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May 5, 2016

Computer Interface Feedback Through Haptics

Abstract

Inspired by Sightlence, an entirely haptic interpretation of the game of Pong (Nordvall & Boström, 2013), I set out to broaden the application of haptics to a more traditional computer interface and application, taking a bold move to completely hide the mouse cursor from the computer screen and seeing if people could still navigate using only the mouse and their sense of touch.

Introduction

In 2001, Paul Dourish took a pessimistic approach to virtual reality, calling its users "disconnected observers," compared to the people that inhabit the real world (2001, p. 102). Putting this assertion into context however, a decade and a half ago, it does begin to rationalize that ignorant thought. Andy Clark, later in 2008, had begun to draw connections between digital worlds and the actual world, realizing that they may not be so different from one another after all. In response to Dourish, Clark claims that users of a virtual reality system would inhabit the virtual world in the same way they inhabit the actual world, and would become accustomed to its possibly "limited and clumsy" interface such as a baby would with its actual *limited and clumsy* body (2008, p. 10). Clark's observations are still almost a decade in the past, whereas the advancement of virtual reality within just the past few years has been immense, arguably starting with the announcement of the Oculus Rift in 2012. However, the use of this technology does not have to be limited to brand new virtual and augmented experiences, they can also be applied to the systems we use now. In one system we look at a screen and we tap a button on the keyboard or mouse corresponding to the position of the cursor. These are the computers many of us use on a daily basis. How can this experience be improved? What other senses can we implement to create a more encompassing or embodied experience?

Research and Development

In Sightlence the haptics were provided by the vibration motors built into two video game controllers. While one controller is held in the hands naturally, the other is awkwardly merely sitting in the lap of the user. In initial brainstorming I realized that this did not have to be the case; our sense of touch is quite precise and could be shrunk down to a single small area: a hand. Using small vibration motors attached to an Arduino, something I am familiar with using, can allow the simultaneous control of different motors for different areas of feedback. Just like in Sightlence I immediately focused on tracking the X and Y axis, in this case of the mouse cursor instead of the game's ball, so that the further along the axis the cursor is, the stronger the vibration feedback would be. Tracking just these two axis, however, is a bit limited. Sightlence also notifies the player as the ball bounces off the paddles or walls by an additional thump of the vibration motor, but this is not entirely relevant to navigating a computer screen. Later while playing with a Nintendo Wii remote controller I noticed that when moving the remote's cursor around it also causes a thump of the vibration motor, adding a tactile sensation when hovering over digital buttons. This is the final dimension that my project needed, henceforth called the "Z" axis, representing the metaphorical depth of the computer screen. I began with a simple sketch (figure 1) of how the motors would be placed, and what dimension each one would focus on.

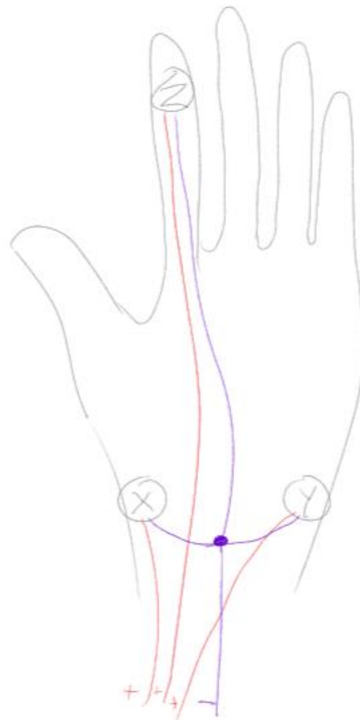

Figure 1 - Initial sketch

I decided to place the X and Y axis motors out of the way on the sides of the hand, and the Z axis motor placed on the finger where our sense of touching and feeling objects most often occurs, each far enough away from one another to be easily differentiated.

Since I was already adept in using the Max software, this gave me an easy way to read the position of the mouse cursor and transmitting that data to the Arduino. I chose to use the bottom left of the screen as the origin where no vibrations would be felt, just like the origin in typical graphical mathematics, while the actual origin in computer software is in the top left.

One small challenge remained, how to track when the cursor was over objects on the screen? Typically, elements like text on the screen are black over a white background, so this gives ample contrast for a good data reading, and luckily, there is a Max object to easily read colors on the screen at a given location. While this returns RGB values, I merely summed the resulting values into a single darkness value, such that white would return 0; either pure red, green, or blue would return 256; and black would return the sum of the three colors: 768. The X, Y, and Z axis were then to be each transmitted to the Arduino in a 0-256 scale, which is then assigned to each motor. This actually proved to be the most challenging aspect of the project, because I have never dealt with transmitting more than one value at a time before. In serial communication everything is sent in a repeating stream of numbers, so you need a way to identify the start or end of each transmission, and Max proved to be a challenge in doing exactly that. I ended up changing my axis values to only be between 0 and 255, and a single 256 value would be added at the end of the transmission to signify the end of the message. The Arduino software could then easily figure out that the first value corresponds to X, the second to Y, and the last to Z, before starting over again.

In my last steps to preparation I realized I needed a tailor-made interface for users to work with, because while ultimately I would like to see this system work with any computer interface, it is far too limited to adequately communicate those intricate details with the users. I created a simple white webpage in HTML, CSS, and with JavaScript buttons. The buttons were estimated to be large enough targets for the user to find while learning the system. They were colored solid red in order to trigger the Z motor while the background would not, and they would turn to green when clicked by the user in order to show their progress. I was able to fit seven of these buttons fairly randomly on the screen, with the first being toward the top left corner as a sort of starting point. The mouse cursor was hidden merely by changing the cursor's image to a blank image in Window's settings.

In my initial playing with the system and figuring out how I would present it to the users, I swapped the X and Y axis motors compared to my initial sketch. I found that the further right along the X axis the cursor was, parallels could be drawn by placing the X motor on the right side of the hand. Also after a suggestion, I attached the motors to a knit glove, rather than attaching the motors directly to the hand. While the question was raised why not place the motors on the mouse itself, I felt the vibrations would resonate through the hand less, leading to less confusion, but I also enjoyed the idea that my system was not exactly limited to the mouse. Laptop touchpads and joysticks could also be used using the same feedback my system provides. I did not explore these possibilities, but they are worth keeping in mind. I experimented by moving the cursor back and forth on the screen and over different colored objects to see how it would feel. I then hid the cursor and tried to replicate my experiment on myself. It was challenging. I had made tweaks to the size of the buttons to make them larger and easier to find. I also adjusted the speed latency of the system, because trying to read values too fast in Max would actually slow it down from the intense computation, introducing time gaps in the data the Arduino received, meaning these lapses also had to be accounted for or else the motors would stutter.

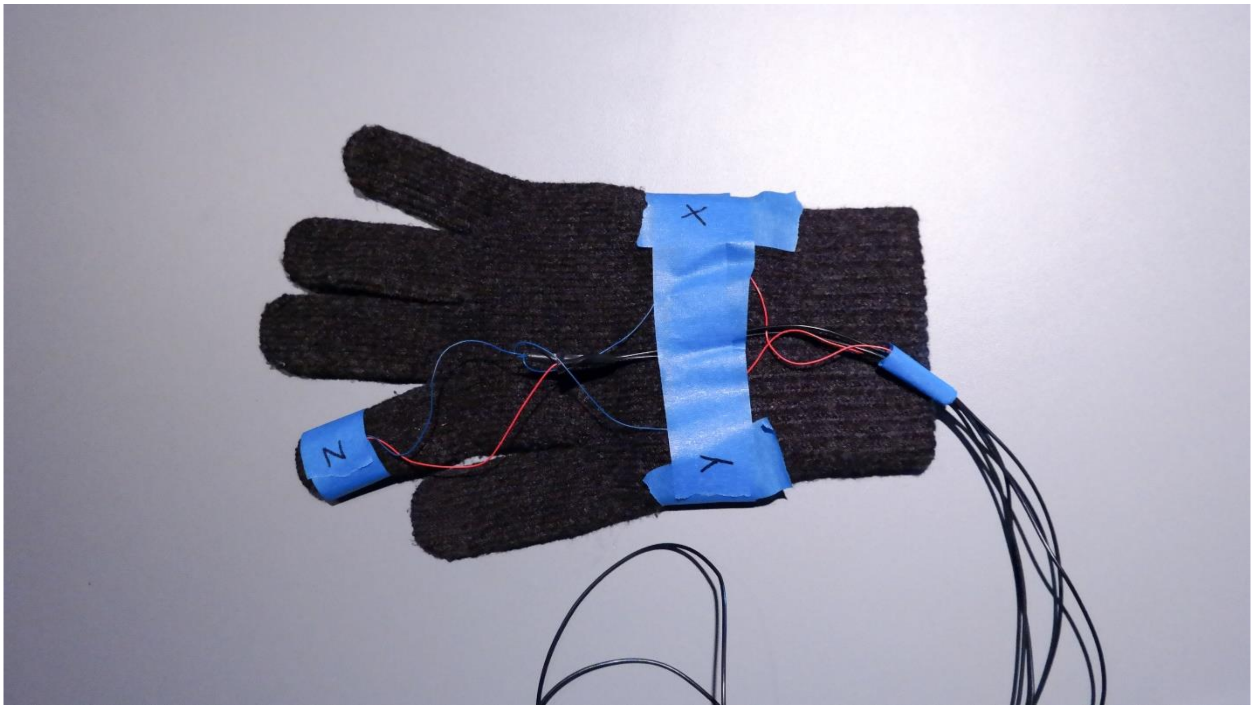

Figure 2 - The glove upon final assembly and testing

Demonstration

Figure 3 - Final setup at the Digital Culture Showcase

I set up my laptop with a hidden cursor, the webpage, Max, and the Arduino with the glove wired and faced it outward for the visitors of ASU's Spring Digital Culture Showcase to see (figure 3). After a short while I began to regret not having made a sign to draw people in, but soon enough I started having frequent visitors interested in what I had to show. I would explain to them that I had hid the mouse cursor, and that they would have to navigate the buttons on the screen using only the vibrations from the glove. When they placed on the glove I would use the touch screen on my laptop to demonstrate how it would feel moving along the X axis, then the Y axis, then whenever the cursor would be hovering over a button they could click, before moving the hidden cursor back to the origin where no vibrations were felt telling them that is where they would begin. I often had to reinforce that they would be using the mouse, not the touch screen.

Figure 4 - A user trying the system

Findings

Between the dozen or so people that tried my system throughout the showcase, roughly half or a bit less were able to click about three of the buttons on the screen within a few minutes before being satisfied and wishing to stop. A few people I would assert were too impatient, or did not understand very well the purpose or goal of my experiment. Another few people were extremely adept at my system and were quickly able to navigate to all of the buttons and click them in the same amount of time as the other users, proving my system a success.

There were many observations I made through the showcase, a particular one being that the users tended to navigate from the left, starting with the easier corner button, and working their way over to the right (figure 5). This brings a question of whether to number the buttons, so they wouldn't be clicked in this easier fashion. A few people, when rather lost on the screen, understood they could move back to the origin on the screen to reestablish their bearings, while others would haphazardly move the mouse around trying to find any button at all. Sometimes the buttons users would click on were not the ones they were expecting to click, and they would click a button they have already clicked, one that was already green, possibly because the animation of the button being depressed wasn't visible enough.

Overall, most users found the system fun and like a game, while not exactly being my intention. Some other feedback I received included adding vibration feedback when a button clicked, but this also ties in with the depress animation described above. Another user asked why I placed the origin in the bottom corner, rather than in the center. If it was placed in the center it would introduce a challenge to differentiate between left and right, and up and down. Perhaps with more motors this could be explored. Finally, many users felt the vibrations were too strong. For such tiny motors, it is surprising, but I understand. After several minutes of receiving vibrations on the hand the sensation becomes too much to bear.

Figure 5 - A user in progress with the system

Future Progress

Overall I am satisfied with my system as a prototype and proof of concept. It is limited and in some areas crude. I would definitely like to address the feedback I received and the observation I made in another iteration. Beyond that, there are limitations that would have to be overcome in order to explore further. Different or more advanced haptics hardware is available out there and would have to be researched for a more precise system. Particular applications of this could be embedding it into dedicated mice or other hardware for general users and applications, but also special needs users and special applications. As this system expands upon an established system, the possibilities are basically endless. While some companies seem to be introducing touch screens in all of their products, there are certain limitations to touch screens, like “gorilla arm”, fatigue caused by extensive touch screen use, that secures a future for traditional computer interfaces as well. Anything that can improve this experience should be considered.

References

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