Wearable Haptic Gaming Using Vibrotactile Arrays

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Abstract

In this paper we describe the design process of expanding vibrotactile displays from single channels devices to multichannel vibrotactile displays. The purpose for this exploration is to add simple, interactive visual and vibro-tactile patterning with button arrays to wearable gaming devices intended for young children. In order to facilitate movement we have created numerous prototypes to examine the affordances and limitations of a circular pattern of tactors.

**Key words:** haptic gaming, vibrotactile arrays, wearable devices, multi-sensory

H.5.2Information interfaces and presentation (e.g., HCI)User Interfaces.

Wearable Gaming, Vibrotactile display, Wrist

## 1 Introduction

Vibrotactile displays allow for a variety of information communication scenarios, most compelling for use are those where the user can receive information without having to look at the signifying device [10, 8]. Gaming provides a venue for tactile feedback, often used to enhance immersion into the experience. This project explores whether it is possible to create wearable gaming experiences that involve visual and vibrotactile spatial and temporal patterns. While there are many examples of projects that do this they are almost certainly tethered to on screen experiences. This project uses an wearable device that is able to offer play experiences to the wearer without being tethered to another device.

Our approach is to explore the simplest of patterns and study their affordances. The patterns are presented to the user both visually and through tactile stimulus. As the games progress the pattern is presented only through tactile stimulus. The goal is to determine the spatial and temporal resolution of the wrist for tactile stimulus.

Our demo experiences focus on an attempt to make the interactions very simple, such that they convey information in a way that presents few cognitive demands on the user and which the user would tend to find enjoyable and engaging, even if they were not participating in a mobile game.

## 2 Related Work

Wrist-worn actuators serve many functions including: assessment of cognitive performance in the elderly [6], notification during gaming [9], discrete patterns for alerts for the on-the-go users [7, 2]. A wrist-worn haptic device for swimmers is described in [5] and an assistive technology wayfinding project is described in [3].

HandJive is a handheld device used for communication and play between people [4]. Researchers found that participants were able to successfully replicate purely haptic patterns at increasing levels of difficulty in a gameplay situation, and enjoyed improvising their own patterns. These findings suggest that haptic feedback can be incorporated as an enjoyable and meaningful way of conveying game information.

Wrist wearables must fit on wrists and must not have excessive tactor density. Matscheko notes that physiognomic studies innate that average U.S. male wrists circumferences are 18.38cm and 14.8cm for women. A minimum threshold distance, that is, the minimum distance that people are able to discriminate between actuators on the wrist or forearm is 38mm [10]. This gives a fairly constrained amount of wrist ’real estate’ available if the purpose is to transmit discrete symbolic messages using the actuators.

Various types of tactor wrist arrays can be found in the literature: a 3x3 array [2], a 3 tactor circular array [7] and a 4x1 wrist-encircling array [10].

Lee and Starner describe patterning for wrist-worn tactile displays [7]. They note that for these patterns, intensity is the most difficult parameter to distinguish and that the temporal parameter is the easiest. Reaction time to perceive tactile alerts was not deteriorated by visual distraction.

Bronner notes that a sense of touch is basic to human processes of testing, expressing reality and meaning. Often people must both see with their own eyes as well as touch with their own hands to believe in a phenomenon[1]. He also notes that people surround themselves with particular, touchable objects to reinforce their own feelings and identities.

Chen at al. examine where to place actuators on the wrist. They reason that if a mobile device is to be worn like a watch, then factors can be placed on both sides of the wrist (that is, both the dorsal and volar sides) [2].

In our research we have built prototypes that build on previous research to explore the ways that very simple tactile and visual signals can provoke rich play. Our prototypes explore the use of the whole wrist, including the sides, as a site of vibrotactile information display.

## 3 Prototypes

### 3.1 Simon Says Wristband

This is a wearable version of the traditional *Simon Says* game mounted onto a flexible velcro and felt wristband (see Figure 1). The game is controlled by four push buttons each with a corresponding LED light. The LEDs flash in a random pattern and a single vibration motor signals the beginning of a new game. To play the game the wearer repeats the pattern as flashed by the LEDs by pressing the buttons directly adjacent to each LED.

### 3.2 Rubber vibration band version 1

This wrist band with a thick rubber band has vibrating motors and LED lights (see Figure 2). Vibrating motors and lights are arranged linearly with motors alternating with lights. It connects to and is controlled by an Arduino Mega microcontroller board. The prototype device is thick and unfortunately can’t be worn (some components come out the back of the device). The device has no input buttons or other input devices.

### 3.3 Rubber vibration band version 2

This band is similar to the first band but instead of a linear pattern, there is 3x8 array of buttons, lights, and vibrating motors (see Figure 3). Each row of this array has one button, one light and one vibrator that are all independent, allowing for the creation of interactive buttons games like *Simon Says*. The 3x8 matrix starts to afford more possibilities for user interaction. Modal play becomes possible since many types of user notifications are possible with such an array.

### 3.4 Wearable Vibrotactile Game Interface

The final interface (see Figure 4) utilizes the learnings in the rubber band prototypes, combining visual and tactile feedback, with a form factor that is able to be comfortably worn, like our first prototype. Additionally, the buttons on the final interface are soft buttons that are activated by pressing on the tactors.

### 3.5 Informal User Study

## 4 Future Work

The resolution of the haptic channel on the wrist in both the spatial and temporal dimensions are not fully studied. The next prototypes will include different sizes of vibrotactile arrays so that we may figure out how many motors are required to maximize the information reception through the tactile channel in the wrist. Specifically, are going to build and test devices that include 6, 4, 2, and 1 vibrating motors.

In addition to gaming applications, the devices will be used for encoding more critical information and testing the effectiveness of non-gaming contexts with vibrotactile arrays. We are currently developing a method of authoring the vibration sequences so that they may be more effectively created, stored, processed, and shared.

## 5 Conclusion

Vibrotactile arrays combine with simple visual patterns present new possibilities for information display to users through their body. We have demonstrated the use of a wearable multichannel vibrotactile and visual display intended for gaming in order to explore the uses and affordances in a non-critical usage scenario.

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