Flex-N-Feel: Emotive Gloves for Physical Touch Over Distance

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Abstract
Many couples live apart due to work or study reasons, experiencing the challenge of maintaining a long-distance relationship. These couples rely heavily on existing communication technologies, which are limited to textual, verbal, and visual mediums. Our approach was to provide couples with a haptic experience of affective touch through vibrotactile sensations. We designed and built a vibrotactile glove called Flex-N-Feel, that allows couples to feel the flex actions of their remote partners' fingers through vibrotactile sensations on their skin. We describe our design and its rationale along with a discussion of the design space.

Author Keywords
Long Distance Relationship; Intimacy; Haptic; Remote Touch; Vibrotactile, Gloves; Tangible, Wearable.

ACM Classification Keywords
H.5.2. Information Interfaces and Presentation: User Interfaces: Haptic I/O;

Introduction
Co-located couples stay connected on a regular basis by relying heavily on communication technologies to share their daily experiences with each other. Yet some couples are separated by distance because of education or work, which makes computer mediated

Figure 1: Flex Glove capturing the flex action of the fingers.

Figure 2: Feel Glove transmitting the flex actions using vibrotactile sensors

communication critical for maintaining their relationship [1,7]. Often at the core of such routines is video communication technologies [7,8]. While beneficial, the challenge is that communication is still limited to textual, verbal or visual mediums. This can lead to an absence of a partner's physical presence and means that long distance partners cannot experience affective touch from one another [11]. Currently, there are no affective means to send a remote touch. This is a problem as touch can strongly affect a couple's feelings of intimacy and connectedness [11].

Previous research has looked into supporting intimacy by designing prototypes, mimicking the intimacy observed in co-located couples. These prototypes provide non-verbal cues, which could be either physiological signals (heartbeats [12], pressure, vibration [2], heat), complete physical gestures (hugging [6], kissing [9], hand-holding [5]) or a combination of both. Most of the prototypes are comprised of physical objects used as communication tools where they are usually confined to an indoor location due to their design. This means it is not possible to easily use the prototype from a variety of locations. To solve these problems, we present a vibrotactile glove called Flex-N-Feel which captures the flex actions of fingers and transmits them to a remote partner as vibrotactile sensations.

Related Work

Traditional communication technologies lack one of the most important tangible aspects of face-to-face communication: the ability to touch. As these tools, cannot fully address the needs of remote partners and support intimacy, there have been many attempts to develop technologies specifically for this purpose.

Prototypes range from interconnected physical objects to digital ones. For example, this has included a pair of interactive picture frames that light up based on remote interaction [4], rings that vibrate based on a partner's heart rate [12], the ability to share a hug over distance via an inflatable vest [6], and gloves to experience holding hands [5]. All of these prototypes represent physiological signals through either explicit acts (e.g., touching or hugging) or implicit ones (e.g., heart rate, sleep patterns).

Tactile technology has been used in several studies, such as vibrating motors which are embedded in mobile and wearable devices [2,6,9]. As real touch has been shown to be capable of conveying the intended emotions, it has been assumed that touch mediated by means of vibrotactile technology would have a similar capability [10]. Most of the previous work has mapped vibrotactile sensations in a very specific manner such that it is accessible to a particular body part. Our approach was not to limit the touch to any specific part of the body; instead, we wanted our design to convey an understanding that touch could be felt anywhere and it was up to couples to decide where and how. For this reason, we provided couples with a large degree of flexibility and mobility to use the prototype.

Prototype Design

Flex-N-Feel is composed of a pair of gloves. Each partner receives one of the gloves. When one person bends their fingers in the Flex glove (Figure 1), they are translated and sent them as vibrotactile sensations to the Feel glove (Figure 2).

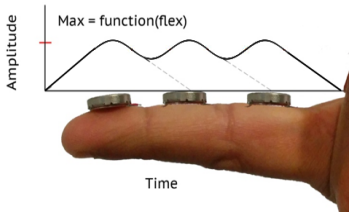

Figure 3: Vibrotactile Waveform

Figure 4: User pressing the soft-switch on one of the gloves.

Flexing Interaction
We felt that the act of bending or flexing one's fingers is a gentle and subtle way to mimic touch. We recognized that touches most often come from fingers and hence, we designed our prototype to capture finger movements. To capture the flex actions (bends) of fingers, we developed DIY flex sensors using Velostat and attached them to a Teensy 3.2 microcontroller as shown in Figure 1. These sensors provided a value for bend in each finger and were transmitted to the Feel glove using a Wi-Fi module.

Vibrotactile Sensations
On the Feel glove, we placed three actuators mapped to each finger on the flex glove; this included a total of 12 actuators as shown in Figure 2. We placed the actuators at the palm side of fingers so that the partner wearing the Feel glove could move it to different parts of his or her body, making the touch accessible to a variety of locations on the body. For example, a person could place the hand with the glove on their shoulder or arm, depending where they want to feel the 'touch.' Couples can adjust the amount of pressure used and the strength of the vibrotactile sensations by placing their hand either gently against their body or with added pressure.

Vibrotactile Pattern
We wanted to design a vibrotactile pattern which simulates a stroking or caressing pattern on one's skin. Research has shown that different tactile sensations can be created by varying the frequency, amplitude, duration and rhythm of vibrotactile sensations [3]. We created this sensation by creating a waveform (as shown in Figure 3) in which the actuators reach their maximum amplitude and then slowly reduce it by transferring the sensation to the next actuator in a linear fashion. The maximum amplitude of the waveform is determined by the value of the flex action of each finger transmitted from the flex glove.

Initiation
We felt that it would be unnatural for partners to initiate a touch at any point in the day without the other partner knowing. Thus, we wanted to embed a subtle way to ask the other person if it is okay to initiate a touch. We designed an initiation mechanism with the use of a soft-switch on both the gloves (Figure 4). With a soft-switch, either partner can initiate the touch by pressing the soft-switch on their glove. Once it is pressed, a small green LED starts blinking on both the gloves. When the other partner notices the blinking LED on his or her glove, they can choose to respond to the request by pressing the soft-switch on their own glove. This causes the LED to turn on indefinitely, which indicates that the remote touch as been initiated. Partners can now send remote touches.

Discussion

Flex-N-Feel was designed with *mobility* in mind so that couples could stay connected throughout their day; it is *flexible* such that couples can appropriate it in a way that makes sense for their relationship; and, it offers *subtle* and *private* interactions so that touches can be discreet, if desired. Certainly, not all acts of touch are possible with the gloves. For example, it would be very difficult to give a full back massage to a remote partner given the reach of one's hands. Instead, the design is flexible within reason where a person could perform a large range of touch actions for their partner, rather than all types of touch. While we intended the gloves to support private interactions, it is possible that the

gloves may be easily noticed in certain settings (e.g., at a workplace when gloves are not normally worn). Thus, even though the vibrations may be unnoticed by others, the gloves might be noticeable which may affect usage and restrict what people do.

We also realize our prototype is currently designed in an asymmetric fashion where one partner sends a touch to a remote partner, and not vice versa. That said, one could imagine having a second pair of gloves such that partners wear both a Flex and Feel glove, one on each hand. This would allow both partners to share touches at the same time. Overall, our research shows that it is possible to simulate touch over distance and that touch can be used as an important communication medium over distance.

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