Cord UI: Manipulating Data on its Flow Path with Augmented Cables

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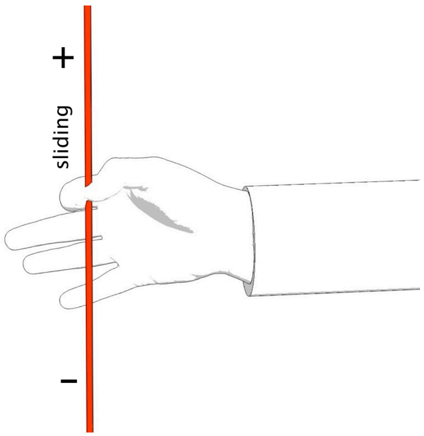
Abstract
In this paper we present Cord UI, a novel user interface that utilizes cords that are connected to our everyday electrical devices. Cords offer unique properties and a diverse set of metaphors that make them potentially interesting tangible interfaces. Cord UI explores different interactions like tying knots or pinching/sliding to control the flow of data and/or electricity. We also look at ways to manipulate data or certain properties of a device by using a combination of the cord and some object. For instance, placing a clamp on a cable can obstruct the audio signal to the headphones. To test and evaluate our ideas, we built prototypes by augmenting standard cables with different sensors. We think that these augmented cords can make certain controls more seamless and intuitive.

Author Keywords
Tangible Interface; Ubiquity; Touch Sensors; Seamless Interface; Sensing Technology

ACM Classification Keywords
H.5.2. Information interfaces and presentation: User interfaces

General Terms
Design, Experimentation



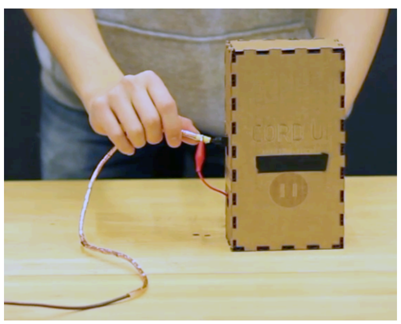


Figure 1: Sliding one's fingers along the cable or applying pressure can be used to control *data flow*

Introduction

Traditionally, electrical devices are dependent on cords, either for power or data-transmission. Wireless technologies have advanced to a point where they can be used to charge devices and appliances – and therefore make cords almost obsolete. However, wireless technologies still suffer from inherent vulnerabilities and security threats [1]. At the same time, cables are still used in most computers and mobile phones for power and to enable data connectivity. Furthermore, the ubiquity of cables provides a new space for exploration of their interaction capabilities. Through our project, we enhance the appeal of cords and thereby make a case for their extended use.

Cords offer many different physical affordances. This is why we believe they have great potential for use as a tangible user interface. They have a deformable long body, which is currently only used passively. However, they provide valuable space for interaction, which allows us to intuitively and directly manipulate data. This can be compared to controlling the water flow in a water hose. We propose interactions that involve wrapping, touching, attaching objects, or making knots or shapes with cords.

One of the underlying principles of tangible interface design is to augment everyday objects with technology aimed at exploiting real-world metaphors. The goal is to take advantage of the richness of human intuition and handling skills developed over time through interaction with these objects. In our opinion cords exemplify this principle.

Related Work

In the field of human-computer interaction, there have been several projects that explored ropes as tangible user interfaces. Yao et al [11] describe in their work how a rope's common affordances can be used to design a novel gaming interface. Games, such as "tug of war" or rope jumping can be played collaboratively at remote locations. Matsumura [5] explored the ability of a rope to resemble a sound wave, by manually changing its shape. A camera records the created wave shape and translates it into real sound. TempoString [2], another tool, lets children use a rope to edit the music they create. Schwarz et al [8] in their work were the first to examine cords as input device but focus on the control of mobile phones. Minguet [6] used a rope with flex sensors to generate visuals and sounds on an iPhone.

These projects use the unique properties and metaphors of a rope or cord to explore different interactions. However, we believe that the affordances and metaphors of cords are not adequately looked into. Also taking into considerations their ubiquity and the ability to transfer signals (power/data), we see a whole new space of possibilities to develop meaningful interactions and applications. Some of these unexplored metaphors and possibilities are exemplified in our prototypes that demonstrate a variety of interactions for cords connected to all kinds of devices.

Interaction

We decided to classify the interactions with cords into three categories:

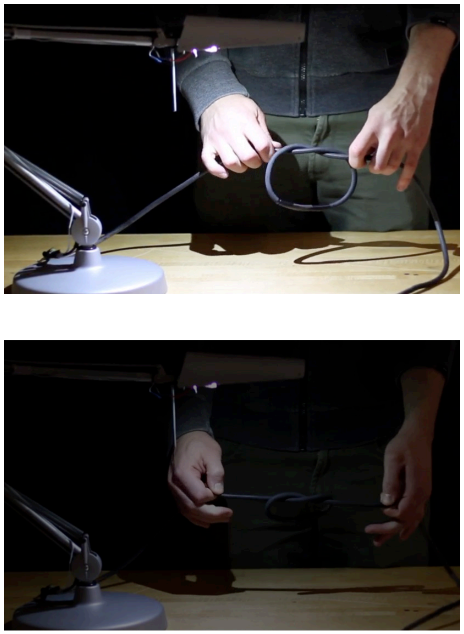


Figure 2: A desk lamp that is dimmed by tightening the knot in the cable

Linear

We touch or apply pressure to the cord to manipulate various parameters of the device to which it is connected [Figure 1]. The form factor lends itself for multiple types of linear interaction with the cords. For example, sliding (longitudinal), pinching (radial), twisting (tangential) or swinging the cord like a cowboy. They all enable a perceptual coupling with the data. For example, pinching the cable and varying the pressure applied, would alter the volume or speed of the music played similar to [10]. We imagine that people could pinch the cable of their headphones to mute the music temporarily and listen to in-flight announcements. These interactions are exemplified in our prototypes.

Sliding along the cords can provide control over the data flow. Users would be able to linearly increase/decrease parameters such as temperature, light intensity, etc. They can also access a specific point in a timeline or playlist. Other types of interaction, such as twisting, squeezing and swinging, can also be used to control or modify data. As an example of this, a rock guitarist can distort the sound by swinging the audio cable.

Knots

Tying knots in our augmented cables can manipulate a specific parameter of an appliance. For example, the tightness of a knot determines the level of data or electricity flow. In our prototypes, a simple overhand knot in the cord connected to an LED table lamp controls the intensity of the light; the tighter the knot is, the dimmer the LED light and the looser the knot, the brighter the light [Figure 2]. This is based on the fact that a knot constricts or cuts-off the flow of something (light, volume, data, etc.) depending on how it is tied. A knot in a fire hose, for example, would limit the flow of water. Another major benefit of using a knot as a control mechanism is that it can be placed anywhere along the augmented cord. Therefore, it can be moved to the most suitable position. It also provides more direct visual and tangible feedback about the current flow than a pinch or a slide. There is also the possibility for multiple knots to control a number of independent parameters of a device. For instance, three knots could represent the red, green, or blue value of an RGB-LED lamp, respectively.

Another source of inspiration was the old tradition of tying a knot in a handkerchief to remember something important. We imagine a cable - connected to a computer - in which the user ties a slipknot. This action automatically creates an event reminder in the user's calendar or a task in the To Do list [Figure 3]. Upon completion the knot can be removed and the event or task is automatically checked off. The cord then acts as a tangible representation of the digital data. We built a prototype to test and illustrate this application.

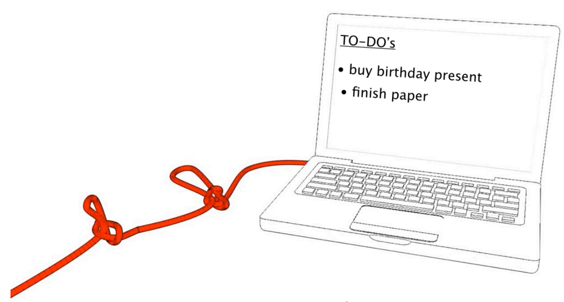


Figure 3: Knots in a cord act as physical representation of digital data.

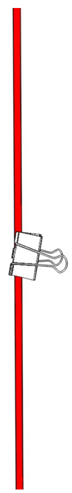


Figure 4: Clamp attached to the cable to control music volume

Of course, knots offer a breadth of options for applications, as there are many types and shapes.

With Appliances
Cords can also interact with the appliances it is connected to by modifying its shape and position. For example, we imagined a blender where one can set the motor speed by coiling the cord around its base [Figure 5]. The more coils, the higher the speed of the blender. Alternatively, the coils could control the duration of the action. Each revolution around an object could add one minute (or any different set amount) to the timer. This would allow for very accurate timing control.

Another way of interacting with appliances is using small objects, each having their own set of affordances, on an augmented cord. For example, users can attach and slide clips on the cord to change the volume of music [Figure 4]. How this would work is very clear to any user based on their experience with clips. Also, the shape and position of the clips provide immediate visual and tangible feedback about the type and level of control.

Technical Implementation
For our prototypes we augmented ordinary cords with different sensors. Conductive material was added to a cord’s surface to detect a pinch. The micro-controller can detect such use of the cord via a high resistance resistor (~1 MOhm) placed in serial, which responds to any resistance changes following contact with the human body and ground [9]. It can also detect the amount of pressure that is applied to the cord, because the resistance is inversely correlated to the area of human skin touching the cord. With regards to interaction through sliding, we had to find a way to determine the exact point of contact. Adding a linearly resistant material (graphite on paper tape) that detects resistance change to the cord proved to be a solution.

To detect a knot in a cord, and use it to adjust the brightness of a lamp by altering its tightness, we embedded a Flexpoint 2.2” bend sensor in the isolation of a four-strand cable. Two of the strands were used to read out the sensor data. The other two strands were used to power the lamp. We used the Arduino Uno to read out the analog resistance value and to control the brightness of the light accordingly. We also explored the use of a potentially stretchable cable combined with a stretch sensor for detecting a knot. Since tying a knot would automatically stretch the tube/cord and untying would un-stretch it we could register these actions. We used this technology, with an Arduino Uno and Processing, for the task and event reminder prototype.

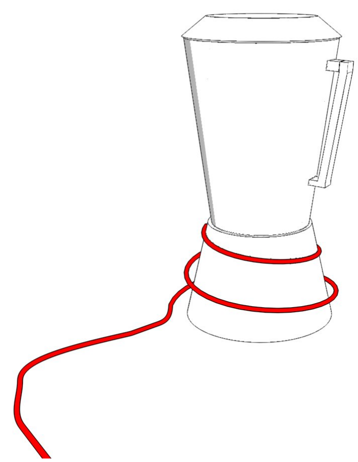


Figure 5: Cable wrapped around blender as speed control

Limitations and Future Work

Our current research focused on cords used with computers or laptops, everyday appliances and electronic accessories such as the headphone. While cords for some of these appliances and devices may soon be replaced by wireless technologies we believe that cables and cords will continue to be the crux of connections.

We are aware that the prototypes we built are limited in their functionality, but they should illustrate the directions in which this research can go. One of these is the development and application of stretchable cords. Even though existing cords cannot be stretched due to the use of copper as a conductor, there has been some research on copper-rubber interfaces, which could potentially be used for this purpose [3]. A second direction could be the implementation of higher quality and more accurate capacitive sensing in cords. We believe that a reasonably good reading of the location of a touch, or even a pinch, is possible when adding a sensor that uses Swept Frequency Capacitive Sensing such as the Touché [7]. This would also allow for detecting more sophisticated gestures.

There are many different types of cords that can be explored in this context. Various cords can have different unique properties. For instance, spiral cords would allow for different types of interactions than straight cords. Also, woven fabric isolation might allow for a better and easier embedding of conductive material or various sensors. It is furthermore valuable to take a closer look at existing technologies that enable sensing on cords. One example would be Piezo Copolymer Cables, which can sense compression and stretch.

Another potentially interesting area for further exploration is the actuation of cords. This means Cord UI could be used as output rather than only input [4]. This allows for ambient, visual or haptic feedback about certain events or interactions. For example, a cord can indicate suffering by wiggling and cringing when a data connection gets weaker.

Conclusion

This paper presents the idea of interacting with cords through touching or making shapes to manipulate parameters of connected devices. As a proof of concept, we developed several prototypes to demonstrate how cords could be used to control 1) the intensity of light in a lamp, 2) the volume of music on a media player, or 3) data on a computer. This form of interaction opens up several interesting opportunities for all kinds of applications. However, there are challenges that need to be addressed before this interaction is to be used in everyday connected objects. We believe that our ideas described in this paper will give cords an additional layer of utilization. After all, cords offer a rich pallet of metaphors and possibilities for tangible interaction.

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