Haptic Conviction Widgets

Gerry Chu[3,1], Tomer Moscovich[2,1], Ravin Balakrishnan[1]

[1]University of Toronto, [2]INRIA Orsay, [3]University of Washington

ABSTRACT

We introduce a haptic mousewheel as a platform for design exploration of haptic conviction widgets. Conviction is how strongly one wants to do something, or how strongly one desires a parameter to be as it is. Using the haptic mousewheel, the widgets allow users to communicate conviction using force, where greater conviction requires greater force. These widgets include buttons that take varying amounts of force to click, a trash can that requires overcoming force to delete files, an instant message client that requires more force to communicate a stronger emotion, and widgets that allow parameters to be locked using force.

KEYWORDS: Conviction, haptic, affect.

INDEX TERMS: H5.2. Information interfaces and presentation (e.g., HCI): User Interfaces, Haptic I/O.

1 INTRODUCTION

Haptics have great potential for desktop interaction as they make use of the sense of touch, a sensory modality that most people do not currently take advantage of while using the computer. Current haptic systems are typically very specialized, such as the da Vinci surgical system [3], or are used for low-fidelity output, such as rumble packs on game controllers. Snibbe et al. [15] were amongst the first to bring high-fidelity haptics into the home by designing devices that used haptics to scroll through media.

Finding more uses for haptics will advance the field and make them more useful for desktop users. To this end, we believe it is worthwhile to integrate haptics into a device people already have and are comfortable with—the mousewheel. In the future, people might see haptics as an upgrade to their existing non-haptic mice. This is supported by the trend of mice steadily increasing in features, adding ergonomic design, optical sensors, and mousewheels. We think this upgrade model for desktop adoption of haptics is more feasible than expecting end-users to buy an unfamiliar haptic device, like the Phantom [9].

We built a haptic mousewheel (Figure 1), which is like a normal mousewheel, except that it is mounted on the shaft of a motor. Using this device, we explored designs for uses of haptics on the desktop beyond scrolling and 3D modeling. Based on this exploration, we believe that the communication of *conviction* (here defined as how strongly one wants to do something, or how strongly one desires a parameter to be as it is) is a promising use for haptics.

An obvious first widget to augment with haptics is the button. Of course, clicking a normal GUI button with the mouse is passively haptic, but with the addition of active haptics, some buttons can be made harder to click than others. This difference in force or distance is used to communicate an extra bit of information to the user, such as the fact that clicking a certain button is discouraged, perhaps because it causes a destructive action, such as closing a document without saving. In this case, the computer is testing the user's conviction that he or she actually wants a certain action to be performed, in effect asking "are you sure" haptically, rather than obtrusively presenting a messagebox. Using this idea, we designed other haptic widgets that work this way: slow trash, and conviction instant messaging.

We also designed widgets where the user exerts more force to discourage the computer or other users from doing some action or changing some parameter. Other users then have to exert an equal amount of force to undo the action. We call these widgets "locking widgets", and created a locking switch and trackbar.

Figure 1. Mouse with haptic mousewheel

2 CONVICTION

The ability to express conviction is well supported by the rich affordances of the physical world, but is poorly instantiated in current UIs. The efforts of interface designers are ultimately filtered by the common input/output devices: the keyboard, mouse, screen, and speakers. Our interactions with other people are increasingly mediated by computers, making human-human interaction as limiting as human-computer interaction.

Many real-world examples of expressing conviction involve the sense of touch. A judge slams the gavel down hard, quickly quieting the courtroom. A screw tightened strongly expresses desire for the parts not to separate. Sometimes we do not want to express strong conviction. Lightly tapping on a glass with a spoon may be all that is needed to begin an after-dinner speech. A screw might be loosely tightened for easy disassembly later on.

Although other sensory modalities could be used to express and experience conviction, the use of touch is especially interesting. The advantage of using a haptic mousewheel to express conviction is that the wheel's position, which is mapped to conviction, is easy to detect. Unlike electromyography (EMG) and galvanic skin response (GSR), which are popular methods of measuring valence and arousal in affective computing, the mousewheel does not require that electrodes be adhered to the skin [11, 16]. Computational classification of facial expressions and gestures are sensitive to noise and are inaccurate [10]. With

gerrychu | ravin @ dgp.toronto.edu
tomer@moscovich.net

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haptics, the control of conviction is voluntary, unlike the methods described above.

The sense of touch is unique among senses since the same organ can be used to both express and experience conviction; for example, the hands are used to screw and unscrew a screw. The haptic nature of conviction widgets allow conviction to be both expressed and experienced using a single device.

3 APPARATUS

We use a Maxon RE-25 12V DC motor powered by an Advanced Motion Controls Z6A6 analog torque-mode amplifier controlled by a Precision Micro Control MultiFlex PCI 1440 motion controller. An Agilent HEDS-5540 2000 cpr optical encoder senses angular position. The system is programmed in C# on Windows XP. The servo loop runs faster than 1 KHz. The touch-sensitive aluminum wheel is 28 mm in diameter and 7 mm wide, and has a knurled texture. In addition to the left and right mouse buttons, pressing down on the wheel middle-clicks.

4 RELATED WORK

This work is related to affective computing, haptic interaction techniques, and the combination of the two.

Picard's book, *Affective Computing* [11], introduces the idea that computers should be sensitive to people's emotional state and discussed methods of detecting this state. For example, Kapoor, Burlesonc, and Picard [6] were able to detect frustration using cameras and a pressure-sensitive chair and mouse.

The main contribution of the paper is a set of haptic interaction techniques. Existing haptic interaction techniques include Brewster and Brown's tactons [2], a set of simple vibration patterns of frequency, duration, waveform, rhythm, and tempo that are presented to the user by a vibrotactile actuator. In contrast, Snibbe et al. [15] designed a set of 1-dof haptic devices capable of higher fidelity than vibrotactile actuators. Using these devices, they designed many interaction techniques for scrolling through video/audio and lists of multimedia. Pokespace [14] is a haptic interaction technique using the Phantom [9] for selecting tools and manipulating parameters that feels roughly like a car gear-shifter. Finally, our work on haptic buttons relates to pop-through buttons that were introduced by Zeleznik et al. [18] and the haptic pen that was created by Lee et al. [7].

There have been several related papers that combine affective computing and haptics. The affect (i.e., emotion) that different haptic effects produce was studied by Swindells et al. [16]. Subjects turned a haptic knob onto which various haptic effects were rendered. Each texture's valence and arousal as experienced by each subject was measured using EMG, GSR, and self-report. Their work relates to conviction widgets because conviction often has emotional basis, possibly related to arousal. However, they did not study the affective qualities of a haptic spring, which we use to implement conviction widgets.

Brave et al. [1] describe inTouch, a set of haptic rollers virtually connected with a remote set of rollers. People informally testing inTouch reported that the rollers allowed them to communicate emotions remotely by turning the rollers. Although the rollers do not control a definite parameter, this device could be used to communicate conviction as follows: one person could try to turn their set of rollers while the other could try to resist by holding their rollers stationary. Additionally, Smith and Maclean [13] had remote pairs of people communicate emotions using a haptic knob (none of which included conviction) with a 54% success rate (chance=25%).

5 WIDGETS THAT TEST USERS' CONVICTION

5.1 Haptic Hard-to-press Buttons

Haptic buttons are clicked by turning the wheel towards the body against a virtual spring, then letting go. Since the wheel only has to be turned a small amount, it approximates linear movement. The techniques described here carries over to a haptic mouse button with linear travel.

Haptic buttons are an example of the computer expressing conviction to the user. Haptic buttons can take a normal amount of force or distance to click, or if the computer has a high level of conviction about a button, the computer can make the button hard-to-press: the button either has a higher spring constant or a greater click-travel distance than a normal button. The user also has a certain amount of conviction, which is expressed as a willingness to overcome a certain amount of force and/or distance. In effect, the computer's and the user's convictions are competing.

Candidates for making a button hard-to press include destructive or dangerous actions such as ones that lead to advanced control panels, or close, don't save, and delete buttons.

While clicking down on a haptic button, the finger resists a virtual spring. Once the spring is deflected past a threshold, the mouse-down event occurs. Users can back out of the click before the threshold, or can move the mouse away from the button before releasing the wheel.

Figure 2 shows a position-torque graph for a normal, not hard-to-press click. Table 1 shows the values of the spring constant and distance for the two types of hard-to-press buttons. The *bottom of press* phase, where the haptic feeling of a click occurs, lasts for 0.9 degrees. After this phase, the torque rapidly increases (k=-26.1 mNm/deg), haptically alerting the user to let go of the wheel in order to finish clicking. The wheel then spins back to below 0 degrees, and the click event occurs.

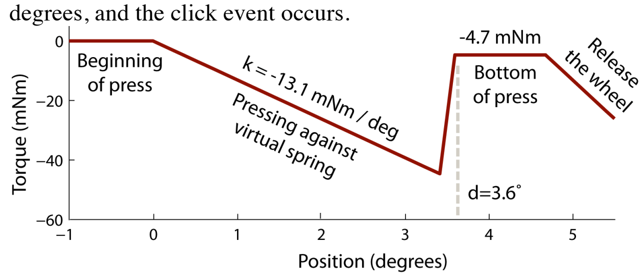

Figure 2. Normal click position-torque graph. Positive sense is towards body

	Spring const. k (mNm/°)	Dist. d (°)
Normal click	-13.1	3.6
High force click	-39.2	3.6
High distance click	-2.6	36

Table 1. Spring constants and distances

5.2 Slow Trash

In the real world, doing things takes time, allowing people to reflect on the consequences of their actions. When interacting with computers, actions done by the computer often happen so quickly that there is no time to reconsider. Although modern operating systems have a "trash" icon, right-clicking the trash and selecting "empty trash" can still be a frighteningly quick process.

In *slow trash*, files in the trash are shown in a listbox (Figure 3). As the user holds the Ctrl key and scrolls up, files start disappearing. (Pressing the Ctrl key disambiguates between deletion and scrolling.) A haptic detent is generated for each file that disappears. This allows the user to see and feel each file disappearing, giving her time to reconsider. If she deletes a file by mistake, scrolling down brings the file(s) back. Only once all the files disappear from the listbox are the files erased. By making the user experience the computer's conviction by overcoming the detents, the computer tests the user's conviction.

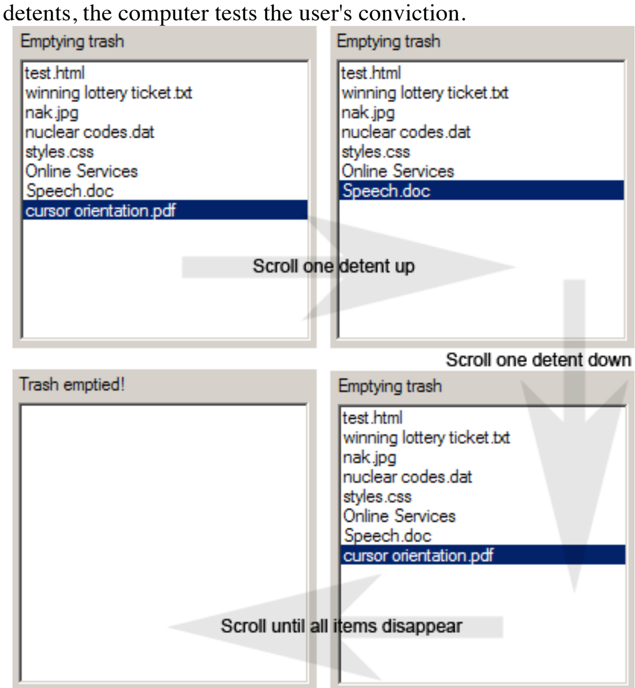

Figure 3. Slow trash

5.3 Conviction Instant Messaging

Instant messaging is limited because all the richness of face-to-face communication is filtered though the keyboard and screen. There have been many research attempts to better communicate emotion between remote people [1,8,12,13,17]. Hancock et al. [5] found that people can accurately communicate emotions in IM using cues such as word choice and punctuation. However, improvements are still possible. One problem with instant messaging is that extreme emotions are as easy to express as normal ones, which leads to emotion exaggeration. For example, "rotfl" (rolling on the floor laughing) doesn't take much more typing effort than "haha".

To solve this problem, we decided to map force and distance to emotional valence. In the real world, shouting takes more effort than speaking. We think that the effort that increased force/distance brings will make people express an extreme emotion over IM only when they really mean it.

We created a mockup instant messaging client (it has no message transmission capability). Below the textbox is a set of buttons, each representing an emotion. Currently, happy, sad and confused are implemented (Figure 4). When the user mouses over one of the emotion buttons and turns the haptic mousewheel against a virtual spring (k=13.1 mNm/deg), the emoticon on the button changes. More force/effort is required to express greater emotion. The more the wheel is turned, the higher the valence the emoticon on the button shows (Figure 5). When an emotion button is clicked, the current emoticon that is displayed on the button is pasted into the textbox.

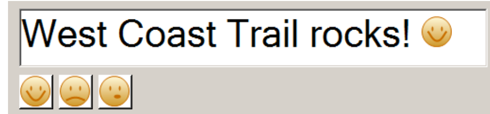

Figure 4. Prototype showing a very happy face

Figure 5. Increasing levels of emotion expressed in emoticon

6 LOCKING WIDGETS

In the context of parameter adjustment, expressing a degree of conviction in a parameter value is synonymous with *locking* the parameter at that value. That is, the more conviction has been expressed, the more the user desires that the parameter stay at the specified value. These widgets were inspired by a light switch in our lab that someone had placed a piece of tape over (Figure 6), locking it to the off position. Other people can remove the tape and flip the switch, but it takes more effort.

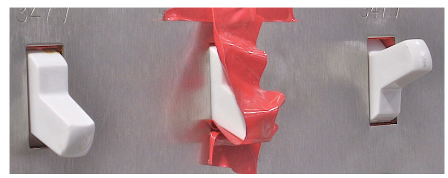

Figure 6. Taped-over light switch

Locking does not have to be a binary value as with the tape. In these widgets, we map the distance the spring is compressed to the amount of locking. The extra force needed to unlock the widget discourages others from changing the widget's parameter value.

6.1 Locking Switch

The locking switch is an on/off switch or checkbox. Starting in the nominally off position, turning the switch nominally on is done by turning the mousewheel up (away from the body) 36° (vice versa for turning off). ("Nominally" means that the switch is not locked; no conviction has been expressed.) There is a detent between the nominally on and off positions. When the switch is nominally on, the status light is light green (light red for nominally off).

Turning the mousewheel past the nominally on and off positions expresses the degree of conviction that the user has in the setting. A virtual spring (k = 2.6 mNm/degree) that feels like a rubber band is attached to the nominally on or off position, so that the more the switch is turned, the more force has to be exerted against the virtual spring (see the locking curve in Figure 7). As the wheel is turned, the status light gets more saturated. To set the switch at the chosen conviction strength, the mouse is moved outside the bounds of the widget. For example, in Figure 7, the widget is locked to the *on* setting at 55 degrees (see intersection of locking curve with gray dashed line).

When the mouse re-enters the widget, the current position of the mousewheel is reset to the number of degrees that the widget was locked at and a virtual spring is attached to that point (see the intersection of the unlocking curve with the gray dashed line in Figure 7). To unlock and toggle the switch, the user has to overcome the force of the virtual spring, turning the wheel in the opposite direction with the same force and distance that the switch was locked with. The spring is oriented such that the most force is exerted right before the point of unlocking.

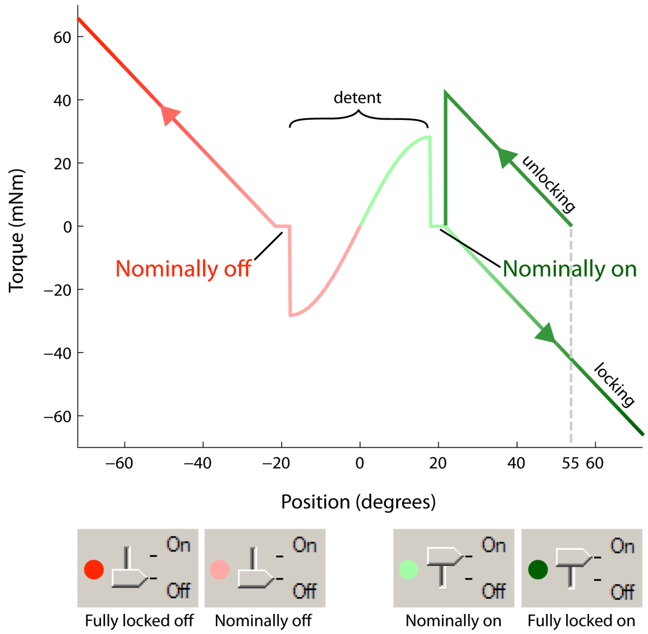

Figure 7. Locking switch position-torque graph. Positive sense is towards body

6.2 Locking Trackbar

The locking trackbar can be used like a normal trackbar by dragging its thumb with the left mouse button. Locking the trackbar to a value is done by scrolling down with the mousewheel against a virtual spring (k= -0.65 mNm/degree) while the cursor is over the widget (Figure 8, locking curve). A status bar indicates the conviction strength with a maroon bar that grows downwards as the mousewheel is turned. To lock the trackbar at the chosen strength, the mouse cursor is moved away from the widget. In the figure, the trackbar's value has been locked at 25 degrees. When the trackbar is locked, its value cannot be adjusted.

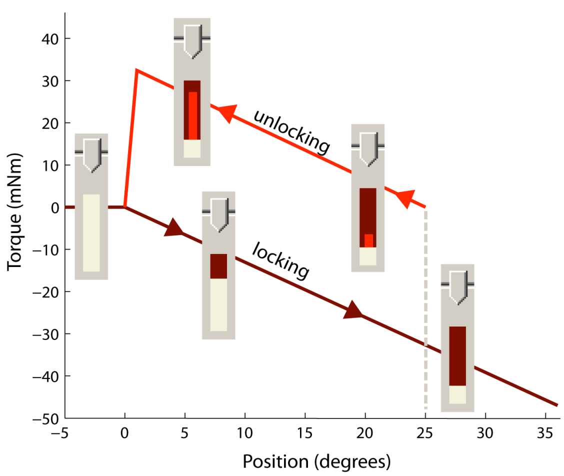

Figure 8. Locking trackbar position-torque graph.

To unlock the trackbar, the user mouses over the widget. The maroon bar indicates the strength of the lock. The current position of the mousewheel is reset to the number of degrees that the trackbar was locked at (25 degrees) and a virtual spring is attached to that point (see the intersection of the unlocking curve with the gray dashed line). As the user turns the wheel up, resisting the virtual spring, a thin red bar beginning at the bottom center of the maroon bar grows upwards until it touches the top (see unlocking curve). At this point, the trackbar is unlocked, and its value can be adjusted. In another version, the trackbar's value can be adjusted when the widget is locked. A light lock has a C/D ratio of the thumb close to 1, while a heavy lock is a C/D ratio greater than 1.

Locking widgets could be applied to "track changes" in MS Word. If the author has a high conviction of a change, he would have to exert more force. It would then be harder for the other author to revert the change.

7 Conclusion

Gentner and Nielsen once argued that human-computer interaction should be more expressive, writing "It's as if we have…lost our facility with expressive language, and been reduced to pointing at objects.... Mouse buttons and modifier keys give us a vocabulary equivalent to a few different grunts" [4]. Conviction widgets allow people to give *intonations* to their grunts, which is a one step towards the vision of expressive interfaces.

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