Designing Tactile Vocabularies for Human-Computer Interaction

Thesis presented in partial fulfillment of the requirements for the degree of Master of Computer Science

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Vibrotactile Communication

• The greatest challenge in this area is the discovery of a set of tactile patterns that, as speech sounds or letters, are clearly discriminated, rapidly processed and easily learned. (Sherrick, 1991)
Vibrotactile Communication
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Vibrotactile Communication
Vibrotactile Communication
Vibrotactile Communication

Complex Signals
Vibrotactile Communication

Obstacle detection

(Yoon, Jeong e Yu, 2009)
Vibrotactile Communication

Complex Signals

Simple Signals
Vibrotactile Communication

“Tap-on-shoulders” approach

(Hao e Song, 2010)
Problem

• Expressive capacity:
  • To increase the expressiveness of a tactile language, keeping it as easy as possible to learn and to understand.
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  • To increase the expressiveness of a tactile language, keeping it as easy as possible to learn and to understand.

• Vibrotactile Navigation
  • Approach for tactile prefixation
  • Design and assessment of vocabularies
Summary

- Introduction
- The Modifier Tactile Pattern
- Initial Vocabulary for Tactile Navigation
- Assessment of Tactile Vocabularies
- Redesign and Application Trial
- Conclusion
Summary

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Tactile Prefixation

• Prefixation in Braille
Tactile Prefixation

• Prefixation in Braille

*the touch
Tactile Prefixation

• Prefixation in Braille

Uppercase Prefix

*the touch
Tactile Prefixation

• Prefixation in Braille

The touch

*The touch
Tactile Prefixation

• Prefixation in Braille

Uppercase Modifier

*THE touch
Tactile Prefixation

• Prefixation in Braille

[Uppercase Modifier]

*THE TOUCH
The Modifier Tactile Pattern

• A Modifier Tactile Pattern is a tactile signal that modifies the interpretation of the remaining signals in a Tacton or tactile sequence.
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• **The Modifier Tactile Pattern**

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- **Initial Vocabulary for Tactile Navigation**
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Initial Vocabulary for Navigation

• Tactile Language Design
• Hand-based Display
• User Study
• Results
Initial Vocabulary for Navigation
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Initial Vocabulary for Navigation
Hand-based Tactile Display
User Study

• 15 individuals (14 males);
• Mean age 25 years old (23-37);
• 3 users have some degree of myopia or astigmatism;
• One user mentioned he suffers from hyperhidrosis,
• Two participants are left handed.
User Study
Navigation task

• Scene 1:

• Scene 2:
Results

• Perception
Results

• Perception
Results

• Perception
Results

• Interpretation
Summary

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**Initial Vocabulary for Tactile Navigation**
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• Redesign and Application Trial
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- Initial Vocabulary for Tactile Navigation
- **Assessment of Tactile Vocabularies**
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Assessment of Vocabularies

• Vibrotactile belt
• Designing the Vocabularies
• User Study
• Results
Vibrotactile Belt
Design of Tactile Languages

• We assessed three tactile vocabularies:
  • A Conventional one, based only on metaphors;
  • A Modifier-based vocabulary with patterns made by juxtaposition of tactons in sequence; and
  • Another Modifier-based vocabulary with patterns made by superposition.

• Five messages: Obstacle, Destination, Warning, Course and Itinerary.
Design of Tactile Languages

• First Vocabulary
Design of Tactile Languages

• First Vocabulary

Tactor position: Obstacles
Design of Tactile Languages

• First Vocabulary

Tactor position: Obstacles

Tactor position: Course
Design of Tactile Languages

• First Vocabulary

- Tactor position: Obstacles
- Tactor position: Course
- Tactor position: Warning
Design of Tactile Languages

• First Vocabulary

  Tactor position: Obstacles
  Tactor position: Course
  Tactor position: Warning
  Frequency: Destination
  Wave form: Itinerary
Design of Tactile Languages

• First Vocabulary
Design of Tactile Languages

• Second Vocabulary

Tactor position: Obstacles
Design of Tactile Languages

• Second Vocabulary

Tactor position: Obstacles

Tactor position: Modifiers
Design of Tactile Languages

• Second Vocabulary
Design of Tactile Languages

• Second Vocabulary
Design of Tactile Languages

• Third Vocabulary

Tactor position: Obstacles
Design of Tactile Languages

- Third Vocabulary

Tactor position: Obstacles

Tactor position: Modifiers
Design of Tactile Languages

• Third Vocabulary
User Study

• 58 individuals (47 males and 11 females);
• Age range of 19-32 years;
• 23 users have some degree of myopia, astigmatism or hypermetropia;
• Three groups:
  • 20 participants used the first vocabulary;
  • 19 participants used the second vocabulary;
  • 19 participants used the third vocabulary.
User Study

• Practice
User Study

• Perception
User Study

• Interpretation
User Study

• Navigation
User Study

• Navigation
User Study

- Scenes played randomly;
- Different lighting levels;
- Tactile messages displayed in different order for each phase.
Results

• Performance

Time in navigation

Collisions
Results

- Performance

![Bar chart showing time in navigation for First Vocabulary, Second Vocabulary, and Third Vocabulary.](chart.png)
Results

• Interpretation of the patterns
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Redesign and Application Trial

• Redesign methodology
• Navigation in underground mine
• User study
• Results
Redesign
Redesign
Redesign

<table>
<thead>
<tr>
<th>Obstacles</th>
<th>Itinerary</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Obstacle Diagram" /></td>
<td><img src="image2.png" alt="Forward" /></td>
</tr>
<tr>
<td><img src="image4.png" alt="Warning Diagram" /></td>
<td><img src="image5.png" alt="Turn left" /></td>
</tr>
</tbody>
</table>
Application Trial

• Navigation in underground mine
Application Trial

- Navigation in underground mine
Application Trial

• Navigation in underground mine
User Study

• 15 individuals (14 males). 4 Mining Engineering students and 10 Computer Science students;
• Mean age 25 years old (23-37);
• 7 users have some degree of myopia or keratoconus;
User Study

• Vocabulary practice
User Study

• Underground navigation
User Study

• Underground navigation
Results

• Performance

Time in navigation

Collisions
Results
Results
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Conclusion

• Work evolution
  • Different levels of immersion;
  • Prototypes of displays for different body sites;
  • Improvement of the experimental setup;
  • Improvement of the tactile interface usability.
Conclusion

• Contributions
  • The concept of Modifier Tactile Pattern;
  • The assessment of dozen families of tactile icons;
  • A usable vocabulary for navigation;
  • Data from more than eighty people;
  • A large review of the research on vibrotactile communication.
Conclusion

• Future Works
  • To improve the tactile belt ergonomics;
  • To test navigation in physical environments;
  • To assess different ambient conditions and contexts;
  • To assess different user profiles;
  • To build frameworks for haptic interaction design.
Submissions

SIBGRAPI 2012
Using Vibrotactile Communication to Assist in Orientation and Locomotion

HAPTICS 2014
Design and Assessment of a Modifier-based Tactile Language

CHI 2014
Introducing the Modifier Tactile Pattern for Vibrotactile Communication

SVR 2014
Tactile Interface for Navigation in Underground Mines

UIST 2013
Introducing the Modifier Tactile Pattern for Haptic Communication

3DUI 2014
Assessment of Tactile Languages as Navigation Aid in 3D Environments
Poster: Applying Tactile Languages for 3D Navigation

EUROHAPTICS 2014
Introducing the Modifier Tactile Pattern for Vibrotactile Communication
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Thank you

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