TapTap: A Haptic Wearable for Asynchronous Distributed Touch Therapy

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Abstract
TapTap is a wearable haptic system that allows nurturing human touch to be recorded, broadcast and played back for emotional therapy. Haptic input/output modules in a convenient modular scarf provide affectionate touch that can be personalized. We present a working prototype informed by a pilot study.

Keywords
Haptic, Wearable, Touch Therapy, Fashion Design.

ACM Classification Keywords
H5.2. User Interfaces: Haptic I/O.

Introduction
Human touch is fundamental to physical and emotional development. Artificial devices can simulate human contact and bring about some of the health benefits of affectionate touch. A number of these so-called haptic systems simulate the sensation of touching remote or virtual objects or persons. Haptics have been used to convey touch synchronously and one-to-one for direct manipulation of virtual objects and communication with distant persons. What if touch could be distributed over space and time, recorded and broadcast like streaming

data? Understaffed hospitals, physical therapists, absent parents or lovers could provide therapeutic touch at a distance, repeatably and to more than one person.

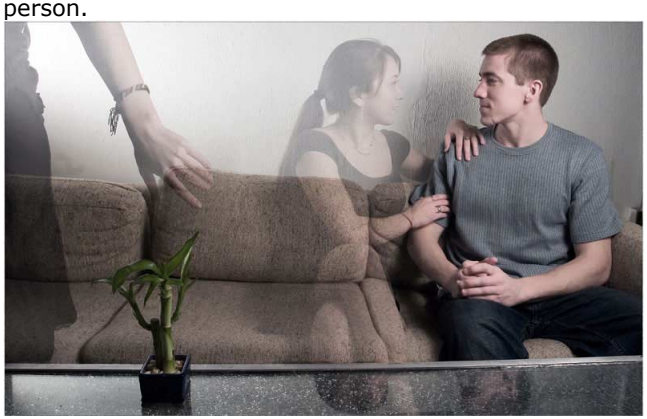

figure 1. *TapTap* can record and play back the touch of a lover, a family member, a therapist or a doctor.

TapTap is a wearable haptic system that allows asynchronous distributed transmission of tactile information to convey affection and nurture for use in emotional therapy. It is envisioned as a comfortable personalized garment that a mother can leave with her child or a therapist with her patient to provide some element of nurture and affection. This paper presents a summary of prior research, a discussion of the concept design and initial pilot study, a presentation of the current prototype and user study results, and a conclusion with directions for future work.

Related Work

Simulating human touch has a long history of being used to engender emotion, in part because even an abstract representation of touch can convey presence. Psychologist Harry Harlow demonstrated that maternal touch was critical to the development of infant rhesus monkeys and that those who could see but not touch their mothers developed erratic behaviors [3]. His research also suggests that some artificial materials can be more effective at simulating maternal touch than others, for example when the infant monkeys had more affectionate responses to a surrogate mother made from soft cloth than to one made from hard steel wire [6]. Modern studies of human infants reveal that the absence of affectionate touch can cause social problems and even lead to premature death [4]. Thousands of orphans in communist Romania were raised in overcrowded facilities where the absence of comforting touch led to the development of serious social and emotional problems [3].

Several machine interfaces have been developed to simulate touch, for example to use in training surgeons and pilots, for sculpting digital models and even in video game controllers [7]. Few of these devices take advantage of the emotionally and physically therapeutic benefits of human touch. *InTouch* is a tangible interface consisting of three wooden rollers that can be manipulated contemporaneously in two locations, demonstrating that a sense of human presence can be established through the communication of haptic motion [2]. Touch interfaces can be distributed over the rest of the skin, leaving hands free to perform more intense tasks. One such wearable haptic device has been developed to assist people with balance problems: it consists of a vest worn on the torso that sends vibrations to indicate which way the user is leaning [9]. Haptic interfaces generally only provide feedback in real time and to one person. *Curlybot*, a roving toy that can re-play the path it is taken through, demonstrates that

digital "record" and "playback" functionality can be embodied in physical form [5]. *Body Mnemonics* is an interface design concept for portable devices that uses the body space of the user as an interface [1]. A number of wearable computing platforms have been proposed that incorporate computer sensing and actuation. *TapTap* is a wearable haptic interface that can record and play back patterns of tactile information so that people can experience the emotional and physical benefits of human touch in different times and places.

Design

TapTap is a platform for recording and playing back simulations of human touch. The iterative design process considers three main areas: actuation, sensing and overall form. Two generations of working prototypes have been produced and evaluated.

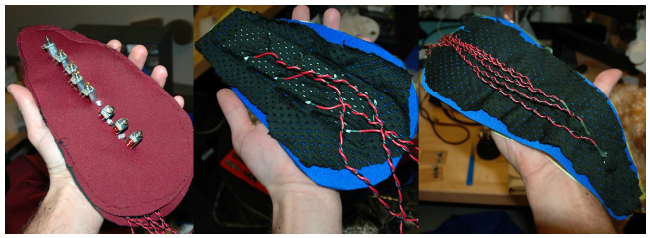

figure 2. The actuators for the first prototype were sewn into different types of cloth pads depending on their touch modes: solenoids in thick neoprene (left) , Peltier junctions (middle) and vibrating motors (right) in thinner neoprene with a layer of thin elastic mesh.

First Prototype and Evaluation

TapTap seeks to reproduce the most common kinds of human touch: tap, press, stroke and contact. The pilot study explored whether commonly available actuators could create sensations that recall human touch. Four kinds of actuators were tested on a common platform: vibrating motors, solenoids, air bladders and Peltier junctions (see Figure 2). The platform is an adjustable neoprene brace that secures one of the actuators at a time over a subject's shoulder blade, an area where we are often touched and where tactile acuity is low (See Figure 3). The vibrating motors and solenoids were each mounted in groups of eight and activated in sequence, intended to feel like a stroke. The vibrating motors were calibrated to move very slightly so as to feel more gentle than the vibration ring of cell phones. The solenoids were actuated in rapid sequence over a short distance to simulate a stroke from a continuous series of short pokes. The air bladder is filled by an air pump to simulate pressure, while the four Peltier junctions are activated in sequence to simulate the heat of contact.

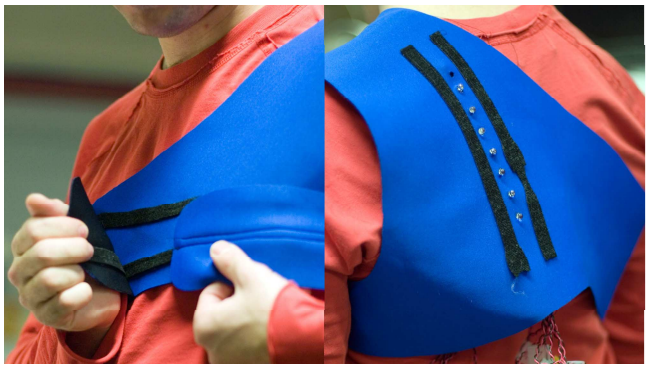

figure 3. The first actuators were held on to the body with a neoprene brace that ultimately proved too constraining and reminded one user of physical therapy.

To evaluate the first prototype, we mounted one of the actuators on the brace at a time and asked a series of questions intended to discover which actuators were better at simulating pleasant human touch. With each of the actuators, subjects were asked if the sensation reminds them of someone they know from a family gathering, from a friend's party or from an embrace before a goodbye. Four men and four women were tested using the vibrating motors and the solenoids. The air bladder and Peltier junctions were abandoned before the study, the first because of the bulkiness of the compressor and the second because of mechanical failure.

The pilot study of the first prototype revealed interesting lessons that were applied to the design of the second. First, men and women had distinctly different reactions to the two types of actuation: women preferred the gentle vibrating motors and disliked the more violent solenoids, whereas men had the opposite reaction. To both, the vibrating motors were subtle, sensual and soft. The solenoids were interpreted as a tap, a bump or the touch of a stranger. The exact location and sequence of actuators were also important: they often had to be moved to the right place and angle on the shoulder to feel pleasant. The repetitive sequence pre-programmed into the actuators were too machine-like, and universally the solenoids were considered more like machines than the vibrators. Nearly every touch, however, reminded subjects of someone they know, be it a slap on the back from an over-eager uncle or the soft touch you feel when someone is reading over your shoulder.

Second Prototype

The second prototype considers the lessons of the first pilot study to provide more touch-like actuator designs and a more personalizable platform in addition to basic record and playback. New configurations of vibrating motors and solenoids were developed to feel more like human touch. In addition to the linear arrangement, the vibrating motors are arranged concentrically and activate from the center out and back to simulate pressing. Two new solenoid configurations were tested: a large single solenoid that acts to expand and contract inside a cloth pocket, and a circular array of small solenoids at an oblique angle meant to feel like fingers tapping. Recording is achieved through momentary switches attached to large plastic contact pads.

figure 4. In the most recent prototype, the flexible i/o haptic insert tucks into the felt scarf (left) and connects to central power through conductive steel snaps (right).

Two main problems of the brace design were that it was difficult to adjust the position of the actuators and that it was perceived as constraining overall. For the subsequent prototype, we adopted a personalizable

design that could serve as an everyday garment or else be outfitted with the right actuation and activated only when desired. The second prototype is a felt scarf with pockets into which actuators or a wallet and keys can be placed (see Figure 4). This design allows different actuators to be placed in different pockets, and for the system to work only when the scarf is held against the body. This way, the touch will appear more pleasant and less invasive. Six different actuation circuits mounted on flexible plastic sheets can be inserted into any of six pockets on a scarf, where they connect to conductive snaps that provide power. Not only can someone choose which actuation to use where, but the entire scarf can be worn in a variety of styles for men, women, and children and fastened on parts of the body that are receptive. The entire scarf can be emptied of electronics and worn as a regular scarf or washed. The first prototype is made from two layers of felt: one gray, impersonal, to be worn on the exterior while the other is a warm pink with pockets where touch is recorded and played back for private enjoyment (see Figure 5).

figure 5. The current prototype is a scarf with large pockets with a power supply. The design of the scarf is intended to make it wearable in a number of ways and allow specific TapTap actuators to be mounted wherever the wearer desires. The outside of the scarf is a public color (gray) while the inside and its intimate actuators are a warm color (pink).

Discussion and Conclusion

TapTap is a work-in-progress to develop a system of wearable sensors and actuators that can remember and play back various types of nurturing human contact. The current prototype succeeds in recording and playing back certain kinds of touch in a manner that can be controlled and customized by each wearer. The reconfigurable nature of the scarf and the fact that people have to wrap it around themselves to feel the simulated touch mean that the system is never surprising, constraining or invasive. In addition, the extra pockets and central power distribution inside the scarf make it ideal for carrying and charging personal electronics like mp3 players and cameras. The flexible plastic backing used to hold the input/ouput arrays are strong yet flexible, and would ultimately be replaced by flexible printed circuit boards. However the current prototype relies on an external power source for driving the solenoids and heat pumps; a truly wearable version would be limited to the low-power vibrating coin motors as actuators. More sophisticated sensing will be necessary to record touch more precisely: we are considering quantum tunneling composites, force-sensing resistors and capacitive sensing for this purpose [8]. Further user studies and refinements to patterns and the haptic actuation will be necessary so that users can carefully tune the touch to their preference. This paper presents the first steps towards making human contact available in ways that it never before was, to be recorded, broadcast, played and re-played so that we never have to be without the comfort and nurture of physical affection.

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References

[1] Angesleva, J., Oakley, I., Hughes, S. and O'Modhrain, S. 2003. *Body Mnemonics: Portable device interaction design concept*. Proceedings of UIST'03 , Canada.

[2] Brave, S. and Dahley, A. 1997. *inTouch: A Medium for Haptic Interpersonal Communication*. In Proc. CHI'97.

[3] Carlson, Mary. 1998. *Understanding the 'Mother's Touch*,' The Harvard Mahoney Neuroscience Institute Letter on the Brain, Vol. 7 No.1.

[4] Field, T. 2002. *Infants' Need for Touch*. Human Development; 45:100-103

[5] Frei, F., Su, V., and Ishii, H.2000. *Curlybot*. in Proc. CHI'00.

[6] Harlow, H. F. 1958 *The Nature of Love*. http://psychclassics.yorku.ca/Harlow/love.htm

[7] http://www.sensable.com/

[8] Stiehl, W.D., Lieberman, J., Breazeal, C., Basel, L., Lalla, L., and Wolf, M. 2005. *Design of a Therapeutic Robotic Companion for Relational, Affective Touch*. IEEE International Workshop on Robots and Human Interactive Communication.

[9] Wall, C. III and Weinberg, M.S. 2003. *Balance prostheses for postural control*, IEEE Engineering in Medicine and Biology Magazine.