Tug n' Talk: A Belt Buckle for Tangible Tugging Communication

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Abstract
Tug n' Talk is a prototype of a tuggable communication device, allowing for intimate communication between two individuals using tugging as a metaphor. In this paper we discuss the advantages of tugging over other haptic communication modalities, such as vibration, with a focus on input/output spaces and meaning construction.

Keywords
Tuggable, tangible, haptic, communication

ACM Classification Keywords
H.1.2: Models and Principles: User/Machine Systems., H.5.2: Information Interfaces and Presentation: User Interfaces. K.8.0: Personal Computing: General. J.7: Computer Applications: Computers in Other Systems.

Introduction
A tug is an intimate and quiet way to request the attention of another. Children will often seek the attention of a parent with a simple tug on their clothes. We believe there is significant potential to use tugging as a communication metaphor. A tug from a child on her father's shirt while he speaks on the phone can be easily processed without necessarily interrupting the flow of the phone call. Tugging also has a variety of

advantages over present means of wireless interpersonal communication. Current modes usually require the immediate attention of both parties: a cell phone, even on vibrate, must be picked up, a text message must be read, and a page must be identified. Furthermore, the present paradigm of vibration for "quiet" communication notification is insufficient for communicating any more than a request for attention; the emotional content of the message, be it urgency or playfulness, is only decipherable upon answering to call, or reading the text message. Vibrating, as currently implemented, tends to still be audible. Even when it's not audible, the act of responding to it (to stop it vibrating) is itself disruptive. Attempts at wrangling pressure into vibration into language suffer from losses in translation. Most users have very little, if any, experience with reading vibrations, as very little else, barring cell phones, pagers, and other constructed haptic interfaces, utilize vibration for communication.

While exploring tugging is the main contribution of this paper, we also want to contextualize our work by situating Tug n' Talk on a variety of other design axes. Tug n' Talk uses a coincident input/output space – to send a tug, you must tug on a chain. We avoid the challenges of symmetric input/output spaces (ie using the same chain to both send and receive) by using two different chains with an implied connection. Tugging also lets us send continuous signals, which supports our goal of rich non-verbal communication.

Related Work

There are a variety of other projects that have similar design spaces. We describe their relationship to Tug n' Talk here.

The work done by Brave and Dahley on the *InTouch* system served as important conceptual inspiration for our work [2]. *InTouch* also uses a coincident input/output space to create the illusion that users on both ends of the device are interacting with the same physical object. While our input/output space isn't as purely shared as in *InTouch*, we believe our design shares some of the same benefits as studied in *InTouch*.

The idea of a digitally reconstituted discontinuous string has been addressed in the art work of Atau Tanaka and Kasper Toeplitz [8]. Their *Global String* project created a string that was digitally connected and spanned multiple rooms across the globe. A pluck on the string in one location would reverberate in each location. A similar idea involving a tug-of-war was described in Mueller, et al.'s "Exertion Interfaces: Sports over a Distance for Social Bonding and Fun" [6].

TapTap, by Leonardo Bonanni et al., also explores the intimate physical touching space of Tug n' Talk, although its asynchronicity and focus on memory of presence sets it apart from the communicative goals of Tug n' Talk [1].

ComTouch is of particular interest because of its discussion of the vocabularies that arise in haptic communication [4]. While vocabularies in the *ComTouch* study tended to be stochastic because of the nature of the interaction, we suspect the patterns Chang et al. describe will likely occur in our analog communication space.

Communication vocabularies have also been explored using vibration in the *Haptic Instant Messenger* [7] and

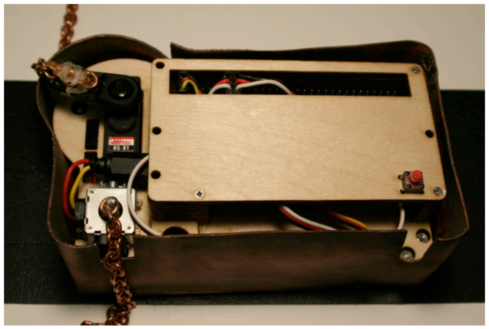

figure 1. The final prototype with top cover removed.

Hapticons [5] work. Moving forward with our project, we would like to see if certain specific signals arise (as predicted in *HIM*). We also expect that because Tug n' Talk is used in context (away from computers), context will prove a more critical element in its communication than it is in the *HIM* system.

Closest to our project is *Tug Tug*, an interface created by Haiyan Zhang and Aram Armstrong at the Interaction Design Institute in Ivrea, Italy [9]. *Tug Tug* links the cords of two analogue phones together, such that a tug on one end will retract some of the cord on the other, as if the two phones shared one cord: a coincident input/output medium, like *InTouch* and Tug N' Talk.

While *Tug Tug*, *HIM*, and *ComTouch* are intended to augment verbal conversation with touch, Tug N' Talk is intended as means of communication in itself. Further, while *Tug Tug*, *ComTouch*, *HIM* are tethered to previously explored means of verbal communication (phones, mobile phones, and computers, respectively), Tug N' Talk proposes a new mobile means of communication, breaking away from the foreground communication technologies that presently dominate mediated modes of communication.

Tug n' Talk

The aim of our tuggable interface is to allow a more robust quiet interaction between two parties. We propose a device with a belt-buckle form factor with an attached pair of chains – one chain connects to the user's shirt and one dangles below the device. Tugs on the bottom chain are transmitted to a paired belt and represented as tugs on the chain connected to the shirt itself. Each belt also has a button on it to interrupt a tug in process. See Figure 1 for a picture of the assembled prototype. With this system, a request for attention can be urgent (a quick series of sharp hard tugs), playful (a rhythmic succession of short tugs), or affectionate (a slow tug or two). While it is up to users to construct the meanings of tugs, direct analog control over the extent and length of a tug creates a space for a rich interaction.

Physical interfaces have both great potential and great challenges. Our sense of touch is quite refined, and the sense of being touched by another person is powerful and hard to replicate. Many haptic projects rely on vibration to represent touch. Past work has shown this to be effective, but we believe there is great potential in exploring other modes of physical interaction. Tugging, in particular, is interesting because a tug is already mediated by the clothing that is tugged: further mediation through the addition of a digital interface between the tugging hand and the clothing has much less effect on the physical experience of the tug. By using a coincident medium for input and output (the chain, which passes through the buckle), we can imply a connection between the two chains without having a truly symmetric mapping which is prone to collisions [3]. Another benefit of our design is that there is no need to map the input space onto something else in the output space; tugging can be implemented as both an input method and an output method.

In attempting to engineer a device for functional semiosis, it is paramount for the user to be able to mimic the inputs he or she experiences. This is the primary way that one learns to assign meaning and utilize an act for communication. If one has to inquire as to the experience of another when communicating (eg. “How did that feel?”), or explicitly assign meaning (eg. “Let’s let one long tug mean ‘no’”), the process of semiotic development is necessarily slowed. Tug n’ Talk is intended to engender a semiosis all to itself. We want a streamlined, quiet interface: one detached from any type of foreground verbal communication. This choice removes the time-consuming crutch of users verbally agreeing upon meaning. Thus we needed to utilize a modality of interaction with minimal translation, best achieved by a coincident input/output space, which should allow for easier mimicry, and thusly expedite the development of a semiotic system. Furthermore, given the constraint of a single channel for interaction, we realized that we should use a metaphor or modality that leveraged previous experience to create a meaningful interaction. Tugging, as described in our introduction, is familiar to most users as a request for some sort of attention. The extent and repetition of that interaction, in addition to its context, can further complicate the meaning the tug conveys.

User Scenarios

We imagine that our interface could be utilized by a number of different types of closely connected individuals. A few of many possible scenarios are included here.

Newlyweds wearing the devices could stay in touch throughout the day, periodically sending quick tugs to suggest they are thinking about each other. Later, when the two are eating with in-laws, the wife could subtly tug her husband to let him know her conservative parents will not appreciate his impending diatribe about leftist politics.

A parent and child pair could use the device so that the child could get the parent’s attention in situations where verbal communication would be disruptive. A parent could use the device to let her child know that she is outside the school, waiting to pick him up from after school activities.

Prototype Implementations

Initial Prototype

We have created two different prototypes for our tuggable interface. Our initial prototyping was done using the Vex Robotics Design System. This kit allowed us to quickly construct a workable prototype of our basic communication concept, a (one way) tug from one device to another, separated by distance. The tug was initiated from a model cell phone and served as a prelude to a phone call. We were pleased with the reaction we received and chose to refine and extend our project using more robust and custom hardware.

Second Prototype Hardware Design

We felt that the belt buckle form factor was an important part of the experience and so we focused the second prototype on miniaturizing the device to better understand the implications of the concept. The constraints of the buckle guided most of our technical decisions. We needed to fit batteries, actuation, sensing, communication, and control into a single self-contained package.

For the most part, we used simple off the shelf components in our design. For actuation, we used a small servo with sufficient torque to feel like a "tug." For sensing, we used the potentiometers from inside a PlayStation 2 game controller. These potentiometers are already biased with a spring, providing tension to

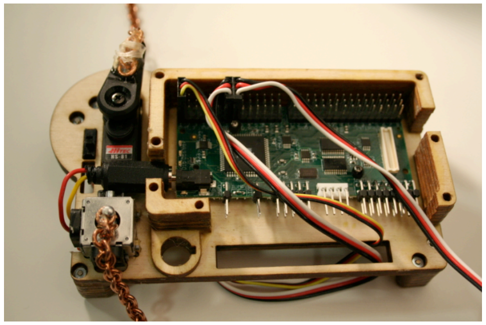

figure 2. A view of the microcontroller.

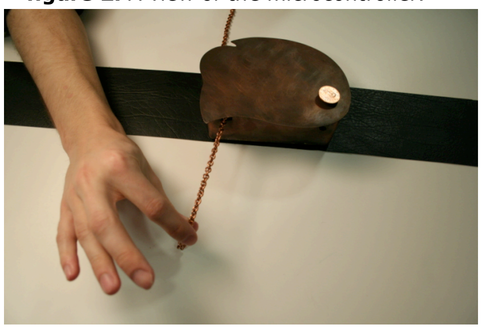

figure 3. The final prototype being tugged.

figure 4. An individual wearing the final prototype.

the "sending" chain. To control the system, we used a Robostix controller board. These boards have an ATmega128 chip as well as breakout pins for driving servos, analog to digital conversion, digital input/output, and serial communication. While these boards are somewhat bigger than we really needed, they made prototyping relatively easy. To communicate between the devices, we used a four pin serial cable. The protocol was quite simple - if a buckle sensed that it was being tugged, it would send a single byte over the serial cable from 0 to 255. The buckle receiving the signal would convert that value into a PWM waveform and drive the servo, provided the interrupt button wasn't down. For actuation, we used a small servo, Hitec model HS-81, with sufficient torque to feel like a "tug."

Packaging issues were addressed with a focus on component placement in relation to the actuation, sensing, and user interaction requirements of our design. For simplicity, a single mounting surface was chosen to arrange the hardware on a common plane. A two dimensional plywood lay-up was implemented to create the controller box and spacers which insulate hardware housing from the copper belt buckle enclosure. The completed hardware housing consists of 8 unique parts, laser cut from 1/8 inch Baltic Burch plywood, for a total of 31 individual parts laminated in 13 layers. Plywood was chosen for the insulating hardware housing as an ecological alternative to acrylic and because its material properties coincide with manufacturing processes available.

The belt-buckle case was fabricated out of copper using traditional metalsmithing techniques. The pieces were precision cut and carefully soldered together, creating the box that contained the wood packaging. We used a copper penny and attached it to the button that was used to stop the tugging motion. A patina was added to create an antique-like finish to the piece, which was then carefully brushed for effect. The whole device was then mounted on a strip of leather that fastened at the back.

Conclusion and Future Work

Based on our experiences prototyping tugging interfaces, we think the most important design implications that come from this work are related to the benefits of tugging in physical interfaces. In Tug n' Talk, we use tugging as both an input space and an output space, avoiding any sort of mapping between modalities entirely. We believe this will help facilitate the creation of meaning using this system, because there is no need to understand the translation between input and output. While we think tugging is particularly interesting, we also think it is only one of many potential physical interfaces that have been largely unused in the field of haptics.

The work described so far is the first step in a larger project investigating the ways in which we can use different varieties of physical social interaction to provide a more tangible social experience.

To do effective user testing of our design, we need to miniaturize the devices and make it possible to communicate between them wirelessly. Neither of these changes are a significant obstacle - a more refined mechanical design based on lessons learned from the construction of this prototype would be substantially smaller and the board we're using is easily integrated with a wireless module.

figure 5. A close up view of the prototype.

We are also looking to extend the tugging interface with a contact selecting interface so that the belts could contact multiple other belts. We're also very interested in the possibilities of force feedback in the interaction, so the person sending a tug can feel the recipient's response. This fits nicely with a more "analog" solution for the ignoring button for a rich two-way communication channel.

We are also looking to reimagine the device's form. While our brushed copper buckles are attractive and appropriate for certain kinds of users, we are looking to identify other designs that would better fit business people, parents, or children. We want to look particularly closely at children, since tugging is a child-like interaction. Further, though tugging may be the best interaction for familiars, we hope to investigate other modes of interaction like tapping or patting. We suspect that a broader vocabulary of haptic methods might help make this device more accessible to different groups of users.

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