2. CreaTs – A New Way Of Creating Tactile Patterns

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Abstract
CreaTs is an interface that provides a new, easy-to-use, efficient solution for creating tactile patterns. It offers researchers a working environment to easily create, edit and experience complex tactile patterns without needing to interact with coding concerns. Our literature research in the field of tactile feedback revealed a gap in terms of creation tools for tactile patterns. As creating tactile patterns in general is an abstract, non-visual task, changing the development environment and bridging the gap by implementing a graphical user interface will contribute with a valuable spatial and temporal understanding of tactor activations. The whole system is created to be extendable and modifiable to reach a broad range of usage and functionality. We designed and implemented an electronic circuit to test the functionality of the CreaTs interface. A first usability test, conducted with experienced participants, confirmed that the interface is easy enough to use.

Author Keywords
Tactile patterns, interface, tactile displays.

ACM Classification Keywords
H.5.2 Haptic I/O, Graphical User Interface, Interaction styles, Prototyping, Input devices and strategies.

Introduction

Haptic interaction and interfaces are a relatively new area of research when compared with the areas of vision and audition, although the interest and amount of research has especially been growing particularly the last decade.

As tactile interfaces are still in an early stage of adaptation they are mostly used for innovative and research based projects. Commonly used haptic displays provide relatively simple tactile feedback, such as vibrational signals from mobile phones, although research has shown that tactile feedback holds promising potential for supporting communication [1]. Providing information through an underutilised sense, like the sense of touch, can improve the cognitive processing of information, by reducing cognitive overload [2]. Seeing the potential of tactile feedback, especially in high-cognitive-load environments, we find it necessary to investigate how to convey complex information to the user through tactile feedback. Tactile patterns and sensations have already proven their ability to communicate even complex messages to users [10,13], but designing, creating and editing high-fidelity tactile messages is a potentially complex and time consuming task.

In this paper we describe the rationale, development and testing of an interface that provides an easy, efficient and precise working environment for creating tactile patterns. The extendable nature of the interface takes into consideration the variety of technical equipment used in the creation of tactile feedback. To test the functionality of the interface, we designed and implemented an electronic circuit as an example of a possible arrangement.

Related Background and theory

The skin accounts for roughly 18% of the human body mass [3] and therefore offers great potential for receiving a vast amount of information through the human sense of touch. In current interfaces this potential is greatly underutilised and should therefore be considered and researched as a communication medium [4]. Even simple tactile feedback offers a great potential for providing warning signals, despite of cognitive load from other senses [3, 5, 6]. The core parameters to convey tactile messages are identified as frequency, amplitude, location and duration [1, 4]. Using all these parameters enables systems and users to transfer complex information through tactile feedback.

In creating and testing tactile patterns, Jones et al [7] investigate if tactile patterns can be used to navigate people through a grid of cones guided only by tactile feedback. Further research investigates if tactile patterns can convey distance information [8] or if tactile displays can deliver attention and direction-related information [9, 10, 11, 12]. Researchers working with tactile patterns regularly use custom tailored software for sending predefined tactile patterns or messages [7, 10, 13].

Current research in the field of tactile feedback revealed a gap in terms of creation tools for tactile patterns. To bridge the gap, we aim to improve the process by creating an interface providing immediate visual and haptic feedback. As creating tactile patterns in general is an abstract, non-visual task, changing the development environment by implementing a graphical user interface will contribute with a valuable spatial and temporal understanding of tactor activations. A literature review providing further details can be seen in the portfolio, section 3.1.

The System

Description

We implemented a java program with the following concept design: The CreaTs system comprises three basic packages model, GUI and I/O. The model package contains the whole logic behind the program. It is responsible for the configuration, the management of tactors, timelines and activations as well as the property settings. The GUI package contains all the graphical components and links to the model to update it. The I/O package holds the responsibility for saving, loading and exporting. For further details on the implementation see the portfolio, section 3.3.

Setup

The general aim of CreaTs was to give users the opportunity to easily create, edit and feel tactile patterns without needing to concern themselves with coding details. The setup used for the project consists of a 3x3 array of vibration motors from Precision Microdrive [14], equally spaced in a layer of cold foam added to the backrest of a chair, an external power supply of 9 Volt batteries and an Arduino Mega 2560 board [15], which supplies and controls power to the vibration motors. The tactors are controlled through the use of PWM pins on the board, which again is connected to a computer via USB. For further details on the setup and electronic circuit, see the portfolio, section 3.2.

Design rationale

In order to create a useful tactile pattern, an interface needs to satisfy a set of functionalities to provide an easy-to-use efficient and precise working environment. Basic functions should cover a simple-enough, but still essential configuration of the electronic setup. Further, the system needs a straightforward yet flexible way to configure the physical setup in order to provide visual feedback.

Based on the important parameters of tactile patterns, time, amplitude and frequency, the interface has to provide access to adjust these properties. As the temporal property is crucial for the creation of tactile patterns, we focused on this point in the design of the interface. Working with timed properties the interface needs to provide playback functionality with a real-time precision, to experience and evaluate the designed patterns. To realise this, the interface builds on the configuration of the electronic setup to send information directly to a microcontroller board, as well as exporting the patterns to the chipsets native language. Further, to edit work in progress the interface saves and loads in the interface's format.

Design considerations

Previous research in the field of tactile feedback stated the demands and needs for a tool to easily create tactile patterns. Coding of tactile patterns calls for having a lot of numbers, start times and end times in ones mind, which makes changes at the same time very demanding. Before implementing the interface we made some design considerations and decisions.

To simplify the initial electronic setup we chose the Arduino Mega 2560 board, as it provides easy access to several PWM output pins. Further, we chose the Arduino platform, as the Java Firmata Client Library [16], which permits controlling an Arduino board through the Firmata Protocol [17], enables programs to send real-time messages directly to the Arduino board in Java programs. To access a large range in terms of amplitude the Pico Vibe 9mm Vibration Motors from Precision Microdrive, was chosen, but the interface implementation affords modifications and extensions regarding tactors, boards and connection types. As many tactile displays uses durations between 80 and 500ms, the guiding timeline markers are set to 50ms to afford the creation of a broad range of activation durations [1].

To meet the aforementioned requirements, the interface was structured in three components: setup, timeline and details. The setup should give the user the opportunity of configuring the physical setup with representative tactor figures in the interface with a high flexibility. The idea behind the timeline is derived from audio editing software, as this kind of software works with timing in different time layers and a high accuracy. Hence, the timeline is designed with a layer for each tactor in which the activations are made. Providing 50 millisecond intervals in the timeline, as well as providing visual and/or tactile feedback from the playback functionality, helps the user to work very accurately with activations. A detail section is needed in the interface to provide necessary information regarding the activation, including voltage, amplitude, frequency and the exact temporal duration.

Implementation

As the focus of the implementation is the GUI we continue with describing the main components, which can be seen in Figure 1. Within the setup component the user is able to configure the physical setup of the tactors by dragging and dropping the labelled tactors to the desired position. We included the capacity to display a background image of the physical layout in order to add spatial understanding of the visual tactors.

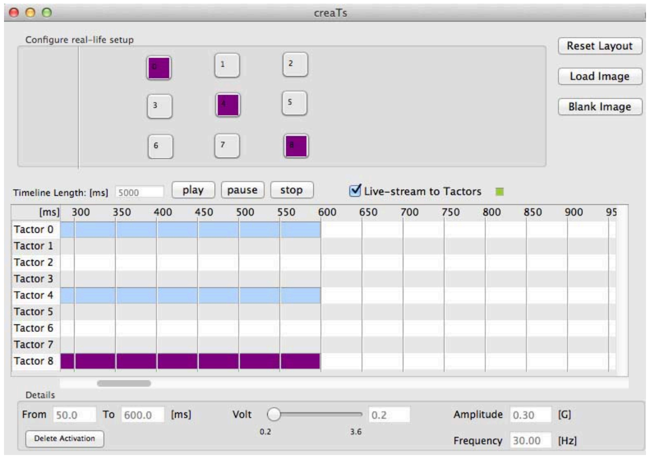

Figure 1 Activated Tactors change background colour during playback of timeline

The timeline component provides the main functionality for creating tactile patterns, which enables users to activate the different tactors for a specific time period with millisecond accuracy. Activations are created, moved or extended, each with a single mouse click. The timeline provides a playback function, which plays the whole timeline with the created tactile pattern in real-time. The activated tactor provides visual feedback in terms of changing background color during the playback of the timeline. The playback can be paused and stopped and the timeline excerpt is automatically synchronised with the proceeding time. A marker indicates a valid COM port connection and the selection of the Live-stream option ensures the activation of tactors while playing the timeline.

The details component presents relevant information of the selected activation element. Exact start and end times are displayed and synchronously updated while editing. The applied tactor voltage is set via a scale, which ranges from minimum to maximum voltage. The exact amount of the set voltage as well as the amplitude and frequency are shown, where the latter two values are changing dependent on the selected voltage, which is a characteristic of the chosen tactors.

Extension

The whole system is created to be extendable and modifiable to obtain a broad range of usage and functionality. Future extensions or modifications could include different microcontroller boards (e.g. from Arduino, Atmel), different tactor types (e.g. Electronic Rotating Masses Vibration Motors, Linear Resonant Actuator Vibration Motors) or different board connections (e.g. USB, Bluetooth, Wi-Fi). The current CreaTs interface provides an export to Arduino code, because the chosen microcontroller is an Arduino Mega 2560, but the program is designed to easily add exporter for any kind of format. For further details, see the portfolio, section 3.3 and 3.4

Usability Study

A usability test was conducted on eight male participants, to evaluate how understandable and approachable the interface is. For this purpose we selected experienced participants already familiar with interfaces, interaction and tactile feedback, rather than novice users. The participants were between the ages of 23 and 47 years and included three M.Sc. students, one M.Sc., and four Ph.D.'s all affiliated with the Department of Architecture, Design and Media Technology at Aalborg University.

As we believed the end-users had an appropriate knowledge of the electronic setup, the participants were guided through the primary configuration. The initial tasks of matching the visual representation of the physical setup, creating, extending, moving and deleting activations as well as changing properties such as voltage of activations revealed all necessary functions for creating tactile patterns.

The participants' main task was to create a pattern resembling a movement from one side to another. Observations revealed that the participants did not have any major problems understanding the visual representation of the physical setup, and further no problems identifying which tactor should be activated, for creating their tactile pattern.

As the created patterns were not completely similar, ranging in complexity, detail and duration they are not directly comparable. However, participants reported that it was easy to create patterns with the interface, once they were familiar with the editing tools. Our observations supported this. Participants did not hesitate before or while designing a tactile pattern and had no problems or questions during the editing.

We recorded the time spent on the creation of moving patterns, to have a better understanding of the complexity of the task. The participant, who spent the most time creating the pattern took less than three minutes and managed to created a moving pattern with 27 separate activations and a redesign of the entire pattern. Just one participant seemed to create a misplaced activation, which he identified through the visual and tactile feedback from the system. For further notes on the test and the results, see the portfolio, section 3.5.

Summary of Findings and Implications

In the development of the interface, we focused on the main functionalities of the GUI, internal communication as well as connections for providing feedback. Consequently, we had several comments from participants about the specific GUI design components, including the location of the delete button and modifying the property setting directly through text boxes: issues we were aware needed addressing. Further tests to correct the GUI should help clarify these issues in detail. To create a working prototype initial considerations resulted in a specific micro-controller board and tactors system. Therefore the system was required to take these particular specifications into account, although the software is designed to be easily modifiable and adaptable.

Conclusion and future work

With the interface, CreaTs, we provide a new, easy-to-use, efficient solution for creating tactile patterns. With the use of CreaTs, researchers working in the tactile field could begin easily creating complex tactile patterns to broaden the range of tactile experiences. Our limited sample of experienced users found the interface easy-enough to use. In future research we will implement a UCD approach to improve the program and begin designing tactile sensations with CreaTs.

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*Last looked up 17-12-2012