Disappearing textile interface with inherent feedforwards

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Abstract
Currently, interactive devices can easily disappear into a wide range of physical context due to the development of microcontrollers, sensors and actuators. However, this disappearing interaction scenario may cause confusion to the users regarding where and how to interact with it. Therefore, a research project has been conducted to investigate different inherent feedforwards for this disappearing interaction scenario in textile surfaces. A Tangible User Interface (TUI) for volume adjusting was designed, which can provide both visual and shape-changing feedforwards. This interface can be implemented in ubiquitous soft surfaces, in this demo, a textile-based Human-Machine Interaction (HMI) in the vehicle seat. The textile interface provides a both natural and enjoyable HMI concept. This report describes the theoretical background, prototype, user test and demo setup and contribution.

Author Keywords
HMI; tangible interface; shape changing; textile interface; inherent feedforward; affordance.

CCS Concepts

- **Human-centered computing~Interaction devices**
- **Human-centered computing~Haptic devices**
- **Human-centered computing~Interface design prototyping**
- Human-centered computing~Interaction design theory, concepts and paradigms

Introduction

In the vehicle industry, the HMI has been going through an evolution from traditional buttons to seamlessly integrated screens. While the conventional control panel in the vehicle is physical in forms, which afford the haptic perceptual-motor skills of the users, the screen-based interface makes the interaction information heavily rely on visual perception [3]. This increase the pressure on drivers' or users' visual perception. Therefore, arguments regarding driving safety have been raised.

Consequently, researches on peripheral interaction have been conducted to explore futuristic interactive approach presenting information to the users in a subtle manner and reduce the attention demand [1]. Comparing to graphical user interface, tangible shape-changing modality provides the third dimension of information through haptic perception, which could release the pressure for visual perception and provide potential usage in the vehicle.

The miniaturization and higher resolution of microcontrollers, as well as electronic components, enable the integration of HMI with daily objects and soft surfaces. This report presents a new interactive approach in the vehicle with a textile surface combining visual and shape-changing information. Although TUI has a physical carrier for the interaction procedure, interaction based on soft surfaces like the vehicle seat could still be confusing for users regarding where to perform the interaction, and how to interact. Therefore, the research project has been conducted to investigate different inherent feedforwards for this disappearing interaction scenario in textile surfaces.

Project Structure

As the development of microcontrollers like Arduino, the new forms of computer can be easily integrated into a wide range of physical context [6]. Thus, the HMI is no longer confined to screens, but emerging into the ambient environment and soft surfaces. The research project has been framed concerning both ubiquitous computing and tangible user interfaces (TUI), with a focus on the interaction through manipulating physical soft surfaces, which are integrated into vehicle seat [2].

From an interaction design perspective, feedforward plays a significant role in term of providing information to the users and facilitate human's reaction towards the intended function [7]. Based on the framework developed by Wensveen et al., four different feedforward modalities, based on visual perception and haptic perception, were proposed in this study to provide more meaningful information and pleasant user experience to the interaction.

With a focus on soft-surface-based TUI, a textile-covered prototype was designed and built. Within this prototype, new carriers were proposed for interaction information using visual feedforward modality based on the light feedforward and shape-changing feedforward modality (Figure 1. Four Designed Feedforward Modalities): a. non-feedforward, b. static-pattern feedforward, c. dynamic-pattern feedforward, d. shape-changing feedforward).

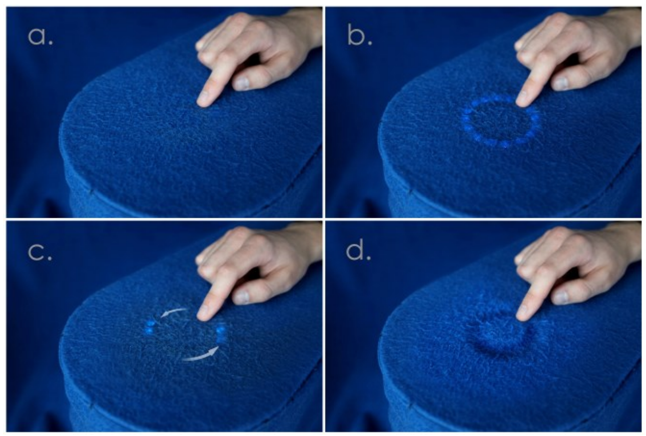

Figure 1: Four Designed Feedforward Modalities (a). Non-feedforward, (b).Static-pattern feedforward, (c). Dynamic-pattern feedforward, (d) Shape-changing feedforward

Figure 2: Shape-Exploration

In this case, LED-based modality is more related to traditional screen display while the shape-changing modality provides a third dimension of information through haptic perception. In order to limit the complexity and novelty effects associated with TUI, both shape-changing modality and visual modality were designed in the simple geometric shape of the circle (Figure 2. Shape Exploration), which was inspired by the work of Tiab et al. [5].

The intended action based on the feedforwards is touching with the finger and rotating motion, and the designed function is adjusting the volume.

Afterward, user tests were conducted to study the usage of the interfaces. The affordance of the feedforwards was indicated by the task completion scale and the user experience was analyzed with the Likert Scale UEQ questionnaire [4] and semi-structured interview. Twenty-five participants participated voluntarily in the user test. During the trial, participants were provided the same context to use the prototype – adjusting music volume while driving.

The research project accesses the effect of four different feedforwards and their affordance and user experience in terms of human-computer interaction. Shape-changing is more expressive comparing to the traditional LED display, which triggers the users to interact with it. Due to its constraint of the fingers, shape-changing takes advantage of haptic perception, which makes it easier to find and use than purely visual perception-based interaction; this reduces the attention demand. Furthermore, the shape-changing interface has the potential of supporting better interaction when it comes to peripheral vision, for example, while driving a vehicle [1]. Based on the insights gained from the findings, the prototype was demonstrated with re-designed feedforward and feedback to generate intuitive and meaningful interaction.

Prototype

The surface of the prototype is covered by stretchable artificial wool felt. A Membrane Potentiometer was used as the input for adjusting the volume. NeoPixel LED ring is integrated under the Potentiometer to create visual feedforward modalities. For the shape-changing feedforward modality, two Micro Servos are installed at the bottom of the prototype, using fishing line to pull the circular moveable part down to generate the shape-changing movement. An Arduino Uno is used for the communication between Arduino and interface, which was created by Processing.

Demonstration

The prototype was integrated with a vehicle seat for the final demonstration (Figure 3. Demo Setup). In the context of the vehicle, the functionality of the prototype is fully interactive, and the users can get instant feedback from the adjusting volume of the music. The feedforwards for the demonstration were re-designed according to the user test findings. The combination of shape-changing and dynamic-pattern presents higher affordance of the action possibility as well as better user experience, which also shows a possible approach to designing intuitive and enjoyable HMIs.

Figure 3: Demo Setup

Contribution

The prototype was used as the research probe for study on investigating different inherent feedforward for the textile interface. It can also be applied as the demonstration of the design based on the findings from the research. By applying to a specific context, the prototype could provoke the discussion on HMI design and interaction design in the vehicle, especially on how to design peripheral interaction regarding driving safety. The demo is fully interactive, which could help users to experience the creative approach of interacting with the cars.

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