Designing Touch-based Communication Devices

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ABSTRACT

Touch-based communication devices allow transmission of tactile sensations remotely. These devices can enhance existing communications by providing additional bandwidth for information. The addition of a new communication channel has appeal for deaf-blind users, as well as mainstream users.

This paper describes design issues encountered while exploring the sense of touch for remote communication. Scenarios are proposed to define possible user interactions. Some challenges in designing touch-based tangible user interfaces, such as human factors and the semantics of a touch language, are presented.

Keywords

Tangible interfaces, interface design, assistive technologies, rapid prototyping, human factors, interpersonal communication

INTRODUCTION

The aim was to design a communication tool using tactile sensation, particularly for deaf-blind users. We are interested in embodying physical interfaces with technology to enable remote communication. Without audio or visual channels available, touch communication tools allow the deaf-blind to communicate remotely. By using the common sense of touch, the barrier between the deaf-blind and mainstream users is reduced.

BACKGROUND

This work is based on previous work done on assistive technologies [1] and tangible user interfaces ([2],[3]). Most communication technologies enable voice and light to be exchanged across great distances. Explorations have been made on using tactile devices for computer input [4]. However, the transmission of touch communication can be further explored ([5]).

Variable	Range of design axis	
Data direction	bi-directional	uni-directional
Data transfer	asynchronous	synchronous
I/O Mapping	asymmetric	symmetric
Data content	analog	discrete

Table 1:Variables in design space for touch communication

Chosen design space

We begin by defining the design space of touch-communication possibilities. Some common ways of describing the design space use the variables in Table 1. The following features were chosen for our exploration into the touch-based communication design space:

- Bi-directional- Each device will have the ability to send and receive signals.
- Asynchronous- Users can send and receive at the same time. The device will not require a protocol for the users to synchronize the transmission of data.
- Asymmetric- Symmetric mappings using tangible interfaces have been shown to result in users fighting for control [2],[3]. The device has separate input and output channels to prevents users from interrupting an incoming transmission.
- Analog- The ability to communicate using analog signals allows more variety in communication.

DESIGN METHODOLOGY

The design process consisted of successive stages of iteration and refinement of the device description. The preliminary design stages were: identifying user needs, establishing device specifications, and creating usage scenarios. In the subsequent design stage, possible concepts of the physical models were prototyped. The next stage of design is to build a working implementation.

At each design stage, new perspectives were generated and reviewed. From reflecting upon the ideas of each stage, more specific design choices were made. The preliminary and secondary stages of our design process are presented below.

Figure 1: Exploration of different form factors using rough prototypes.

Identifying user needs

Formulating questions about communications and potential users helped us gather background research on existing technologies, usages, and identify user needs.

- What are some existing forms of communication devices?

Email, pagers, instant messaging, video-conferencing, and telephones are various communication tools that approach communication differently. We contrasted and compared the different methods and compared them with the ideal of face-to-face communication. It became evident that we wanted to develop a device that could communicate face-to-face subtleties and nonverbal signals.

- What methods do the deaf-blind currently use to communicate?

Braille, sign language, and finger spelling are some existing methods that were identified as widespread. Tadoma is another method where deaf users can pick up the vibrations of speech by touching the speaker's lips.

- What existing tactile technologies can we study?

Chording keyboards allow for single-handed input. The Logitech iFeel mouse uses vibration to give information about mouse movement over screen display.

- What kind of tactile input and output mapping would be suitable?

From asking blind people, it was determined that glove-like devices were not ideal because of the constrictive nature of the glove. They expressed dislike of force-feedback devices because of the difficulty in overcoming the feedback force to communicate. There was also the concern of unintentional injury due to the force applied by a machine, for example, if a force-feedback glove forced the hand into an unnatural position.

Device Specifications

From answering the exploratory questions above, the following specifications were developed:

Communication should use vibrotactile data. Users will be able to send data by squeezing and receive via vibration. The squeeze force will be linked to the intensity of the vibration.

The device should be handheld. It is also important for the input and output areas to be localized. We wanted our device to be small enough to be discretely used and wirelessly connected for mobility.

Touch-based communication scenarios

A list of scenarios was generated to help identify possible interactions. Touch-based scenarios for both able-bodied and special needs users are presented below.

Situations requiring privacy

Where audio communication is impossible, a touch-based device can provide a private channel for communication. For example, one might wish to remain connected even when inside a library. Touch based communication can allow discreet notification of personal messages without broadcasting an interruption to others.

Multiplexing of information and emotional communication channel

In places where remote communication already takes place, touch devices can allow people to increase their communication by multiplexing existing communication channels For example, politicians would be able to talk and get feedback from their advisors about how the audience is receiving them during a live debate.

Loved ones, when separated, often want to communicate without interrupting the flow of each other's work by active conversation. For example, when one partner is in a meeting, the other one might want to express support.

Special needs users

Existing technologies limit the ability for the deaf-blind to communicate. In a wireless touch-based communication system, a deaf-blind person could communicate remotely with anyone who has a sense of touch.

CONCEPT GENERATION

Once user interactions were defined, the exploratory form factors were prototyped with foam and clay. The basic form was a hand-held device that allowed each finger to squeeze independently. The dimensions for gripping and the elasticity of the materials were varied to gauge user preferences. Figure 1 displays some form factors considered in the embodiment of the device. Some features explored were two-handedness, squeezable, ergonomic, wearable, and strapped physical interfaces.

One key issue that came out of prototyping was the need for a strap. Without one, the user might inadvertently send signals. For example, a user might send a squeeze signal when they are simply trying to hold the device.

UNDERLYING DESIGN CHALLENGES

As the embodiment of the device progressed, some underlying questions continued to arise. We found that the main challenges of creating an effective touch-based communication device revolve around the language the device will use, such as flow control, semantics, and feedback.

Flow control issues

How do the users determine who is talking, who is receiving? Should the design allow for asynchronous communication or will there be an arbitrator that allows turn taking?

Language of touch

How do the users communicate ideas? The components of communication we propose are squeeze force and the duration of force on each finger. The speed of transmission provides the syntax (e.g. pauses, vibrations per second), while the vibration on each finger provides the grammar for communication.

Should the language being communicated be alphabetic or conceptual? Examples of alphabetic language devices are chording keyboards, text-based communications, and telegraphs. Examples of conceptual languages are voice communication, hand gestures, and body language.

Finally, what data is the user sending? Is the data encoded and decoded by the device, or does the user simply receive the transmission? Can the transmission be inherently understood, and is it adaptable? How many distinguishable channels can there be in tactile communication? Can the data be superimposed to construct a concept that is communicated?

Feedback channel for the user

Should a feedback mode exist for the user, so that as she is communicating, there is some feedback for what is sent? Perhaps feedback is not necessary, as the sensation of pressing may give enough feedback. In some devices, such as telephones, there is a small feedback channel to allow users to gauge how their transmission is received.

SUMMARY

The following are the main principles desired in designing for touch communication devices.

Ergonomics

The device should allow communication only when intended. Use of the device should feel comfortable and not obstruct the natural functions of the hand.

Features of a Remote Touch Communication Language

The nature of touch will allow personal content to be conveyed in a private manner. Capacity for diverse types of personal content should be supported; both complex meanings and simple ideas should be able to be communicated. Similar to voice, touch communication should be bi-directional and asynchronous. Like visual displays, the use of touch can allow one to focus in noisy situations. By considering touch in contrast to existing modes of communication, we have begun discussion of the architecture of a touch language for remote communication.

CONCLUSION

This paper describes a design space for touch communications, and explores one area of this design space. The details about initial stages of the design process, and key design issues are presented. Some general guidelines in designing a touch-based communications device are identified. Finally, main considerations for designing touch communication devices are summarized, in hope that attention to these concerns will guide future device designers. From these preliminary insights, we hope to build a touch-based communication device that is suitable for the needs of all users.

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