Expressing Human State via Parameterized Haptic Feedback for Mobile Remote Implicit Communication

Jeffrey R. Blum and Jeremy R. Cooperstock
McGill University, Shared Reality Lab
Centre for Interdisciplinary Research in Music Media & Technology (CIRMMT)
[jeffbl,jer]@cim.mcgill.ca

ABSTRACT

As part of a mobile remote implicit communication system, we use vibrotactile patterns to convey background information between two people on an ongoing basis. Unlike systems that use memorized tactons (haptic icons), we focus on methods for translating parameters of a user's state (e.g., activity level, distance, physiological state) into dynamically created patterns that summarize the state over a brief time interval. We describe the vibration pattern used in our current user study to summarize a partner's activity, as well as preliminary findings. Further, we propose additional possibilities for enriching the information content.

Keywords

Haptic communication; implicit communication; haptic patterns; tactons; vibrotactile patterns

Categories and Subject Descriptors

H.5.2 [**User Interfaces**]: [Haptic I/O]

1. INTRODUCTION

Although most commonly used for smartphone vibration notifications, haptic feedback can also be used for communicating information directly between two people. This was most recently popularized by the Apple Watch, which allows one to share their heartbeat with a remote partner, who feels it as a physical tapping on their wrist. Projects such as CoupleVIBE instead focus on implicit communication between two people at a distance, in this case using haptic icons, or tactons [2], to represent a partner arriving at or departing from pre-chosen locations [1]. Whereas CoupleVIBE uses static haptic icons (combined with an "arrival" or "departure" cue) mapped by the user to specific locations, the feelabuzz project instead continuously varies the stimulus felt by the remote partner, by vibrating their phone more when their partner's motion increases, providing ongoing feedback about a partner's activity level [3].

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Figure 1: Pebble smartwatch attached to ankle with strap.

We propose haptic feedback between these two extremes, specifically for remote implicit communication: more dynamic than CoupleVIBE, but still partially summarized and thus not as continuous as feelabuzz. Our aim is to avoid the need for specifying and memorizing specific cues, and to provide a rich and meaningful cue without constant vibration, which has device power and user fatigue implications. In particular, we are interested in how such icons can be varied as a function of a person's state, first just their activity level, but eventually including additional parameters.

2. SYSTEM

Our system uses an ankle-worn Pebble smartwatch (Fig. 1) that vibrates with a pattern summarizing a remote partner's leg motion every 12 seconds. The ankle was chosen instead of a location such as the wrist due to its unobtrusiveness and more regular motion. We are currently running a study with couples in a relationship for at least six months and apart for at least 35 hours each week, to evaluate whether a bidirectional, ongoing sense of a partner's motion becomes a background sense that changes their behaviour. Two couples, both co-habitating, have completed a four-week experiment, with three weeks spent wearing the system, and one week without. They were interviewed each week and filled out periodic questionnaires about their experience. In this study, the haptic feedback consists of three pulses, with the duration of each representing the amount of motion in a single axis. In normal walking, for example, there is less side-to-side motion than front-to-back, so the first pulse representing the side-to-side motion is the shortest (Figure 2). This pattern thus attempts to convey not only the quantity of motion by vibrating longer when there is more activity, but also some of the character of the motion. To address uncertainty as to whether a lack of feedback was indicative of a system error or loss of connection vs. a partner simply being motionless, there is a baseline 40 ms duration for each pulse. Thus, each partner feels a (non-literal) "heart-

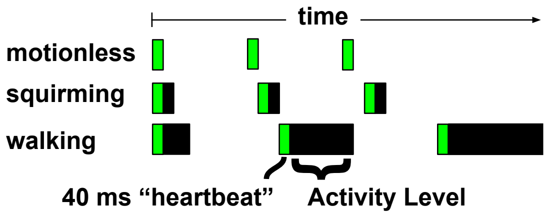

Figure 2: Example haptic patterns with "heartbeat" vibration duration in green; activity level duration in black.

beat" set of three pulses just letting them know they are successfully connected, which then increase in duration as their partner is more active (Figure 2).

3. INITIAL USER FEEDBACK

In our user study, when the haptic feedback including the "heartbeat" completely disappeared, one participant could tell that their partner had entered the subway system, and was thus on her way to a particular location since he knew where she was planning to go that day. Likewise, the same participant was reassured when his partner's signal re-appeared, indicating she was close to arriving at her destination. Even without any activity level information, simply knowing when a partner is connected to the Internet thus provides useful information about their state. Of course, if the couple is connected continuously, without dropouts due to connectivity issues, then the changes in the activity level pulses on top of the "heartbeat" can instead provide contextual clues. As another participant states:

> "I noticed that essentially all the communication we have as a couple is 'I'm leaving now' or 'I'll be there at 10'. Just basic confirmation of our physical movements when we're apart. Wearing the watch has basically eliminated the need to communicate via text between us in that regard. We know when each other is leaving for work because we can feel it. The physical element makes it feel much more natural."

This suggests that the primary value of the system is not in being able to classify a single set of pulses into a specific activity, but rather that it helps to identify activity transitions, especially those that a partner may be expecting due to other knowledge of their partner's typical activities and schedule. We further hypothesize that *not* feeling an expected transition will also provide valuable information, e.g., if we are supposed to meet, but I feel you are motionless, I expect you will be late since you are not on your way.

A vibration every 12 s could be distracting or annoying. However, preliminary feedback indicates that after the first few days, the signal does indeed fade into the background.

4. PROPOSED EXTENSIONS

The above feedback indicates value in perceiving connection and overall activity levels, but not necessarily from the three separate axes of motion. It remains to be seen if the three axis activity information is useful to other couples. Either way, we are motivated to explore changing or extending the information conveyed by the system to more reliably disambiguate state transitions in a wider variety of situations. One option is to map additional information onto more complicated haptic patterns. The challenge is that we wish to provide an ongoing background signal to the user's brain for interpretation. Because of this constraint, we believe it is important to design a system that does not require memorization of discrete patterns, but instead provides parameterized haptic patterns that vary in consistent, straightforward, and therefore predictable ways. Our existing feedback meets this requirement since it is a "more is more" mapping, i.e., the more motion in an axis, the longer (more) the corresponding vibrations last.

We envision multiple possible extensions to the existing haptic feedback. For example, the meaning of an increased activity cue may be relatively obvious since it matches an expectation about when a partner leaves for work. In this case, one can infer the starting location and where the person is heading. However, if the partner instead unexpectedly walks in the opposite direction to do an errand, it does not change the existing haptic feedback. We could retain the durations of the pulses representing activity level, and instead modify the gap between the pulses (currently fixed at 300 ms), to express the distance between the two people, based on the phone's GPS location. Feeling the activity level pulses actuating with smaller and smaller gaps between them could indicate a partner getting closer.

In addition to gap length, we can also alter the vibration intensity, even on a commercial device such as the Pebble, via a pulse width modulation (PWM) implementation that runs the vibration motor in short pulses which reduce its perceived overall intensity. Using this or other mechanisms, and possibly replacing the existing three-axis activity technique, additional user parameters that could potentially be mapped onto more complicated haptic patterns include:

- Orientation relative to north, potentially helping to disambiguate situations such as a partner sitting at their desk (always facing the same direction), vs. in a conference room (facing a different direction).
- Breathing or heart rate, perhaps a better indication of stress or strenuous physical activity, e.g., weightlifting, which may not be evident from the motion pulses.
- Ambient audio levels, perhaps disambiguating whether they are at the library or office vs. a restaurant, or are likely engaged in conversation.

5. ACKNOWLEDGEMENTS

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