TapticWidgets: Haptic Interaction Techniques for Accessible and Multimodal Desktop Computing

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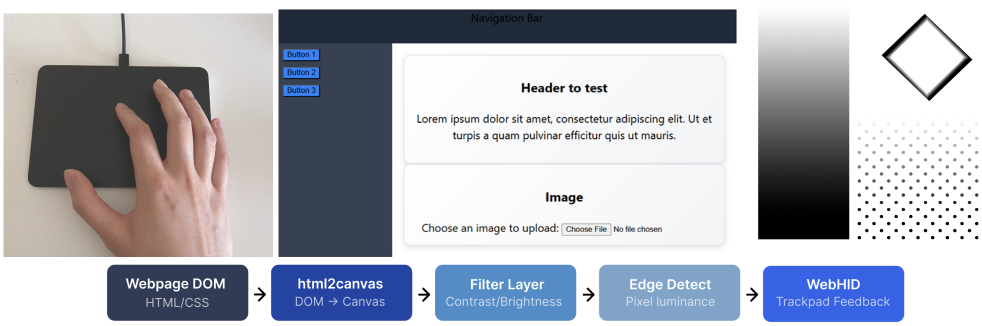

Figure 1: Left: Apple Magic Trackpad 2. Middle: example webpage. Right: Sample image used in developing haptic feedback for images. Bottom: Image to haptic feedback pipeline.

Keywords

interaction techniques, haptic feedback

1 Introduction

Everyday desktop computing relies almost entirely on visual feedback, creating significant barriers for users who cannot depend on sight and limiting the expressive potential of interaction for all users. Even for users without visual impairment, they also rely on mostly visual cues and sometimes audio. Despite already using hands and fingers for mouse and keyboard as a means to send information to the computer, the users currently receive very limited information from their hands and fingers. Therefore, we explore the possibility of using haptic feedback on simple and widespread haptic devices to improve the 2-way communication system between users and computers in everyday tasks.

Although haptic feedback has been explored in other areas such as teleoperation and entertainment, its application as an information channel in everyday desktop computing remains underexplored, despite the widespread availability of programmable haptic trackpads in commodity hardware. This work aims to improve the user experience and accessibility on the web and establish a foundation for multimodal desktop interaction for hardware already deployed at scale and for designing use-case-driven hardware.

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This project investigates how a vibrotactile actuator on an Apple Magic Trackpad 2 (Figure 1, left) can communicate the visual structure of a webpage in real time, including element boundaries and interactive regions. We present a web-based prototype that lets users feel the structure of the webpage through their trackpad, and maps visual boundaries and element types to haptic sensations in real time. We took inspiration from how CSS augments HTML visually; Here, we explore how vibrotactile feedback can augment HTML haptically.

The key findings of this work so far are: (1) edge-strength, i.e. the difference between neighboring pixels, produces more spatially meaningful haptic feedback than single pixel values, (2) distinct *pulse patterns* across element types are perceptually distinguishable when both intensity and duration are varied together, and (3) the *intensity* and *duration* of a vibration are perceptually indistinguishable and collapse into a single degree-of-freedom.

2 Background and Related Work

2.1 Haptic Feedback

Haptic technologies have advanced significantly within human-computer interaction over the past several decades. See et al. [4] and Mallouk et al. [2] explored multiple approaches including force feedback, tactile displays, mid-air haptics, and surface haptic interfaces across domains such as VR and AR, tele-operation, surgical simulation, and robotics. Together, these systems demonstrate that touch can effectively convey spatial, structural, and material information through both kinesthetic and cutaneous feedback channels. As See et al. [4] note, vibrotactile and surface haptics have emerged as lightweight mechanisms for communicating texture and contact properties without the need for large mechanical actuators, making them great candidates for integration into everyday computing.

2.2 Haptic feedback for Accessibility

Force feedback devices have been used to assist target acquisition by stabilizing cursor movement and compensating for tremor or reduced motor control. Holbert and Huber [1] evaluated a haptically enhanced GUI using a force-feedback mouse, incorporating assistive effects such as gravity wells, damping forces, and boundary constraints to guide users toward interface targets. However, the results also revealed important design challenges: overlapping or poorly tuned force effects could introduce fatigue, reduce precision, or distract users. The findings emphasize that while haptic assistance can significantly improve accessibility, its effectiveness depends on careful force calibration, adaptability, and ergonomic integration.

2.3 Vibrotactile feedback on Desktop and Laptop devices

Ouchi et al. [3] developed a 3D desktop environment using the Novint FALCON force-feedback device, enabling users to manipulate windows and objects with haptic cues such as force and vibration. Among the two experiments, participants preferred the haptic-enabled interface and showed improved performance in complex spatial tasks, particularly those that require depth perception. However, the system was designed for controlled, task-specific 3D interactions rather than everyday desktop workflows. Participants reported fatigue, difficulty adjusting force magnitude, and limitations in precise manipulation, and the device did not fully replicate conventional mouse functionality. These limitations highlight a broader gap of everyday computing remaining mainly visual, and haptic feedback typically restricted to simple notifications.

3 Method

3.1 Hardware and Software

The prototype is implemented entirely as a web application running on Google Chrome, communicating with an Apple Magic Trackpad 2 via the WebHID API. We chose Google Chrome as it is one of the most popular web browsers and supports WebHID API. We found that a higher *intensity* produces stronger haptic feedback, while a higher *duration* produces weaker haptic feedback. Hence, there are multiple pairs of *intensity* and *duration* that are perceptually hard to differentiate via the sense of touch. Therefore, although technically the hardware supports 2 degrees-of-freedom (DoFs), they collapse to one perceptually. Hence, we use a fixed *duration* for our methods and use different *intensities*.

3.2 Haptic feedback for general HTML elements

For general HTML elements such as text elements, buttons, etc., we explore how to deliver the data encoding the type of the element effectively. We introduce two more DoFs, *repeat* and *interval*, for controlling the vibrotactile feedback. *Repeat* is the number of times we render the feedback and *interval* is the time between each render. The trackpad does not support these DoF natively, but we controlled them via our application. Hence, a *pulse pattern* consists of 4 DoF: *intensity*, *duration*, *repeat*, and *interval*. When the cursor moves from one element to another, we check the HTML classes and tag of the element and issue the corresponding pre-defined pulse pattern for the element to the trackpad via WebHID API. Currently, we have 3 patterns for each of our 3 self-defined HTML classes and 1 pattern for HTML text elements (`<p>`, `<span>`, `<h1>`, etc.), a sample webpage is used to test these functionalities in Figure 1 in the middle.

Element	Intensity	Duration	Repeat	Interval
`.button`	100	130ms	3	30ms
`.navbar`	120	130ms	2	30ms
`.card`	80	130ms	1	30ms
`p, h1, ...`	35	130ms	1	30ms

The patterns and the elements are being hard-coded as one if-else statement, so it is hard to extend the number of patterns. We plan to restructure to use a JSON file or another format to store user-defined patterns and their corresponding element(s), similar to using `.css` files to define CSS rules.

3.3 Haptic feedback for images

We are exploring how much information we can convey to the user via haptic feedback. Since images are a complex 2D structure, we design a pipeline to render haptic feedback for images exclusively. Currently, each time the user hovers the cursor to a new position in the canvas, we get the data of the hovered pixel, get the pixel intensity by taking average of the 3 RGB channels, and issue a pulse pattern with the intensity being the intensity of the pixel, the duration of 100ms, repeat of 1. With the *flat luminance* approach, the darker pixels correspond to the lower intensity and the lighter pixels correspond to the higher intensity. In Figure 1, when hovering over the gradient region of the sample image (right), we can easily tell apart if we are going from the dark to light region and vise versa. However, it is hard to distinguish between hovering over a dot and hovering over the edge of the rectangle.

Therefore, we are exploring other methods to encode the information in the image, especially encoding the relationship between pixels in a local region to capture the feature of the region. For example, use simple edge detection and generate an edge-texture in the background and use *flat luminance* on that texture to render the feedback for the corresponding region of the original image (the pipeline is illustrated in Figure 1 at the bottom). This would allow the user to feel the cursor entering a circle or crossing the edge of the rectangle, but it would be hard to distinguish whether the cursor is moving from darker to lighter region in the gradient.

References

[1] Brian Holbert and Manfred Huber. 2008. Design and evaluation of haptic effects for use in a computer desktop for the physically disabled. *Universal Access in the Information Society* 10 (07 2008), 165–178. doi:10.1007/s10209-010-0192-x

[2] Nazih Mallouk, Majid Roshanfar, Pedram Fekri, and Javad Dargahi. 2024. A Brief Review on Recent Advances in Haptic Technology for Human-Computer Interaction: Force, Tactile, and Surface Haptic Feedback. In *2024 7th International Conference on Information and Computer Technologies (ICICT)*. 34–39. doi:10.1109/ICICT62343.2024.00012

[3] Yusuke Ouchi, Hiroaki Nishino, Tsuneo Kagawa, and Kouichi Utsumiya. 2011. A Tangible 3D Desktop Environment with Force Feedback. In *2011 14th International Conference on Network-Based Information Systems*. 349–355. doi:10.1109/NBiS.2011.59

[4] Aaron Raymond See, Jose Antonio G. Choco, and Kohila Chandramohan. 2022. Touch, Texture and Haptic Feedback: A Review on How We Feel the World around Us. *Applied Sciences* 12, 9 (2022). doi:10.3390/app12094686