CS6750 – Project

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1 INTRODUCTION

There is an estimated 1.5 million new cancer diagnoses made in the United States each year. Apart from chemotherapy, the most successful, non-invasive treatment is radiotherapy or radiosurgery. The current market leader in radiotherapy machines is a US headquartered company based in Palo Alto, CA called Varian Medical Systems. The machine developed by Varian is a state of the art linear accelerator (linac) mounted on a Gantry and controlled by a world class sophisticated system of Planning, Service, Treatment, and Hardware Control software. All components have a multitude of developers and designers to make sure each component is above and beyond the current standard.

The User Interface Devices (UIDs), have undergone some revisions but have not changed or been updated to modern standards in any manner. The most interactive UID, called a pendant, is capable of controlling the entire robot in all ways possible. Buttons, at the top of the pendant, control room lighting, special targeting lasers and patient lighting. Buttons at the center of the pendant select special motion axes groups to move in unison. Buttons at the bottom of the pendant select motion groups to allow for manually motion each axis with thumbwheels at the handle of the pendant. A screen at the top of the pendant displays the position for only one axis and the current selection of manually moving axis.

Figure 1: C-series pendant (year 2004)

Figure 2: TrueBeam pendant (year 2010)

Figure 1 and Figure 2 shows Varian machine pendants. Figure 1 is a pendant from a machine design that is three decades older than the design in Figure 2. The design has not improved significantly over the years and the functionality has remained largely the same, despite a myriad of new features introduced into the treatment machine. With more and more features added, the pendant user interface devices demands modernization.

2 INITIAL NEEDFINDING

The initial need-finding will be performed as a Naturalistic Observation of the use of the device by developers, engineers, testers, clinicians and therapists. The same groups of participants will also be questioned with a survey after being observed. The survey will determine features and usability requirements for the interface redesign.

Need-finding Plan

For Naturalistic Observation need-finding, a variety of users of the device will be monitored in regular operating settings. Since each user has varied needs, their interaction with the device will lead to a better understanding of desired improvements in functionality.

Developers and Engineers are mostly concerned with new features and bug fixes. Their interactions are constrained by the number of buttons available on the device and the screen real estate available for displaying information. Testers, clinicians and therapists are more concerned with treatment workflows. Certain button combinations and features which are accessible through the interface enable clinical features of the linac to be accessed for advances treatment techniques.

Three to five representatives from each subgroup will be observed and recorded. Multiple factors will be observed including but not limited to most frequently used buttons by each subgroup, button combinations, user distractions and inefficiencies. For each participant, the following survey will also be distributed and analyzed for interface redesign requirements.

1. What is your specialty in use of the Varian Pendant user interface device? a) Engineer b) Developer c) Tester d) Clinician e) Therapist
2. Which button groups do you use more often?
   a) Manual motion b) Targeted motion c) Lighting
3. Does the information display present all the information you would like to have available for you?
4. Would you be willing to train to use an interface device that utilizes a latest technological advancement, and which one?
   a) Not willing b) Screen Touch c) Augmented Reality d) Virtual Reality
5. Do you prefer dedicated controls for all functions?
   a) One control, one button b) some menu items are ok c) All interfaces should have only one button, like an iPhone.
6. Do you utilize one handed operation or two-handed operation of the user device?
7. Does having a wireless instead of wired device allow for increased flexibility and ease of use?

Need-finding Conclusions

Engineering, testing and design groups rarely use the topmost buttons used to control room lighting and laser positioning systems. The thumbwheels used for manual motion require use of both hands and cannot be controlled single-handedly. The thumbwheels are too far apart to cover six possible axes moves when attempting to operate the machine single-handed.

Target group buttons are only used when we have a target. Most workflows that have multiple targets, a user would have to select each target one after another for the entire machine to get to target. Similarly, manual motion buttons are selected one after another to facilitate manual motion. This observation points to possible button reduction in redesign considerations. Less cluttered button layout would significantly improve user friendly design for the clinician.

According to survey results, Lighting buttons are least often used and are mostly used by clinicians or therapists. All subject groups agreed that the information display did not contain all the information desired by the user. About 60% of the users would be willing to learn the touch interface, with other interface options gaining little favor, and about 25% not willing to learn any new interface interaction. Finally, 70% of participants felt that some menu navigation to reach seldom-used features was adequate without needing dedicated buttons. The vast majority of participants also determined that wireless control allowed for greater flexibility in use of a device.

Although cutting edge technologies like AR/VR did not seem as appropriate alternatives, well established interface technologies, such as touchscreens, appealed to users as a viable design evolution of the interface device. Together with redundancy in buttons and lack of menus observed during the naturalistic observations, a significant amount of changes are shaping foundational requirements for a possible prototype.

3 HEURISTIC EVALUATION

What works well?

The learning curve to use the user interface device, if familiar with the treatment system, is very small. The Gulf of Execution, in particular is small since simply holding down the side buttons while moving a thumbwheel will get the axis of interest moving. Similarly, pressing any lighting button and any target of manual motion buttons will enable that functionality to instantiate. In order to have all features mapped to buttons without having to enter any on-screen menus helps facilitate the ease of use for the user. Thus, discoverability, the notion of lowering the user's memory load in by making objects, actions, and options visible works very well in the current design as all functions are linked directly to a dedicated button.

What makes it work well?

Through the use of highly detailed Documentation, as dictated by the FDA for any medical device, the functionality of the user device is very well understood.

The learning curve to use the device is small since all features are directly accessible through button clicks. Additionally, the analog adjustability of the system axes lends to short Gulf of Evaluation as the speed of an axis is dedicated to a thumbwheel, and not a digital +/- button combination, where the speed could not be controlled as precisely.

What doesn't work well?

Flexibility and expandability of features into the interface device is fairly cumbersome. Being limited by button functionality, any new feature introduction must rely on button combinations, button click induced sub-features, or having the user device be a limiting factor in implementing a new feature altogether. Flexibility should allow both expert and novice users use the system with minimal help. However, since the button cluster is crowded, and each button is only differentiated from another by an image, a novice user may not be able to navigate all buttons clearly as advanced knowledge of each image and it's underlying functionality must be known. As such, the mapping of the system is poorly executed as real world actions are neither labeled, nor described but reduced to a icon image on a button that may not always mean the same thing to one person as another.

Why doesn't it work well?

Flexibility is very low on the device interface. New features must be mapped to static, well defined and understood buttons which may not imply the same functionality as previously understood by clinicians. Users would have to be retrained on new features and the Gulf of Execution must widen to accommodate the button clicks required to reach a desired result. The tolerance for making mistakes is also quite large as the on-screen display shows no error message or warning that an incorrect action is taking place. The only way to determine incorrect behavior is to observe the behavior of the machine. This leads to the fact that the Gulf of Evaluation may be small, since one button of thumbwheel move has direct action on the machine and the effect is immediately visible, but the cost of a small Gulf of Evaluation is a large tolerance of mistakes. The tolerance for mistakes allowing actions to occur which should not, simply because there is no check for right or wrong actions to perform.

4 INTERFACE REDESIGN

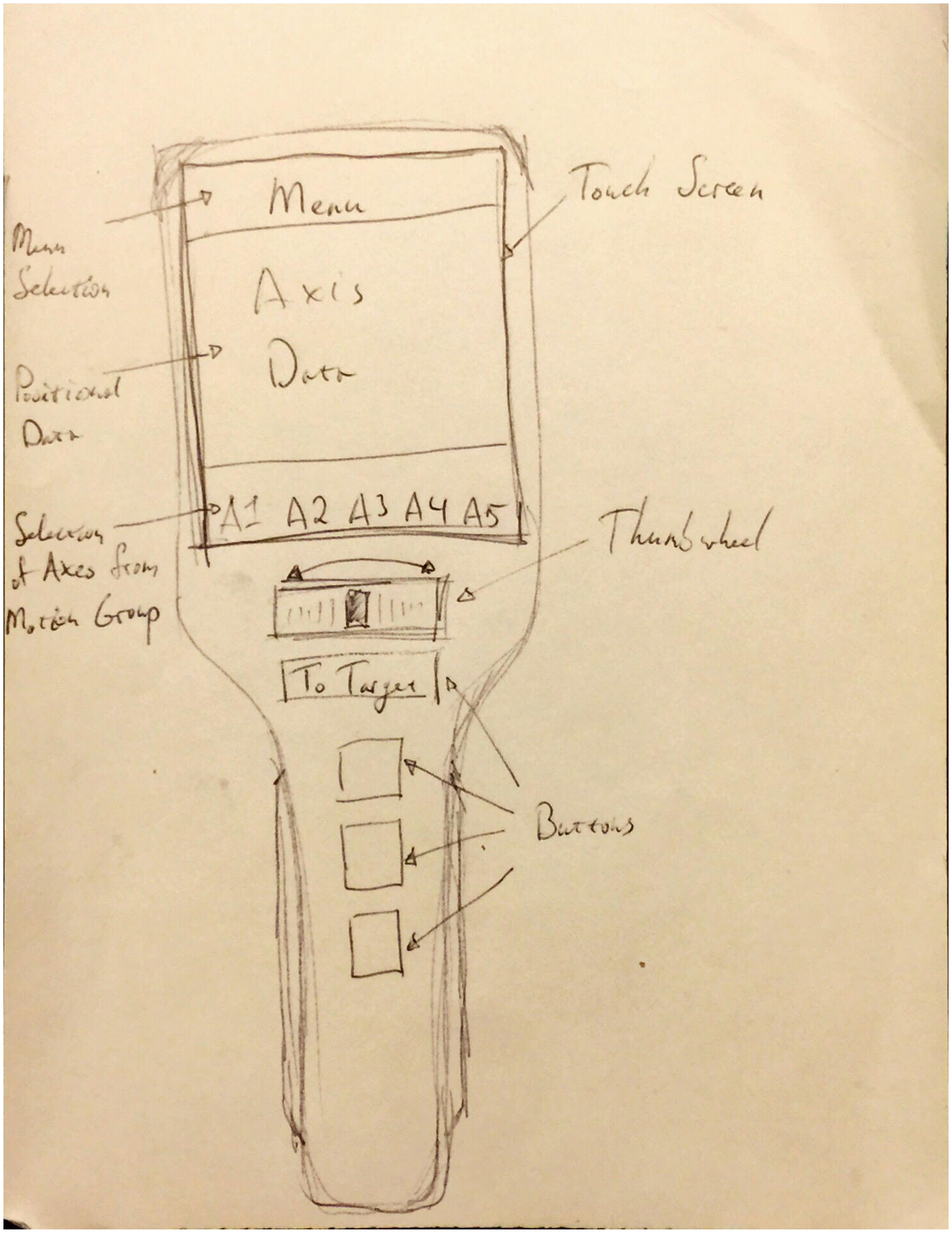

Figure 3: Paper Prototype page 1

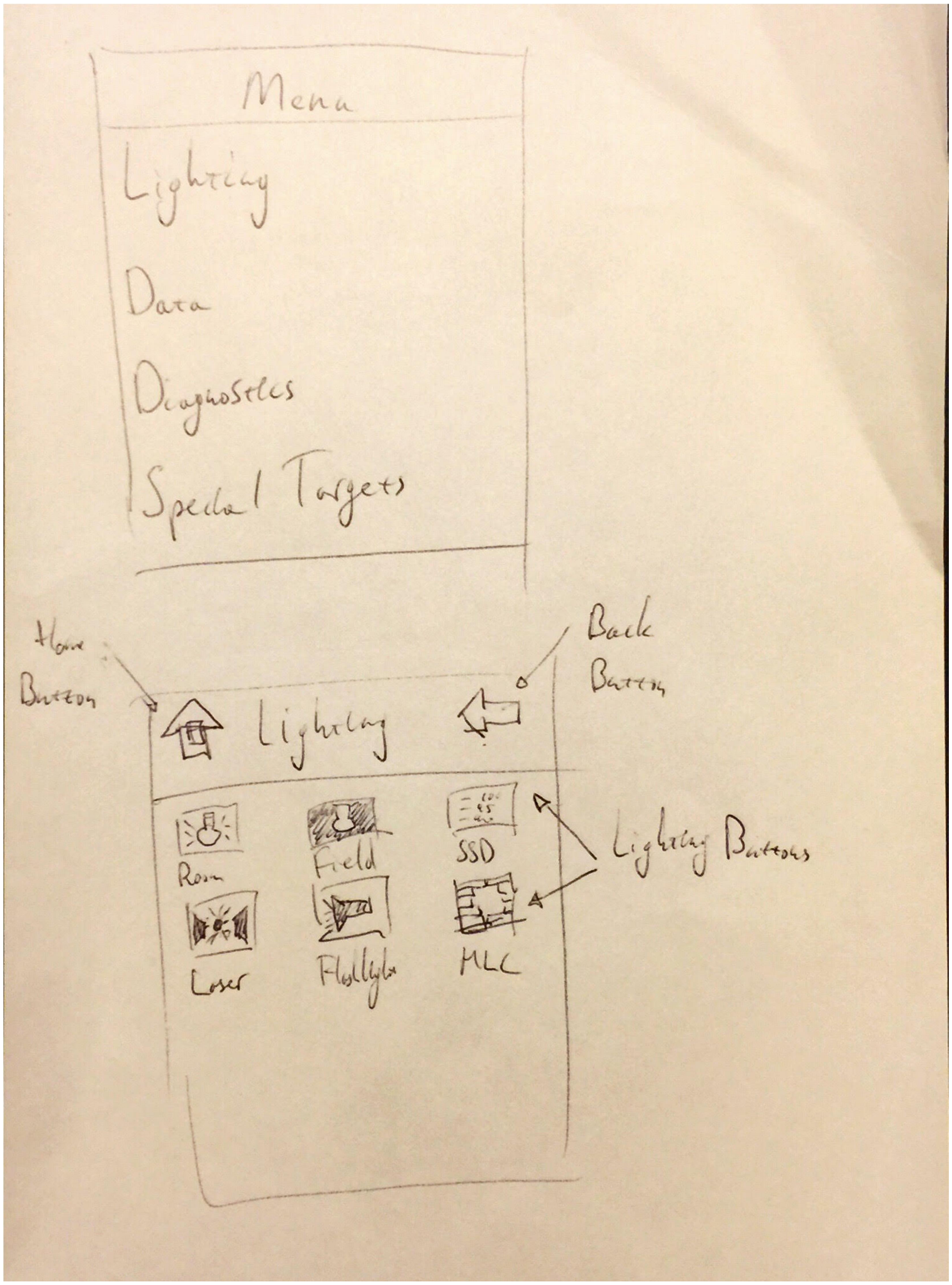

Figure 4: Paper Prototype page 2

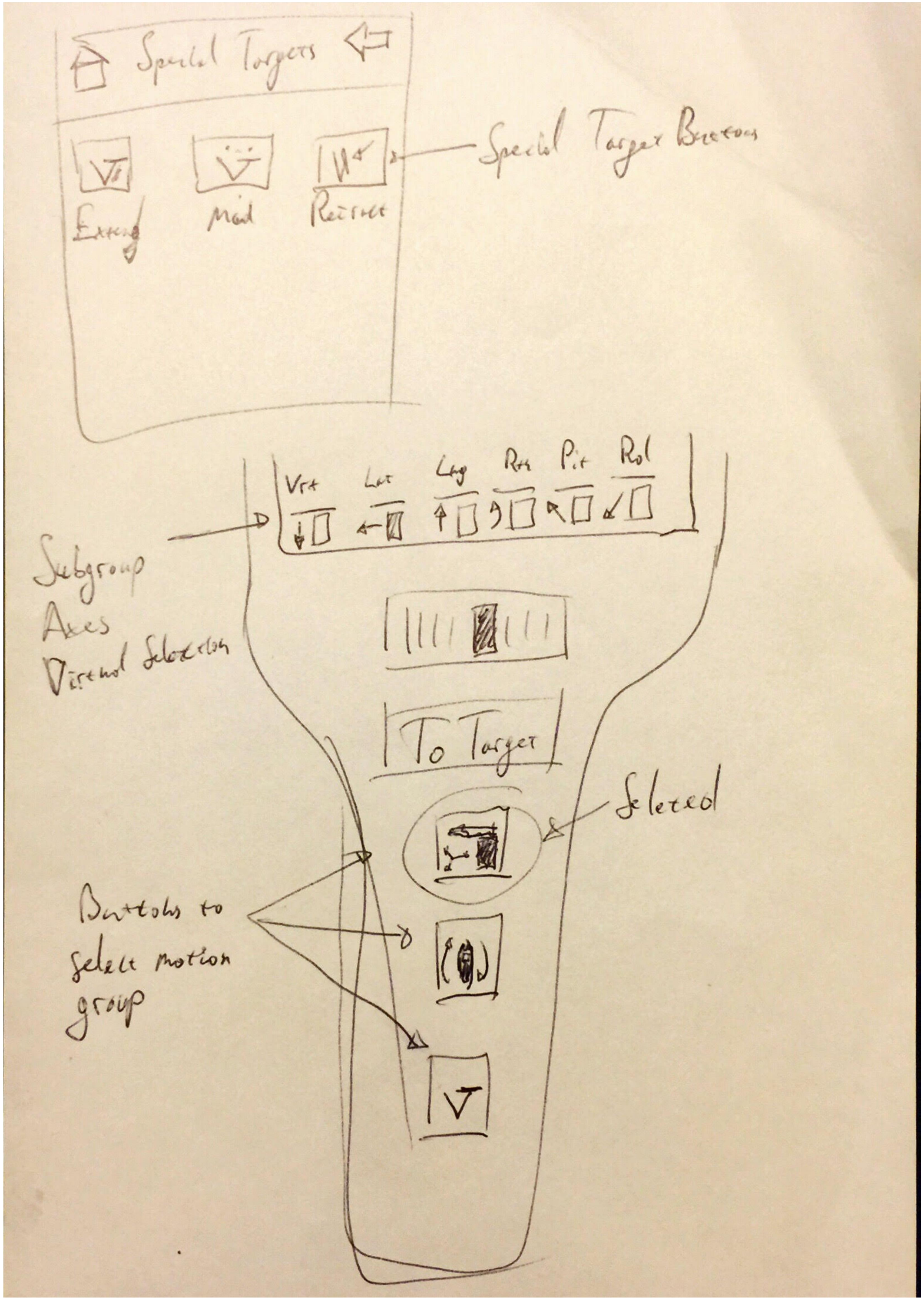

Figure 5: Paper Prototype page 3

The paper prototype displays the various menus and button placement and redesign as influenced by the need finding conclusions. The biggest change to the interface device is the large touch screen which now contains a majority of the action buttons previously assigned to dedicated tactile buttons. Thumbwheels have been relocated and reduced to just one thumbwheel which will control whichever axes is currently brought to attention on the device. All other button redundancies have been reduced or hidden within the menu system of the touch screen. Additionally, new features, such as a full informational display of all possible axes as well as titles of actions located under each icon in the menus would be implemented as well. Additionally, the navigation buttons in the middle of the device are replaced by touch navigation completely. With touch capabilities, the navigation buttons are redundant and unnecessary.

5 INTERFACE JUSTIFICATION

Screen Redesign

The screen redesign is the main, and most significant, redesign portion of the project. By implementing a large touch screen into the system an entire new world of unique programming can come to fruition. Due to the flexibility of the system, new features can be added to be controlled through the touch screen. Flexibility is the notion that both novice and expert users can use the same device to enact similar actions. Previously, all buttons had icons with no descriptions. The clutter workspace also hindered good mapping practices and ease of use capabilities. By moving most of the button functionalities into the touch screen interface, each icon now receives a textual description allowing for clearer understanding of iconography by novices while allowing quick glance decisions for the experts. The mapping of user actions to accurate representative selectors is also facilitated in a more coherent manner when menu descriptions and groupings are implemented, rather than having all possible actions available as buttons on a monotone interface platform with no identifying labels other than icons which can easily be misinterpreted.

Additionally, leveraging the capabilities of a modern, high-resolution touch screen, axes positions and status can be displayed for the therapist to make precise movements. Additionally, an entire myriad of design possibilities are presented to allow for future development of the system to easily integrate into the menu system.

Buttons Redesign

Consolidating the target motion groups and the manual motion groups into the same one button may initially feel less user-friendly. However with intelligent menu design, the use of the single button per group becomes more apparent. If a user is determined on working with a specific motion group, then that motion group is selected in its entirety. From this selection, the screen will display available axes to command fine tuning axes positions, or alternatively to move all selected axes to target. Since the axis section have moved into the menu, the Target button can now be applied to whichever group fo axes is selected. Unless the thumbwheel is interaction with an axis which is also directed to move to target, there should be no conflict in operation. This feature allows for Ease of use and mapping which correctly implements axes as sub-items of a motion group. Additionally, the Flexibility of the interface device to allow novices to manipulate axes forces the user to navigate logically through the process. An initial selection of motion groups would prompt the user to pay attention to the screen, where banners, instruction, or simply new icons appearing will draw the user attention. By viewing the labels axes of the motion group, the user has a better understanding of which actions he is about the take when another menu item is selected.

Similarly, the lighting buttons can all be placed within the menu system of the touch screen. Due to the infrequent use of the lighting buttons, it is more logical to rid the clutter of the device buttons and allow the user to select lighting options from the touch screen, with the added benefit of having labels above all lighting options. This form of mapping increase ease of use and comfort for the clinician, knowing that button groups are now hidden behind a menu when not in use, and are easily accessible and understood when needed.

Thumbwheel redesign

The initial thumbwheel operation was not conducive to one handed operation, took up too much space, and overcomplicated the understanding of controls for axes which were not statically defined as part of the original design. For this reason the number of thumbwheel has been reduced to just one. With one thumbwheel, the find adjustability of an axis position is preserved form the old design. However, the axis selection is now fully controlled by the touch screen. This design change retains consistency of the design language seen in Figure 1 and Figure 2 while improving usability and flexibility of the interface device. Flexibility is greatly improved since the user now has clear markings and labels for any icon chosen on the touch screen for adjustment. Additionally, with expanding feature sets of the machine, new axes or motion groups are able to be selected by the user without having to remember the exact combination being chosen. Namely, the cognitive load on the user is greatly reduced while simplicity of the design is increased by minimizing unnecessary clutter.

Ergonomics redesign

Due to the size and control schema of the original designs, one handed operation would only be possible for simple actions. In order to allow full use of the interface device with one handed operation, the overall height of the device has been reduced The thumbwheel and available buttons have been decreased in number, while increasing accessibility during one handed use. Additionally, the menu system and axis selection of the touch screen can all be reached. The thumbwheel control is also especially placed for easy thumb placement and fine precision navigation of any selected motion axis.

Consequently, the entire user device has been readapted for wireless connectivity. This feature allows users to operate the machine from wherever they are comfortable, without worrying about tangles wires or other operational hindrances. With wireless operation, the simplicity of the in-room machine design becomes cleaner and refined, even while adding more security risk as the interface devices could now be taken away from a machine or placed where false positives may become a likely trend.

6 EVALUATION PLAN

Qualitative Survey Script

The qualitative evaluation plan will consist of a survey evaluation. The survey will consist of question geared towards evaluating the prototype presented in the section 4 of this paper. The survey will be conducted as an asynchronous session of a textual representation of a single prototype as a post-event protocol by many individuals. The questions surveyed are as follows:

1. Does the interface grant access to all necessary tools and applications which enable successful operation of all groups, axes, and accessory (lighting) operations?
2. Do the available tactile controls adequately cover all of the required operational needs?
3. Are there certain modes of operation which must be continuously re-entered but are not easily accessed from the controls available?
4. At any time, is there ever a presence of repetitive or unnecessary actions required by the interface?
5. What is an adequate amount of sub-menu levels to be present in any one application?
6. Is axis micro-adjustment hindered by having less thumbwheels to control all axes?

Participant Recruitment

Participants will be recruited from among the developers, engineers, testers, clinicians and therapist populations. Recruitment will occur through the survey website http://peersurvey.cc.gatech.edu which can be shared with both OMSCS and non-OMSCS individuals alike. Consequently, both the location and storage of the survey will be hosted online, on the peer survey website. It is feasible that there may be multiple versions of the survey if the prototype designs undergo improvement during the process according to initial survey results.

Bias Limiting

Confirmation bias was reduced by asking the users about their needs, rather than pushing prototype design as a possible solution. Observer bias was reduced by having other peers review the survey prior to issuing it. The peers were not part of the persons taking the survey. Social Desirability bias was reduced only by inquiring about objective evidence. Recall bias was avoided by not asking any questions on the survey that required memory recall. Only the opinions on current usability will be asked in the survey.