out the final product to a rehabilitation facility upon completion.

The remainder of this paper is organized as follows. Section 2 provides background for the project, including how the project originated, an overview of the Microsoft Surface multi-touch device, explores the use of similar devices in medical rehabilitation, and overviews the initial system developed - Healing Touch. Section 3 provides a detailed description of the TheraTouch system. Section 4 summarizes project results and Section 5 offers some concluding remarks.

2 Background

2.1 In the beginning

Two years ago, one of the department’s Industry Advisory Board members approached us expressing a desire to work on a project with our senior class. After some brainstorming, and a generous donation of two multi-touch Microsoft Surface units by RadioShack, it was decided to incorporate these devices into a medical rehabilitation application.

The capstone project for the 2010-2011 academic year started the initial work with the Surface units. Those students explored the use of both the iPad and Microsoft Surface by developing several games that could be used as rehabilitation exercises – basically offering a proof of concept. A brief discussion of that project is included later in this section. That project laid the groundwork for the follow-on capstone course of 2011-2012 which is described in Section 3.

2.2 Microsoft Surface

The Microsoft Surface is a commercial computing tabletop platform that responds to touch and tagged objects [6]. It enables people to use touch and real world objects to share digital content. The Surface platform consists of software and hardware that combine vision based multi-touch PC hardware, Windows software, a 360-degree multiuser design to create a natural user interface.

The Surface 1.0, shown in Figure 1, consists of a rear projector display, integrated PC, and five IR cameras that can
see fingers and objects placed on the tabletop. People interact with the tabletop by touch or placing objects on the display surface. The Surface is designed such that multiple people can approach and simultaneously use the unit from all sides. The device can recognize 52 simultaneous multi-touch points.

![Figure 1. Microsoft Surface with TheraTouch Installed](image1.jpg)

The first Microsoft Surface 1.0 shipped in 2008. Since this project originally began, Microsoft and Samsung have released Surface 2.0. The applications described in this paper were developed on the original Surface 1.0.

### 2.3 Multi-touch devices in rehabilitation

The Surface was designed primarily for use by commercial customers in public settings. However, researchers have begun to realize the potential for using multi-touch devices in rehabilitation programs. Researchers from several universities are developing therapeutic applications for multi-touch devices [1,3]. The applications include developing activities for the rehabilitation of motor skills, upper extremity rehabilitation for children with cerebral palsy, and cognitive rehabilitation.

The traditional rehabilitation exercises can be monotonous, repetitive, and boring. The use of more interesting rehabilitation activities, even games, on multi-touch devices is more interactive and engaging. In addition, these multi-touch applications allow for multi-user interaction, can provide precise measurement of patient performance, and allow therapists to customize activities to specific patient abilities and needs. All of these benefits suggest that this type of technology has untapped potential in this field.

### 2.4 Healing Touch

As previously mentioned, the use of the Microsoft Surface units in our capstone course began with the 2010-2011 Senior Project – Healing Touch. In that project students developed a suite of games that could be used in medical rehabilitation. A neurologist and IT professional from Texas Health Resources, a local hospital system, helped identify appropriate therapeutic games. Screenshots of several of the games, including Air Hockey (game for social interaction and exercising motor skills), Meteor Defense (measuring motor skills), “Froggy Says” (memory recall), and Touchdown (deductive reasoning) are illustrated in Figure 2.

![Figure 2. Screenshots of Games in Healing Touch](image2.jpg)

The games developed in the Healing Touch project were designed for both motor skill and cognitive rehabilitation. The initial Healing Touch project saved all game results and provided for Excel spreadsheets containing game results to be produced. The user could obtain desired reports or charts but it was dependent on his ability to use the plotting and charting capabilities of Excel. Figure 3 represents a simple plot of the length of a sequence that could be recalled in the “Froggy Says” game after varying delay times between showing the solution and asking the user to respond. The plot compares results obtained from users of two different mental capacities.

![Figure 3. Sample Plot of Sequence Length Recalled](image3.jpg)

The project received very positive feedback from the client. At the end of the project, the client expressed a desire for enhanced reporting capabilities. The author also felt that a better understanding of actual clinical activities would be helpful in order to provide a system that could be utilized more effectively for assistive therapy. That outcome lead to the decision to develop a system that would provide activities...
similar to those used in therapy sessions, yet at the same time offer the benefits that multi-touch technology could provide. The following year’s capstone project, TheraTouch, is that project.

3 TheraTouch System

3.1 System architecture

The TheraTouch system, illustrated in Figure 4, consists of three primary components: 1) the TheraLink backend; 2) the TheraLink frontend; and 3) the Microsoft Surface units. The TheraLink backend includes a web application and the system’s database that stores patient information and activity results.

The TheraLink backend consists of a web application and the system’s database that stores patient information and activity results. The TheraLink frontend consists of staff laptops or workstations that interact with the web application in order to set up patient accounts, therapy sessions, and obtain patient reports. The staff members have the ability to customize therapy sessions, both with activities to perform and options to set for each activity. This important feature provides flexibility in the rehabilitation therapy by allowing therapists to customize activities according to a patient’s abilities and increase difficulty in the program as the patient shows improvement.

The Microsoft Surface units have the entire suite of TheraTouch activities installed. They run in a “free run mode” (collecting no data) or in therapy session mode (collecting activity data). Login with a preprinted patient Surface tag is required for running the Surface in session mode in order to collect data.

3.2 The web application – TheraLink

The web application gives an administrator the ability to create staff accounts and perform other administrative tasks. Staff accounts are required to set up patient accounts, set up patient therapy sessions, and obtain individual and cumulative results and reports. Figure 5 illustrates a session with six activities. The SeekShape activity is expanded, allowing activity options to be configured.

Figure 5. Configuring Activity Options

3.3 TheraTouch activities

The activities included in the TheraTouch system were designed with input from speech, occupational, and physical therapists. A list of the activities implemented, along with type of therapy primarily covered by each activity, is shown in Figure 6. All activities include some degree of physical therapy simply because of the need to interact with the Surface.

Figure 6. TheraTouch Activities

The activities shown in the table above were all implemented on the Microsoft Surface. In the prototyping of each activity, the appropriate activity options were identified as well as the activity results that would be collected and reported. Four sample activities are described below.
3.3.1 Maze

This activity was an implementation of the classic maze. From an initial starting point the user is required to draw a path to the exit without passing through walls. The activity provides for three levels of difficulty. This activity records wall hits and total time to negotiate through the maze. If the patient loses contact with the Surface display, he must pick up the path at the point where contact was lost. Figure 7 illustrates the Maze activity.

![Figure 7. The Maze](image)

3.3.2 Find the Way

The Find the Way activity was suggested by occupational therapists in order to have the patient find his way through a house to perform some routine task. For example, the patient might be asked to go get a snack from the refrigerator or go get a coat from the closet. This activity is shown in Figure 8. The patient moves a figure through the house with the controls at the bottom of the screen.

![Figure 8. Find The Way](image)

3.3.3 Odd One Out

Odd One Out simply provides a screen of shapes from which the patient was to identify the shape that did not belong. This activity’s options include such things as number and type of shapes displayed and records time to complete and incorrect selections. A screenshot of this activity is shown in Figure 9.

![Figure 9. Odd One Out](image)

3.3.4 What Time Is It?

Activities defined for occupational therapy deal with activities of everyday life. This activity was one of those. In What Time Is It? the patient is required to set the correct time. The therapist configuring activity options selects to have the analog time given and the patient sets the digital time to match, or vice versa. Accuracy and time to complete are reported for this activity.

![Figure 10. What Time Is It?](image)
3.4 Reporting

As previously noted, activity results are stored to a database for subsequent reporting. Reporting can be accomplished in one of two ways. Several custom reports for each activity are provided in the web application, utilizing standard ASP.NET libraries. Such things as accuracy vs. time to complete and user progress reports are readily obtained. Comparative studies are also provided by observing results of a particular patient vs. the patient population. Additionally, any activity results can be selected and exported to an Excel spreadsheet for additional reporting and charting. Figure 11 shows a particular patient’s improvement in accuracy (larger blue dots) and time elapsed (smaller red dots) as the activity was performed four times.

![Figure 11. User Progress Report](image)

4 Results and Observations

The original Healing Touch and the follow-on TheraTouch project have resulted in very interesting and relevant capstone projects. Though the pressure of actually producing a project to be delivered to external clients was often intense, the students responded well. An initial roll-out of the system to the rehabilitation clinic, complete with the donated Microsoft Surface unit, was accomplished three weeks prior to the end of the semester. We felt that this was particularly important in order to get initial feedback of the system for the students prior to their graduation. A subsequent roll-out of all completed activities and reporting will occur at the completion of the semester.

Since the activities were developed with input from practicing therapists at the facility, we are eager to see how the TheraTouch system will be accepted as an assistive therapy instrument. Preliminary feedback received at the final project presentation was extremely positive. That will have to be the subject of a follow-up report.

5 Conclusions

Identifying the “ideal” capstone project for a senior class is a challenge. It is often hard to find projects that both meet the requirements of the course and are engaging and interesting to the students. The initial enthusiasm for a senior project is often tempered by the grind of working on a project over an extended time (one academic year in this case) and of this magnitude. Up to this point in their academic careers, students have not had to work in groups of this size (eleven students in the case of TheraTouch), produce the required documentation, learn as much new material on their own, or be subject to as much review and evaluation.

In this author’s opinion, the group size noted is probably larger than ideal (because of accountability and communication issues) unless the project being developed has some clearly defined components that allow for smaller working groups. That was the case here. A group of four students worked with the backend web application and database while others developed the individual Surface applications. All students were involved at various times with client interviews and developing documentation.

We believe that the interest in working with a technology that was new to the students, working to meet the requests of external clients, and realizing that the product delivered was actually intended for use in a rehabilitation facility provided additional motivation and incentive and helped keep the students interested and engaged.

6 References


