TremCasso: Haptic Color-Picker for people with tremors

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Tremor is a common movement disorder that can be caused by a number of medical conditions. Since tremor is often incurable, individuals with tremor rely on adaptive aids to accomplish simple everyday activities such as eating and writing. In this work, we present some design principles using haptic augmented design concepts that could improve the accessibility of digital devices and make interactions with applications that involve selection and target acquisition tasks more pleasant. The iterative approach adopted to develop the haptic colour picker prototype and the design principles derived as a result have been presented in this work.

CCS Concepts: • **Human-centered computing** → **Haptic devices**; **Accessibility technologies**.

1 INTRODUCTION

Tremor is a commonly observed movement disorder. It can be the isolated manifestation of a condition as in the case of essential tremor (ET) or occur along with other neurological disorders as in the case of Parkinson's disease [4]. Tremor has an impact on the daily activities of individuals, especially those involving fine motor skills. However, there is no cure for most forms of tremor. Depending on the severity of the condition and the cause, invasive methods such as medication and surgery and less invasive options like occupational therapy and adaptive tools are used to manage the symptoms.

Some of the commonly used adaptive devices include orthotic glove systems, tremor-cancelling devices and weighted stationery and utensils. Hardware devices including trackball mice and large button keyboards and software applications/features such as SteadyMouse and Bounce Key can improve the accessibility of digital devices in particular. These solutions are often designed to work individually and although they are used in combination, they are not optimized for this. This limits their ability to meet some contrasting accessibility requirements such as the need for larger targets but reduced false triggering and requirement for physical movement.

Our work proposes design concepts combining both hardware and software aspects to possibly address some of these contrasting requirements. These principles have been implemented into a haptic colour picker presented in this paper. We were initially drawn in by this use case owing to the universality of art as a leisure activity, and the challenges and frustrations an individual with tremor would face when trying to draw. The suitability of the Haply 2DIY force feedback device to imitate the concepts of common adaptive devices such as weighted pens and to add augmentations like keeping the user within the lines or guide navigation further motivated these explorations. Our initial ideas and thoughts have moulded over the course of this project's development. While a colour picker is not necessarily the most utilitarian use case, it possesses the quality of having a myriad of options to choose from and also being as complex or as simple depending on its intended use case. Therefore, we hope that the design concepts explored here will extend beyond a colour picker to other useful applications that involve selection and target acquisition tasks.

This paper details the iterative approach we adopted to arrive at our final colour picker design and the outcomes and learnings at each stage. We then propose the salient features of our final prototype as potential design principles that could inform future work.

*All authors contributed equally to this research.

2 RELATED WORK

The prevalence of tremor has engendered a significant body of research on adaptive aids. Studies have been conducted to ease the process of selecting adaptive tools for computer interactions and also to identify their salient characteristics to foster further development. While no single recommendation of adaptive tools has been made, buttons that are easy to reach and trigger and pointers that are easy to move but still insensitive to small movements were identified as desirable characteristics[2]. Other works explored the introduction of a delay in triggering [3], the use of swiping rather than clicking, and swabbing rather than tapping [6]. These findings have been explored in our work and the original ideas have evolved in our prototype implementations. Further, some research has focussed on noninvasive electrical and mechanical suppression of tremors; these have been reviewed in [5]. While the solution we have proposed admittedly has mechanical elements, given its prototype nature and the limitations of the hardware device used we have limited our focus to the principles of commercially available adaptive aids and do t dive into these aspects in our work beyond the conceptual level.

3 APPROACH

We developed a haptic augmented colour-picker using Haply 2DIY for people with tremors. We conducted our work in a three iteration process. For each iteration, we formed an objective and then worked individually to achieve the objective of the iteration in a complementary manner. In the first iteration, each one of us created a design concept for a colour picker in Haply using Processing and Fisica. After that, we presented the design concepts to Professor Philippe Archambault, a professor at the School of Physical and Occupational Therapy at McGill University, to receive feedback on our design choices and to gain more knowledge about the target group. His research focuses on the use of technology for the rehabilitation of physical disabilities. He provided us with insight regarding the difficulties that patients with tremor face when trying to access technology. The professor gave us a positive first impression of the design and emphasized the importance of customizability when designing assistive technology for people with tremors.

In the second iteration, we combined our design choices into one and worked on customizing the interface of the colour picker. Additionally, we created force-feedback navigation buttons that enable the user to navigate the hierarchy of swatches through two pages.

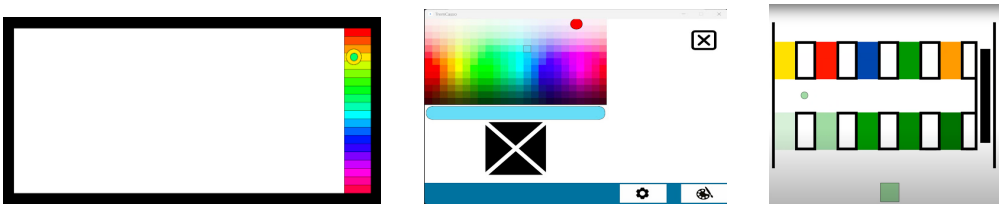
In the third iteration, we refined the design by adding visual cues and allowing the user to choose among different design presets. Each preset draws the interface of the colour-picker differently according to a set of parameters. We added the configuration button where the user can toggle between three presets. The first preset is easy to use but has fewer colour options, while the third preset is harder to navigate but provides plenty of choices.

4 PROTOTYPING

4.1 TremCasso V0

Three diverse design concepts were developed in the first iteration. Select components and/or concepts from each of these were adopted and augmented in the subsequent prototypes.

4.1.1 Design Concept 1. The design presented in Figure 1a involved a colour picker that could be accessed by moving the end effector to the top right corner of the screen. This prototype presented a wide variety of colours as a discretized gradient. The area occupied by individual colours, and consequently the number of colours, was intended to be configurable based on the dexterity of the user. The feel of a subtle bump was implemented as the user slid the cursor



(a) Design Concept 1 (b) Design Concept 2 (c) Design Concept 3

Fig. 1. Three initial design concepts for TremCasso

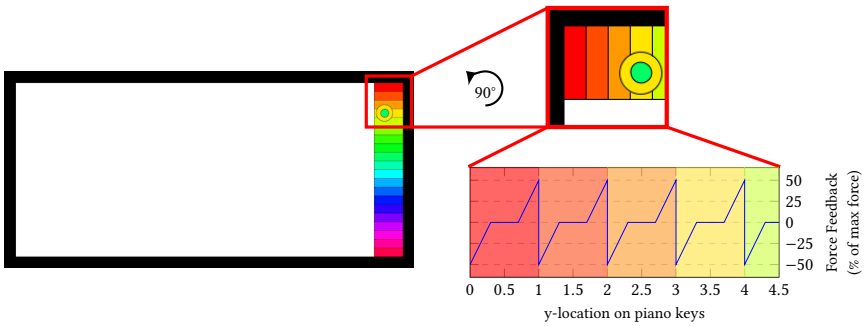


Fig. 2. Force feedback experienced when using the "piano keys" prototype.

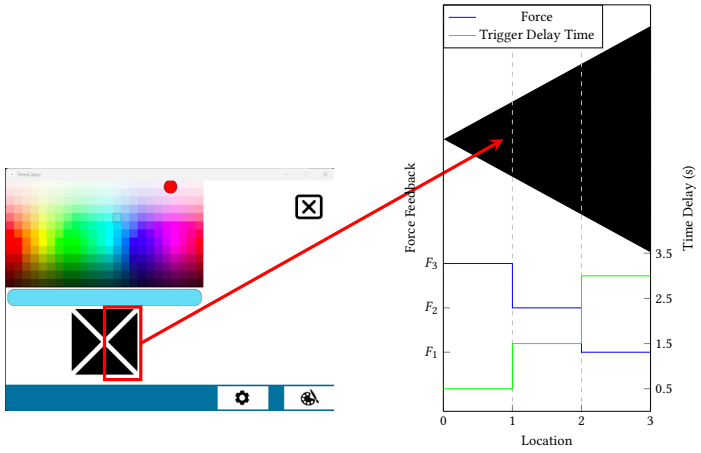
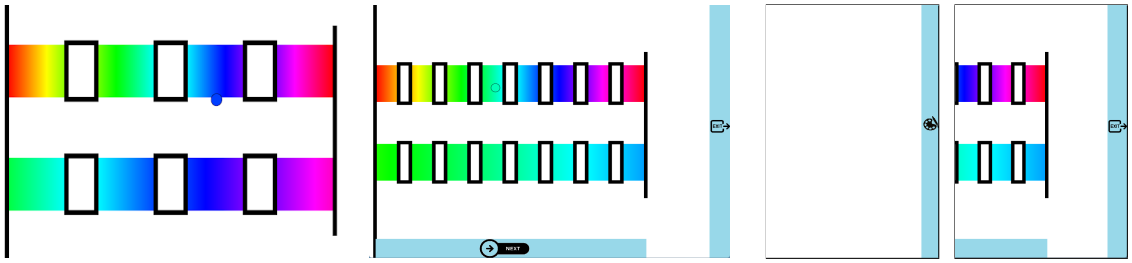


Fig. 3. Force feedback experienced when using the "joystick" prototype.

from one colour to the next by manipulating the vertical forces of the end effector at the boundary between two colours as explained in the graph in Figure 2 and damping was introduced throughout the application to attenuate the tremor.

4.1.2 Design Concept 2. The second design concept consisted of two separate screens: one for the colour picker, shown in Figure 1b and the other for the drawing canvas. The colour picker consisted of a palette of colours and buttons to manipulate the position of a colour selector which moved based on the directionality of the button where the end



(a) Gradient Colour Picker

(b) TremCasso V1 Colour picker design

(c) Button to enter colour picker when the user is on the canvas

(d) Button to exit colour picker when the user is in the colour picker

Fig. 4. TremCasso V1 prototype and components

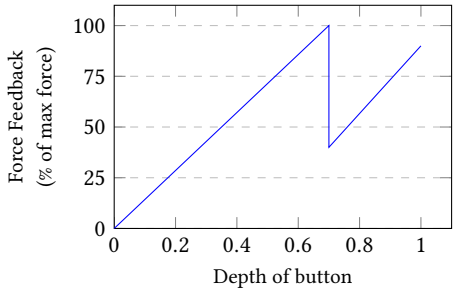


Fig. 5. Force Profile of the buttons; Depth of the Button: 0 indicates the start position of the button and 1 indicates the position of the button when it is fully pressed.

effector rested by taking a step after a configured time delay. The haptic effects in this prototype were a viscous damping effect applied at the boundary between the buttons to avoid accidental crossing over, a subtle bump triggered with each step of the colour selector to imitate a click and a discretized gradient repulsive force implemented on the buttons as shown in Figure 3 to ensure that the triggering was intentional.

4.1.3 Design Concept 3. The colour picker in this design also spanned the entire screen as shown in Figure 1c. This prototype consisted of two horizontal rows containing colour swabs which were separated from each other by hard walls implemented using force feedback. The walls were intended to assist navigation and prevent unintentional selections. The colour was selected by moving the end effector through the desired colour in the first row. The selection of the shade resulted in the second row being populated with the swatches displaying varying degrees of luminance of the selected colour. The desired shade could then be chosen by moving the end effector through the second row. Thus, a hierarchical selection style accessed through path navigation was presented in this prototype.

4.2 TremCasso V1

The initial design concept presented us with a wide range of ideas and options to choose from. The initial prototypes also put us in a better position to present our ideas to Professor Archambault and gain insight. At this stage, we were already pondering the need for incorporating customizability to avoid having to make too many assumptions about

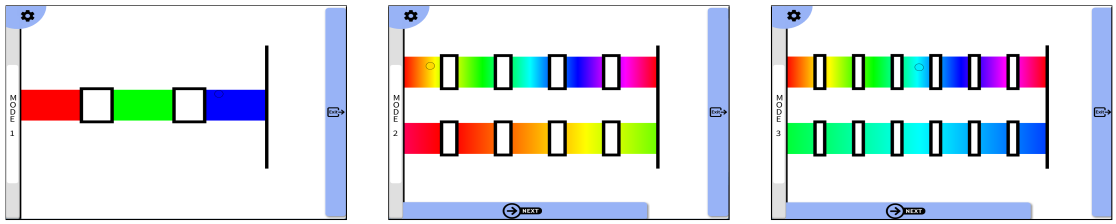
what would be most suitable during the design process since we were not conducting user tests. This tentative idea was concretized as the focus of our new prototype following our discussion with Professor Archambault. He pointed out to us that there was wide variability not just in the types of tremors or the severity of the condition in individuals but also for a single individual depending on the time of the day (or more specifically, factors like time since medication and fatigue levels).

The third design concept seemed to have the most potential for incorporating customizability for the target population. It could be easily simplified to suit someone with very limited fine motor abilities, by limiting the options at each selection stage, and still be able to provide the user with multiple options, by increasing the hierarchical levels when necessary. Conversely, it could also present multiple options in a single stage and make the selection faster if the user had the manual dexterity to navigate a more complex layout. Hence, we adopted it as the base concept to develop on. The first design concept involved an elegant implementation of presenting colours in Processing; this was incorporated into the new prototype. In order to preserve the full-page layout of the base concept the multi-page implementation and the canvas from the second design concept were also adopted. Further, the corner positioning of the buttons and the haptic click effects explored in the earlier design concepts were also implemented in TremCasso V1.

Pulling apart components from three very different prototypes and putting them together was naturally not particularly smooth. However, building parts of it all over again gave us the flexibility to augment earlier implementations. We implemented customizability for features like the number of hierarchical levels/ rows presented on each page, colour swatches in each row, the ratio of swatch width to the space between each swatch, and the number of pages within the colour picker. Given that the number of swatches was variable and the number could be configured to be small (say, two or three), there was a need to find a way to make all colour options available upfront and then let the user filter the options at each stage. In order to make this possible, each swatch was presented as a gradient of colours such that the swatches in the first row segmented the entire colour spectrum as shown in Figure 4a. The user could select a swatch that contained their desired hue as described in the initial design concept (Section 4.1.3). When a particular swatch was selected, the gradient within that swatch was expanded and presented in the next hierarchical stage allowing the user to make a finer selection from within that gradient range. This could continue for as many stages as configured with the final stage allowing the user to select the brightness component of the colour similar to the final stage described earlier.

The haptic components of the colour picker were retained as were in the base concept. Additionally, buttons with haptic effects were implemented to enable the user to switch between the canvas and the colour picker and also to navigate between the pages of the colour picker. To make these buttons easily accessible they were positioned along the walls of the interface and button spaces were repurposed so that a single button was to serve multiple purposes. For instance, a single button served as the entrance to and exit from the colour picker depending on whether the user was in the canvas or within the colour picker as shown in Figure 4c and 4d. This made the UI cleaner and limited the number of buttons present at any instant. To ensure that the button triggering was intentional, a repulsive force directed so as to repel the end effector away from the buttons was introduced in their vicinity. This force was built to vary with the position of the end effector as in the spring force formula, configured as if the spring was attached to the wall and oriented opposite to the direction of the button push. In order to more explicitly convey button triggering and achieve coordination between the visual and haptic modalities, the button was made to appear to move and disappear into the wall as the user pushed against it. This was implemented to be in congruence with the physical metaphor of pushing a spring-loaded button. Finally, a subtle click effect was also implemented to indicate successful triggering. The force profile has been presented in Figure 5

The final look of the colour picker at the end of this iteration can be found in Figure 4b.



(a) Preset Configuration 1 (b) Preset Configuration 2 (c) Preset Configuration 3

Fig. 6. Three presets of TremCasso V2

4.3 TremCasso V2

The focus of the final prototype was to enable the user to customize the settings from within the application, convey the hierarchy of the colour picker better and smooth off the rough edges. When we discussed how customization could be done from within the application we came to the conclusion that the precise setting changes could be made with assistance and that these would not necessarily have to be accessible for someone with tremor. However, given that tremor intensities could vary for an individual on a daily or even hourly basis, there was a need to make at least a few different custom configurations accessible to the user. These configurations would essentially be a set of settings specifying the various parameters such as the number of swatches in each row, swatch-to-separator ratio, and the number of pages in the colour picker. Since working on a complete settings page added little value to our concept exploration, we instead concentrated our focus on making it possible for the user to switch between preset configurations. Three presets were defined for this purpose.

The frequency of changing the interface parameters was not expected to be as high as accessing the colour picker or navigating between the pages of the colour picker making it ideal to position this feature sufficiently out of the way but still readily accessible. Hence, the button for this was placed at the top left corner of the colour picker. This button was designed to be activated with a horizontal push and the haptic effects on this button were implemented to be similar to those described in the previous prototype (Section 4.2). Further, since only three preset configurations are defined, and the intention was never to increase this number significantly, the button worked by updating the application to the next preset configuration each time it is pressed and looping through them cyclically. The three preset configurations and the preset change button are shown in Figure 6.

Besides making the customization accessible from within our application, our other goal was to make the hierarchical nature and flow of the gradient colour picker more understandable for the user. Despite the gradient colour picker's ability to present the user with many colour options, we learnt during our meeting with our mentors and TAs that the implementation in TremCasso V1 was somewhat hard to understand. Therefore, an animation indicating the hierarchical flow was implemented as a visual cue. The animation is intended to convey the stretching of the gradient in the higher hierarchical level to populate the swatches in the next level as the user makes a selection.

Figure 7 shows the resulting final UI(user interface) and the interactions with each of its elements. A video of the overall working of the prototype can be found here: link. Additonally, Table 1 summarizes the evolution of the design.

5 PROPOSED DESIGN GUIDELINES

We derived design principles from our final design that we think are useful for designing such an assistive technology. We did not make a formal evaluation, hence we can not ensure that these principles are going to be helpful for the

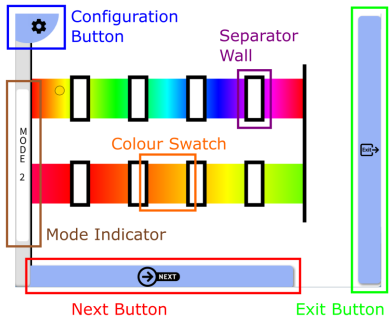


Fig. 7. UI elements in TremCasso V2. The Configuration Button *(blue box)*, Next Button *(red box)* and Exit Button *(green box)* visually slide left, down and right respectively when pushed by the end effector and exert a repulsive force against the direction of movement. The Mode Indicator *(brown box)* indicates the current configuration of the colour picker. The Colour Swatches (one of which is marked with the *orange box*) set the 'active' colour as the last colour touched as the end effector is moved through them. The Separator Walls (one of which is marked with the *purple box*) aid selection on prevent unintentional traversing between colour swatches by forming virtual solid walls.

target group. However, based on the literature and the feedback we received, the main issue people with tremors are having when interacting with digital tools is the unintended selection of targets. Therefore, we designed our tool in a way that helps a person with tremor to select or reach a target easily and with minimal error. The following are the design principles or the guidelines that we embedded in our tool.

Customizability. Tremors vary in their movement and magnitude. These variations are different from one person to another and from one day to another. Besides, tremors are categorized into two main groups, resting tremors, and actions tremors, and there are more than 20 types of tremors [1]. Therefore, having a customizable interface is essential to accommodate all these variations.

Utilizing all the space on the screen. The tool we created has two modes, drawing mode, and color-picker mode. In the colour-picker mode, the user can make a selection of colours, while in the drawing mode, the user can draw or paint on a white canvas using the colour selected. We made the color-picker mode as big as the size of the window of the application and the user can toggle between the two modes using a button. Using all the space on the screen for picking a target would give much space to the user and allow us to create bigger swatch sizes, hence mitigating unintended selections.

Force resisting buttons. To avoid unintentional activation of a button, we used sliding buttons that have force feedback in the opposite direction of pressing. This will require the user to use force in order to press a button and will prevent multiple activations of the button that would occur in the case of a normal sliding button.

Selecting through path navigation. The literature showed that people with tremors have difficulties controlling a computer mouse and clicking mouse buttons. Our design does not require any kind of vertical clicking. The user can pick a colour by navigating a path of swatches to select the intended colour.

Features	Application Versions		
	TremCasso V0	TremCasso V1	TremCasso V2
Buttons	Implemented in design concepts 1 and 2; Design concept 1 considered button positioning for ease of access. Concept 2 explored discretized gradient repulsive force and solid and viscous separators between buttons	Palette(Enter)/Exit and Next/Previous buttons spanned the edge of the walls and gradient force feedback was implemented for ease of access and reduced accidental triggers respectively. Buttons on the screen were limited by repurposing the button spaces to display only those corresponding to the affordances available. Visual feedback in the form of buttons moving when pushed and a haptic click effect aided understanding of the interface.	Button visuals were improved and a back box was added. An additional "Configuration button" was included at the top left corner of the screen. This button was limited to one corner (rather than spanning a wall) as it was expected to be used less frequently than the other two buttons and hence needed to be easily accessible yet sufficiently out of the way.
Colour selection process	The three design concepts explored varied styles of colour selection. (Details can be found in Section 4.1)	The hierarchical selection of colours from Design Concept 3 was adopted and modified. A number of parameters (like the separator size and number of rows) that affected the movement and flow of the colour selection process were made variable	The flow of colour selection was made apparent by including an animation that showed how the selected gradient colour swatch expanded to populate the next stage.
Colour space	All design concepts used solid blocks of colour. The colours that were available were limited by the number of swatches.	Solid colour blocks were replaced by swatches containing part of the gradient in the colour spectrum. The hierarchical selection style enabled finer selection by going through multiple stages.	Same as TremCasso V1
Customizability	Limited consideration was given to customizability. The size of the colour swatches and the time delay were variable (but not from within the application) in Design Concepts 1 and 2 respectively.	Multiple variables like the size of the separators between swatches, the number of swatches, the number of pages in the colour selector and the number of hierarchical stages on each page was made variable but there were no accommodations to make these changes from within the application	A configuration customization button was added within the colour picker application to allow to switch between three preset configurations. A visual indicator was included to display the current mode.

Table 1. Evolution of application features over iterations

Using static separators (walls) between targets. We used separators between swatches that work as firm objects between colours. This will help the user to select the intended swatch without accidentally selecting any neighbour swatch.

Coordinating visual and haptic modalities. The buttons we added visually represent the haptic behaviour added to them. Additionally, we added visual animation that works as a cue to inform the user about the selection they are making. Adding visual elements to haptic feedback defines the functionality and improves the experience for the user, which is crucial, particularly in the case of designing assistive technology.

6 DISCUSSION AND FUTURE WORK

We designed a tool to assist people with tremors to pick a target on a screen using the Haply 2DIY. However, we did not evaluate our design choices nor the use of Haply in this context. We utilized best practices according to the research but that is not sufficient to validate the resulting design. We think that it is essential in the next stage to test our tool with participants from the target group to evaluate our design.

Moreover, it is of great benefit to evaluate the use of haptics in the context of people with tremors. Exploring how haptics, specifically force feedback, can be utilized in designing tools for people with tremors, as well as in other applications where similar force feedback can be beneficial. The tool we provided and the design principles we used have the potential to assist in designing digital tools that offer a broad selection space for people with tremors. We combined haptics and force feedback with UI elements and strategies to design this assistive technology.

The design guidelines we provided are general and can be applied in different contexts and applications. However, because our design requires not only software but a haptic device as well, the integration of such design concepts into a practical application might be challenging. The haptic device is replacing the computer mouse to enable force feedback capabilities, which adds additional cost, and users are mostly unfamiliar with interacting with haptic devices.

Lastly, making the interface configurable is necessitated by the variations in conditions the target group has. In the current final version, we used three defined presets that the user can toggle through using a button. Another option could be to make the user manually set all the UI parameters such as the number of swatches or the width of the separator walls. However, this takes us back to the first problem which is selecting many targets and then setting them. Hence, we decided to take the presets approach where the user can select a desired configuration from a fixed set assuming that external help would be available to the user to make the initial finer setup. In a general scenario, there are multiple factors to consider when designing in this context including the settings of use, the type and purpose the of application, age, and the availability of external aid.

In the future, it is essential to test and evaluate the colour-picker with the target group. This enables the exploration and validation of the proposed design guidelines, particularly in the context of using a haptics-enabled peripheral. Furthermore, it is important to explore the design space taking into account different factors among the factors mentioned earlier. For instance, if external aid is available, then a full and meticulous configuration could be provided. A home-use setting is different than an institutional setting, where the former requires cheaper and more practical solutions while the latter could handle quality and bulky devices. Finally, integrating these principles into an advanced graphics editor would be the first step in making such applications accessible to the target group.

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A INDIVIDUAL CONTRIBUTIONS

A.1 Antoine Aubet

For this iteration, I had 2 main objectives. The first was making the visuals more coherent with the haptics and to give the visuals more visual cues for what the objects on screen do. For instance, the buttons need to communicate that they can be pushed and the navigation through the color picker needs to be more "obvious". Therefore, I came up with several button designs that we examined to see which seemed best for our use, which is a button that is pushed to the side. We settled on the design that can be observed in sample pictures and videos.

We also wanted to make it more obvious where the colors came from when using color refinements in our color picker. This is when using two rows of colors at once. The user will go through the first row and from there, the second row will be populated with colors that are refinements of the first color that was selected. It may not be obvious where these colors come from especially when using a low number of swatches. We thought about multiple ways to convey to the user what the new colors were and we settled on a quick animation. The swatch that is selected "expands" and then populates the second row.

As for the navigation, in order to invite the user to travel through the color picker in the direction that we intend them to, the second row is initialized with white or no color. This way, it appears empty and the user will be drawn to the first row where colors are present. Once the color in the first row is selected, the second row is populated.

This brings us to the bug fixes. Over the iterations, our code has become much more complicated. The "blank" initialization of the second row did not work consistently. With the addition of presets, it did not work when the preset changed. Sometimes, the gradients were not drawn properly or showed the wrong "range" of colors. This all degraded the user experience and the code is much more stable.

For the final report, I helped to address the comments that we received from our supervisors. I made edits to remove contractions, add clarity where it was needed, and I worked on the video for the submission. The video was overhauled for the WHC submission and we are using the same one for this submission. It now features voiceover to talk through what is happening on screen, highlighting the haptic aspects that may be more difficult to convey through a video. I also spent a lot of time on figures. The feedback mentioned that having force-distance diagrams would help so we made sure to include some of these. I also added some details to make sure to highlight more of the "haptics" from our project.

A.2 Venissa Carol Quadros

For iteration 3, we majorly worked on providing the user with the feature to customize the colour picker from within the application and improving the understandability of the application (i.e. how the stages of the colour picker are updated with the selections). Since the goal was to demonstrate the customizability, we decided to make this feature available in the form of three 'presets' or sets of configurations for the colour picker. Given the input from Prof. Archambault about the need for customizability even for a single user (depending on the time of the day, fatigue level etc.) we wanted to

make the toggling between presets easily accessible for a user. Hence, a switch which could cyclically loop through the presets was added within the colour picker.

I mostly worked on the visuals and haptics of the switch for switching between the presets during this iteration.

Our focus up until this point had been to make buttons big and span entire walls. However, unlike the other buttons in our application, the preset button is expected to be used much less frequently. With this in mind, the focus was to make this button easy to access and yet sufficiently out of the way and unlikely to be falsely triggered. Therefore, we decided to position it at the top left corner of the screen. As I started implementing this with the Haply though, I realized that the rendering of the forces at the top left corner was fairly unreliable. My experience was that the left colour picker wall occasionally seemed to exert a force about 0.5cm or more to the right of where the wall visually appeared to be. The reliability of force feedback seemed to improve slightly as we moved away from the extreme edge. Hence, ultimately the colour picker was shifted slightly to the right and made to occupy a more centred position on the screen. The preset button was then placed along the left wall of the colour picker.

For the button design, I wanted to keep the 'push' concept consistent with the other buttons in the application. Since this button was rounded unlike the other rectangular buttons the logic to implement the visual push cue was also a little different in this case. The unused space at the left edge of the application was used to build a visual display to indicate the present configuration of the application. Besides this, I worked on some minor changes like making the next button disappear when the number of pages in the colour picker was set to have a single page and fixing some application layout features. The code for this can be found here: Iteration 3.

For the presentation, we retained a structure similar to the one we had made for the informal demo with a brief background, the evolution of the design concepts and a demo. We generally edited the slides for the parts we were presenting - which was the introduction and background in my case and otherwise discussed and made minor edits to help the overall flow. We didn't do any development following the iteration 3 submission but rather focussed on refining the draft report based on the feedback we received from our supervisors. I refined the the abstract, introduction, related work and prototyping sections I had written for the draft report. Antoine created the force profile graphs in the Prototyping section. Besides this, I only did some overall proofreading and editing.

A.3 Yaman Sanobar

For the third iteration, our focus was on refining the design and enabling the user to select a customized version of the color-picker. We worked on adding customized presets to the design, adding the "modes" button, and adding visual cues. My role was in creating and adding the presets.

We created three presets where each has different parameters to draw the color-picker. The first preset is the "easiest" to pick a color from with its one page, one row, three swatches, and wide spaces. The second and the third presets consist of two rows and two pages and have 5 swatches and 7 swatches respectively. This will allow the user to select between different customized designs but they have to compromise between the number of swatches and the ease of use. Going with this approach of presets rather than enabling fine-tuning of all parameters minimizes the number of buttons to be clicked at the expense of having only three fixed customized designs.

Further, the first preset is designed to be suitable for any user providing only three colors to select from. In our design, the more swatches drawn on the screen the more shades a user can access. Hence the user can access more shades on the third preset than on the second one. Besides, One key thing I learned is that customizability is essential in assistive technology, in addition accessing the customized presets needs to be accessible as well. We did not conduct any evaluation tests but I'm wondering if our design and using haptics in this scenario is effective.

For the draft report, we prepared the project structure, then each one of us wrote different sections of the report and applied modifications to the project as appropriate. I wrote the "approach", "proposed design guidelines", and "discussion and future work" sections. For the final report, and after receiving feedback from the instructors, we modified, updated, and completed writing the report accordingly. We added a graph to demonstrate the force nature of buttons, and a graph that explains the UI elements of our interface. We added a table that shows the evolution of features over iterations and explained aspects of our work and potential future work. Finally, we proofread the report and made adjustments accordingly. As for the presentation, we used the same structure that we used in the previous one by showing the motivation and the story of our design, then sharing a demo of the final version of the color-picker.