Visualizing a Library of Vibrotactile Effects

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1 INTRODUCTION

The rapid proliferation of vibrotactile (VT) devices and applications calls for vibration libraries and tools that can support end-users in customizing their VT notifications. The question is: how can users find their desired effects in a library of VT effects? Which taxonomy of VT effects can better help users in browsing the library and finding their desired effects?

Although VT designers usually use low-level engineering parameters, such as energy and tempo, to design vibrations, past researches [3, 4, 6] showed that end-users used to describe vibrations in different ways. Some of these include describing physical properties of vibrations or using sensory and emotional words, metaphors, or providing usage examples for a given vibration. Each of these ways can be used to categorize VT effects, and we refer to each as a vibration taxonomy.

In this project, we aim to visualize a library of vibrations that are annotated according to the five abovementioned vibration taxonomies: physical, sensory, emotional, metaphor, and usage example.

1.1 Dataset

The library includes around 150 vibrations with the following attributes for each vibrations:

- Physical includes four sub-attributes:

  - Duration (quantitative): 1000 ms
  - Energy (quantitative): 150 (measured as Root Mean Square of the waveform)
  - Note length (categorical): short note, medium note, long note, variable note, constant
  - Tempo (ordinal): slow, medium, fast, constant

- Sensory includes two sub-attributes:

  - Roughness (ordinal): -10, -5, 0, 5, 10
  - Tags (categorical): descriptive words such as "sharp"

- Emotional includes three sub-attributes:

  - Valence (ordinal): -10 to 10
  - Arousal (ordinal): -10 to 10
  - Tags (categorical): descriptive words such as "calm" or "urgent"

- Metaphor

  - Tags (categorical): words and phrases such as "heartbeat"

- Usage example

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- Tags (categorical): words and phrases such as reach a "milestone"

Note that, we interchangeably use main attribute and taxonomy to mean the same thing.

1.2 Tasks

The visualization is intended for two types of users: VT researcher and end-users. We anticipate four main usages of the visualization:

1. End-users use the visualization to do general browsing of all VT effects;

2. End-users use the visualization to find specific vibration patterns for their VT applications;

3. VT researchers/designers use the visualization to find less-explored areas of the design space for each taxonomy;

4. VT researchers investigate end-users' interaction with the library to better understand the VT design space and prominent characteristics of vibrations for end-users.

1.3 Personal expertise

This visualization course project is part of Hasti's ongoing PhD project on understanding the design space for vibration and VT customization requirements. Hasti has collected a library of vibrations and provided initial annotations for them which we will be using as our dataset. She is planning to collect end-users' annotations for the library in a user study next month. Although our project does not depend on data from that study, if that study is completed in time, we will have access to real end-user data for our project near the end of the term.

Kailun studies HCI but does not have a background in haptics. She also has limited experience with programming.

2 PROPOSED SOLUTION

We propose two initial design alternatives to visualize vibration patterns - mixed taxonomy or separate taxonomy. In the mixed taxonomy design, all taxonomies/attributes are incorporated in a single view. One advantage of the mixed taxonomy design is saving a lot of screen space. Therefore, end-users will not need to go switch between different views while exploring the VT collection.

We call the alternative design approach a separate taxonomy design where each category of attributes (aka, taxonomy) has its own view. The separate taxonomy design is not as concise as the mixed taxonomy, but it help researchers to better track users' interactions with various taxonomies to distinguish how important each taxonomy is and how they interact with each other.

2.1 Mixed Taxonomy

The Mixed Taxonomy design consists of an overview (Figure 1) and a card view (Figure 2) for the details.

Figure 1 gives an overview of the Mixed Taxonomy design. All vibrations are placed in the 2D space created by their emotional sub-attributes – valence and arousal. All other attributes, such as physical attributes, metaphor tags, usage example and etc., are filters to help users browse and locate a specific vibration of interest.
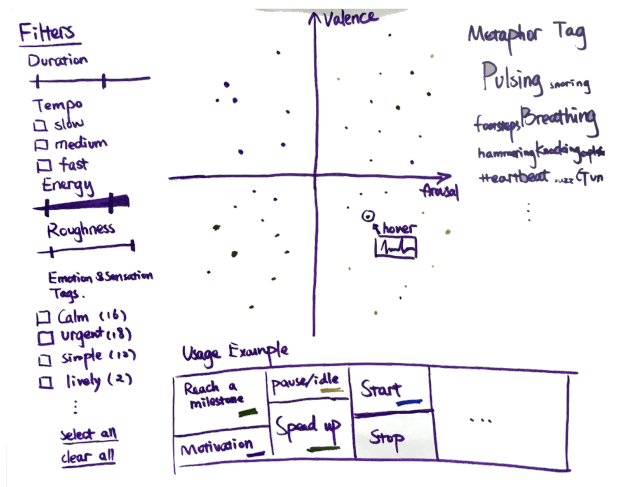
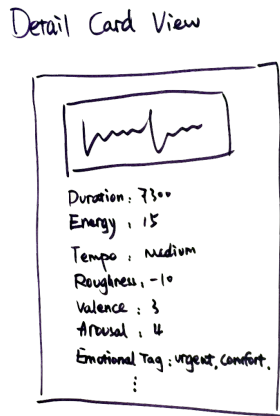Figure 1: Overview of the Mixed Taxonomy Approach

Figure 2: A detailed Card View for both Mixed and Separate Taxonomy Approach

Note that another design option is to put two physical sub-attributes - duration and energy - as the axes to replace valence and arousal. We will consider the tradeoff space between using emotional and physical attributes in main view and make a decision later.

We use the idea of "scented widget"[7] to guide user selection. For example, the energy slider is coded with increasing thickness; more energy corresponds to thicker in the slider, which is also reflected as a bigger size dot in the main view.

Figure 2 gives a detailed view for each VT effect. We call it a card view where each vibration has all its attributes listed in a card accompanied with a representation of its vibration waveform.

Scenario of Use

Katie is a university instructor. She recently got a smart wristband. The wristband sends unintrusive vibration patterns during her lecture so that she can get timing feedbacks about her talk (e.g., whether she is overtime). Katie finds the default vibration pattern for overtime alarm is not intuitive. She opens up this visualization of all VT effects to find one that better suits her need.

In the first screen, Katie see the overview of all VT effects in the library (Figure 1). First, she filters the vibration by choosing the "overtime" usage example. She then filters the remaining vibra-
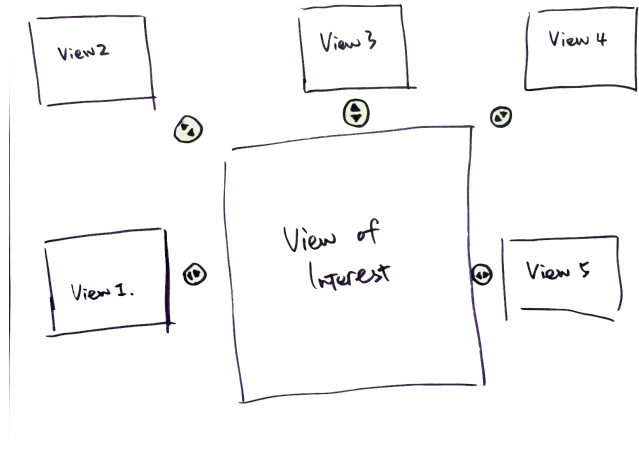

Figure 3: Illustration of the overall interface for the Separate Taxonomy design (four taxonomy views and one similarity view). Each view is described below.
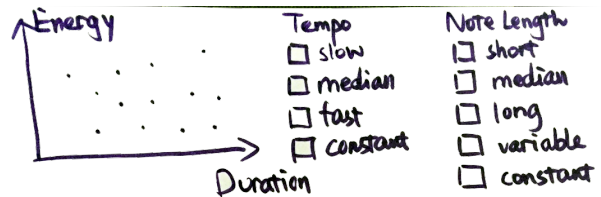

Figure 4: Physical Attribute view in the Separate Taxonomy design

tions using "urgent" tag from the emotional taxonomy. Among the remaining three VT effects, she hovers over each one to see a small preview of the vibration pattern (shown in Figure 1). She clicks on the one she is interested in to see the details of that vibration (Figure 2).

2.2 Separate Taxonomy

In the Separate Taxonomy design, we use a separate visual encoding view for each taxonomy. We combine emotional and sensory taxonomies due to their considerable overlap. The whole interface includes four views featuring a current view in the center and all other views surrounding it (Figure 3). Users can interactively bring a view of interest into the center of the screen. We will use linked highlighting to enhance smooth context transition between views.

2.2.1 Four Taxonomy Views

We propose a similar visualization encoding for 1) physical, and 2) emotional and sensory taxonomies. Both taxonomies have a mix of quantitative, ordinal and categorical sub-attributes (Figure 4 & 5).

Similarly, metaphor and usage example taxonomies are composed of categorical attributes. We are exploring two possible visual encodings: treemap (Figure 6), or list view (Figure 7). Once users select an item in the List View, they will see detailed information of a vibration in a Card View (Figure 2). We have not decided on the zoomed in view for the treemap yet.

2.2.2 Similarity View

Another interesting parameter is the similarity among vibrations. This is especially useful if the user is partially satisfied with a vibration and wants to explore similar vibrations. We will derive a
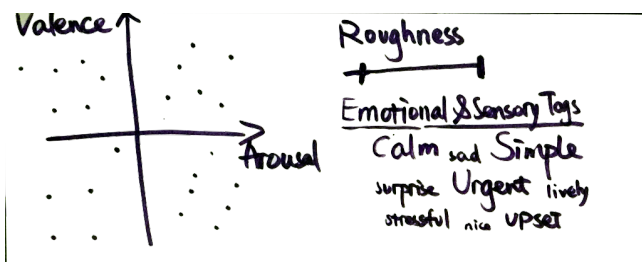
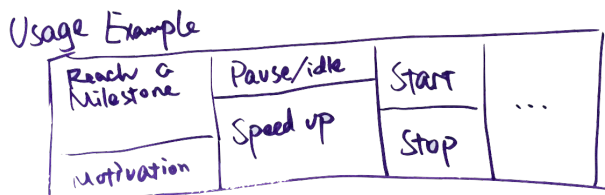Figure 5: Emotional and sensory view in the Separate Taxonomy design

Figure 6: A treemap illustration of the Usage Example taxonomy
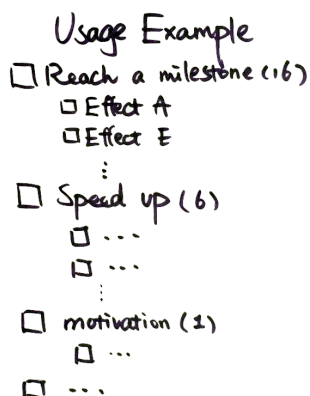

Figure 7: A list view of the Usage Example taxonomy

Figure 8: Sample glyph with mixed waveform and abstract design

similarity measure for vibrations (e.g., number of similar tags between two vibrations) and visualize it using a node-link view.

Scenario of Use

Katie wants to customize the vibration pattern for the "overtime" notification. She opens the library with a default physical view in the middle and other views surrounding it. She is not familiar with physical attributes of vibration patterns, so she taps the usage example view and brings that view to focus. She selects "overtime" and gets 15 vibrations provided for that usage example. The system automatically updates her choice in other views. She then selects the emotional and sensory view and chooses the "urgent" tag, which leaves three vibrations. She clicks on each one, which brings up the card view (Figure 2) and then decides to use one of the effect.

2.3 Glyph Design

We refer to glyphs to mean how we represent individual VT effects in the system. The glyph intends to give user a preview when they mouse over an VT effect or when they use the Card View. A simple straightforward glyph would be the exact vibration waveforms as drawn in Figure 1 or the envelope of the vibration color-coded according to its energy (Figure 8). We can also design an abstract glyph to denote VT effect; for example, a dot with size coded as vibration length, color as vibration energy, texture as its roughness and so on.

To sum up, here is a list of design decision to make before finalizing our implementation:

1. General design approach: Mixed or Separate Taxonomy design;

2. If we choose the Mixed Taxonomy design, whether to use the emotional or physical attributes to represent the space/main view;

3. If we choose the Separate Taxonomy, whether to use Tree map or List view for metaphor and usage examples attributes. How should the zoom-in view of the tree map look like?

4. Glyph design: waveform, color-coded VT envelop, or abstract design.

3 PROPOSED IMPLEMENTATION APPROACH

For the design and low-fidelity prototyping stages, we will use paper prototyping and existing visualization tools such as Tableau and Shiny. For the implementation stages, we are planning to use Javascript and d3.js library. We are not going to build our system on any existing interfaces.

4 RELATED WORK

Musicovery is an online music streaming tool that visualizes its music collection based on mood and emotional content of music tracks [1]. The interface makes good use of space and color coding to include various pathways for filtering, for example, based on genre, date, artist, intended activity, etc. FilmFinder is an earlier research prototype of a similar visualization system for exploring and searching movie collections [2].

Bohemian bookshelf is a visualization interface for browsing a book collection with the goal of supporting serendipity [5]. The interface include five interconnected visualizations that encode physical and/or semantic properties of the books in various ways. The interface was designed to support playful interaction and provide various pathways and access points to explore the collection.

Our work shares many characteristics with the above examples. However, we think what distinguishes our project from the above examples is that compared to music, film and literature domain, the vibrotactile perception and metadata is much less understood. For example, in Musicovery, FilmFinder and Bohemian bookshelf, the a priori knowledge about the importance of various metadata has presumably guided the design of the visualization. In contrast, part of the goal for our visualization system is to allow VT researchers to examine relative importance of various VT metadata. Also, in contrast to music, film and literature collections, vibration items in our dataset do not have a unique public name (identifier) which could be used for search. In this sense, our library is similar to graphical icon and sound libraries.

Flamenco is another example of visualizing a collection of items, in this case images, for exploration and browsing [8]. The interface provides hierarchical list views of the collection organized based on various facets of the image metadata such as image content, date etc.

5 MILESTONES AND SCHEDULE

Deadline	Tasks
Nov 10th	Further explore the design space & design alternatives
	Lit review
	Finalize platform
	Set up programming environment
	Clean up and prepare the dataset
Nov 20th	Narrow down the designs for actual implementation
	Implementation Phase I:
	Low-fidelity prototyping
	Focus on visual encoding/static vis
Nov 30th	Implementation Phase II:
	Medium/high-fidelity prototyping
	Focus on interaction
Dec 10th	Refine/debug the system

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