VibroSquare: Vibro-Tactile Display for Body-Centric Implicit Interactions

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Abstract. Importance of touch cannot be underestimated. Touch is the first sense that a human develops already in a womb and the last sense that one loses with age. Touch can serve as a powerful modality for developing novel human-computer interfaces. We present *VibroSquare* - our first vibro-tactile display we designed to enable first set of experiments to test our research assumptions. During the experiments we will explore how vibro-tactile feedback can be communicated on an unconscious (implicit) level of perception. The objective of the demonstration is to offer first hand experience of the interaction with *VibroSquare* and create conversations around designing technologies for supporting body-centric interactions using mediated touch.

Keywords: peripheral interaction · vibro-tactile · body-centric.

1 Introduction

The importance of touch for humans has been demonstrated in numerous studies. Sense of comfort and attachment through touch has been shown in humans. Other studies revealed that touch affects generosity level and increases oxytocin level - the hormone of happiness [4]. Knowing all the evident advantages of touch, why cannot we use haptic technology to mediate touch to make life of people more enriched and comfortable? A lot of research in HCI concerns the mediated-touch technology and understanding how various vibro-tactile stimuli may affect the perception [2]. We already know that specific combinations of parameters (frequency, intensity, location on a body) may simulate variety of touch types and are associated with qualitatively distinct affective states. Most of these studies work in the plane of conscious or explicit perception.[7, 5, 3]. Very few however touch upon the implicit or unconscious [6, 1]. *VibroSquare* is our first attempt to investigate how a vibro-tactle display can be designed to communicate information unconsciously.

2 Application Scenarios

Unconscious perception, evoked by tactile stimulation, opens numerous opportunities for novel application scenarios in the contexts of remote communication, well-being, healthcare and many more.

We focus our research in the context of remote communication. We aim at recreating a sense of presence through mediated touch. Imagine a situation where a husband and a wife are remotely located from each other. The husband expresses his care by sending a caressing to his wife that she would feel on her skin via a wearable vibro-tactile display. Meanwhile, the wife who is fully engaged with her office tasks, perceives the virtual caressing. Since the stimuli is communicated on a periphery of her attention, she is not distracted from her main activity.

Thus, we are interested in recreating mediated touch for social support or simple notification but on an implicit (unconscious) level. In other words we aim at extending the ideas of 'calm technology' expressed by Weiser [8].

3 Design Rationale

By means of *VibroSquare* (Figure 1), we plan to not only simulate various types of touch and test various interaction scenarios but most importantly investigate when and how the stimuli parameters can be perceived unconsciously. The prototype is designed in a shape of a patch that can be attached to almost any location on a human body. The ability to program each actuator independently and place it in various body locations will provide greater flexibility for the experiments.

A well established classical apparatus of psychophysics [4] will constrain the vibration parameters and the intensity of the stimuli that will be programmed into the prototype. Humans can consciously detect the vibration from about 1 Hz to 1,000 Hz but they are not equally sensitive to frequencies over the whole range which is determined by the type of the mechanoreceptors. The vibrations below 15 Hz can often be not detected. We also know that slow stroking and low intensity touch is more pleasant than otherwise. The vibration at about 50 Hz are providing comfortable sensation, where the vibrations above 137 Hz create uncomfortable sensations on the skin [4, 6, 3]. This, and other aspects about human body are fundamental for configuring *VibroSquare*.

As the prototype is meant to be worn on a body, the materials chosen for constructing the display, were carefully selected. The goal was to choose the materials that would be perceived by skin in a most non-obtrusive, natural way. The coin-cell mini vibration motors are known for their ability to produce irritating sensation, so the materials had to serve as absorbents of the excessive stimulation. We tested several types of materials and selected the most appropriate one (highlighted in Figure 1).

The dimension of the vibro-tactile matrix is 7 cm wide by 11 cm height, forming a matrix of 24 coin cell vibration actuators (4 by 6) with inter-actuator spacing of 1 cm. Such distribution of the actuators was constrained by the spatial resolution mapping of cutaneous (tactile) receptors. Spatial resolution determines the sensitivity of the skin in various body parts and the ability to sense two closely related objects on the skin as two distinct stimuli. The discrimination ability is within 2.5 mm to 55 mm range [6]. This means that the prototype

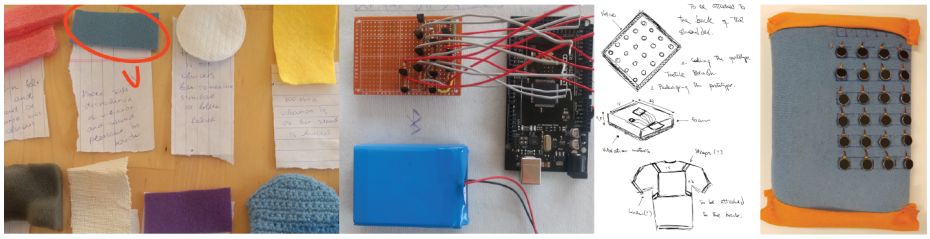


Fig. 1. Design process of *VibroSquare*: the selection of the face fabric, layout of the main hardware parts, prototype sketches, the latest version of the prototype (still in progress).

can be suitable for almost all body parts, except palmar surface of fingers and toes. Since we plan to work in the context of remote communication to simulate pleasant touch we will use an existing algorithm,Tactile Brush [3]. We chose this algorithm because it provides an optimum stimulus onset asynchrony (SOA) producing an illusion of a smooth tactile motion. Such illusion is essential for realistic perception of a pleasant touch.

4 Future Work and Limitations

Current prototype is limited by the current 'off the shelf' technology. It is bulky and the vibration motors are working in a very limited range of frequencies which makes it impossible to work with high (>200) and low frequencies (<80). In future we plan to develop a set of more comprehensive prototypes, integrated (or attached onto) into clothing seamlessly. For that we will need to build custom flexible PCBs to ensure the seamless integration. We will also use more powerful vibration motors that are cable of working in a wider range of frequencies.

5 Engaging with *VibroSquare*

VibroSquare will serve as a testbed for exploring how configured parameters of the prototype may affect the perception of the stimuli. Specifically, during the interaction a participant will experience several versions of pleasant touch. Each version will have a different frequency or intensity configuration or combination of both. The participants will be offered to wear a prototype on various parts of the body, adding another dimension to the interaction. So, we will be exploring three main parameters: frequency, intensity and location.

The infrastructure of interaction will consist of an input device and an output device. The input device will represent a tangible interface with several built-in pressure sensors corresponding to a specific predefined configuration of vibro-tactile parameters (frequency and intensity), resulting in a specific output (touch type). The output device is *VibroSquare*. Connection between the devices will be enabled through Bluetooth low energy protocol (MQTT).

At the conference, the visitors will be able to try *VibroSqure* in pairs or solo. We plan to gather feedback from the participants about their perception while wearing the prototype. We anticipate that partcipants will get the following insights by interacting with *VibroSquare*:

- Getting an awareness about the importance of psychophysics in designing technology for mediated touch;
- Getting an awareness about the key parameters that affect perception of tactile stimuli on a continuum of conscious and unconscious processing;
- The interaction with *VibroSquare* may spark curiosity in the topic, produce discussion and potentially result in future research cooperations.

To conclude, we presented design rationale of *VibroSquare*, with hope to probe our research ideas and gather valuable feedback during the demonstration.

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Technical Details to Run the Demo

1. The connection between input and output devices will be enabled by the central processing unit (CPU), Raspberry Pi, through Bluetooth low energy protocol (MQTT). The CPU gathers information from the input device and subscribes it to the output device by adapting publish-subscribe pattern.
2. Each device is powered by Lithium polymer battery. The input device needs a 5 V, 2500 mAh and the output device - a 3.7 V, 6000 mAh. The central processing unit requires a mobile battery bank to ensure it operates correctly. All will be supplied by our research team.
3. At the venue we will need a separate table and access to the electricity nearby in order to place laptop, prototype and be able to charge the devices.