

Crossmodal Interaction with Mobile Devices

Eve E. Hoggan and Stephen A. Brewster
Glasgow Interactive Systems Group
University of Glasgow, Glasgow G12 8QQ, UK
{eve, stephen}@dcs.gla.ac.uk

Abstract

This paper describes an alternative form of interaction for mobile devices using crossmodal output. These crossmodal displays allow alternative senses such as hearing and touch to be used to perceive information normally presented to the visual modality. Initial experiments show that roughness and spatial location can be perceived as equivalent in both the auditory and tactile domain. This paper discusses how crossmodal displays can be constructed using the results from these experiments and the benefits they bring to mobile human computer interfaces

1. INTRODUCTION

The design of a user interface for mobile devices, such as PDAs and mobile phones, is a challenging task given their small size and restricted input/output capabilities. As a result of the lack of screen space, the amount of information able to be presented visually is limited. Anyone who has attempted to view small icons like the clock or read a message whilst in a poorly lit environment or sitting in a moving train can confirm that such visual output can place considerable demands on the user. When attempting to interact with these small screens, the user's attention is diverted from the rest of the physical world. There are many environments and activities, such as walking, in which the user's eyes may be occupied although they are otherwise able to attend to information from the mobile device via their other senses.

Being predominantly dependent on a single sense such as vision is unnatural because, in the real world, we receive information from several modalities, as when we both hear and see someone speaking. Many of the same issues affect blind people too. Sensory substitution is used everyday by those who are unable to perceive information via a certain modality. For instance, visually impaired people regularly use alternative senses to gain the information usually obtained through vision. For example, Braille provides people with information through touch while human echolocation is a technique where people can navigate by listening to the echo of sounds. It is proposed that these crossmodal interactions can be used to significantly improve the accessibility and flexibility of interaction by offering multiple modalities through which information may be passed between the device and user.

In order to explore the possibilities of crossmodal auditory/tactile output, this research makes use of crossmodal icons. A crossmodal icon [1] is an abstract icon that can be instantiated in one of two equivalent forms (auditory or tactile). These can be used in mobile interfaces as a means of output. The paper will begin by providing some background into crossmodal interaction, then our approach to crossmodal output for interfaces through

crossmodal icons will be described and finally the future directions of this research will be outlined.

2. BACKGROUND WORK

A large amount of tactile and audio research focuses on unimodal or multimodal interaction. Earcons are a type of non-speech auditory display, which Blattner defines as "non-verbal audio messages that are used in the computer/user interface to provide information to the user about some computer object, operation or interaction" [2]. As for the tactile domain, Brewster and Brown have developed Tactons [3] for structured vibrotactile messages which can be used to communicate information non-visually.

We are taking an alternative approach to interface design for mobile devices by creating crossmodal interfaces based on sound and touch which may be advantageous to mobile device users because different modalities may be more or less suitable depending on the user, the type of information received, hardware capabilities, the user's current activity, and the environment.

3. CROSSMODAL INTERACTION

Audio and tactile displays are ideal candidates for crossmodal use because our senses of hearing and touch share several important similarities, in particular their temporal characteristics and their ability to perceive vibrations. Moreover, sounds are often described in tactile terms. Mursell [4] observed that tone can contain tactile values as can be seen when we describe a tone as hard or soft, rough or smooth, wooden or metallic. It has been suggested that the more properties shared between two modalities, the stronger will be the observer's "unity assumption" that information from different sensory channels can be attributed to the same distal event or object [5].

An attribute that can communicate comparable information across modalities is considered to be amodal. Intensity, spatial location, rate, texture, and rhythmic structure are common types of amodal attributes [6]. The auditory/tactile crossmodal interaction design described here is based on the amodal attributes available in the auditory and tactile domains.

4. CROSSMODAL ICONS

Crossmodal icons [1] are abstract icons which can be automatically instantiated as either an Earcon or Tacton, such that the resultant Earcons or Tactons are intuitively equivalent and can be compared as such. Crossmodal icons allow the same information to be accessible interchangeably via several different modalities. For example, a set of

Earcons/Tactons can be transformed into crossmodal icons by ensuring that the information represented can be encoded in both modalities so that users can move from an audio to a tactile presentation of the same information.

This research has built on the concept of the crossmodal icon by investigating the set of parameters that can be used to create auditory/tactile cues. The parameters must be amodal attributes so that the same information can be easily mapped between the two modalities. This is difficult because some of the most effective parameters available in the audio domain do not have direct mappings to the tactile domain and vice versa. For example, pitch is a suggested parameter for use when creating Earcons [2]. However, a melody using different pitches cannot be directly transferred to the tactile domain.

The current parameters or amodal attributes under investigation for auditory/tactile crossmodal icons are:

Rhythm: motifs or rhythmic structures can be used in both audio and tactile displays due to their shared temporal properties.

Intensity: High/low intensity could be created by increasing/decreasing the amplitude of the Earcon or Tacton.

Roughness: modulating the amplitude of a tactile pulse creates differing levels of roughness [3]. It may be possible for users to perceive an auditory equivalent of tactile roughness.

An experiment was conducted to determine which version of audio roughness (dissonance, flutter-tonguing, amplitude modulation, or timbre) can be perceived as equivalent and maps most effectively to tactile roughness. Initial results show that subjects preferred the use of differing timbres in audio. However, the results also show no significant difference in performance between timbre and audio amplitude modulation.

Spatial Location: This research has begun to investigate ways to map from a tactile location on the body to an audio location in a soundscape and vice versa. This would allow navigational cues for instance to be presented via Earcons and Tactons as in Figure 1.



Figure 1. Earcon presented to left hand side of soundscape and equivalent Tacton to left hand side of waist

Experiments have been conducted to determine which body location can be mapped most effectively to locations in a 3D audio soundscape. The experiment involved a computer-controlled belt/wrist band/ankle band with four embedded vibrotactile transducers: each of the small transducers are evenly spaced around the circumference of the body area (waist, wrist or ankle) and mapped to spatial audio played through a pair of headphones.

Results show that participants are able to map the presented 3D audio positions to tactile body positions on the waist most effectively and that there are significantly more errors when using the ankle (Figure 2).

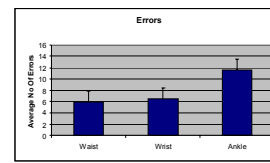


Figure 2. Number of errors per body location

5. CONCLUSIONS AND FUTURE WORK

These experiments have established that it is possible for users to perceive both roughness and spatial location as equivalent in both modalities, so the next step will involve the investigation of parameter interactions. For example, using a certain spatial location may force a particular level of roughness. It will also be necessary to establish the resolution of these parameters so that the number of different distinguishable roughness levels and distinguishable spatial locations can be outlined. This will help to determine how much information can be encoded in these crossmodal displays.

The crossmodal interaction methods developed in this project are not restricted to mobile devices but can also be used to enhance interaction in desktop applications too. Although there are many applications being developed to create accessible applications by incorporating multimodal and crossmodal interaction, these actual development applications themselves rarely feature any crossmodal assistance. Crossmodal assistance could be provided in programming environments while the user writes, debugs, or runs code. For example, compile time error messages could be presented in a variety of forms (visual, audio, or tactile) depending on the needs of the user.

This paper has described the features of crossmodal auditory/tactile interaction and has outlined some of the potential parameters that could be used to create crossmodal audio and tactile icons. Preliminary experiments have shown that both roughness and spatial location can be perceived as equivalent in both the auditory and tactile domain. Furthermore, it has been established that the use of the waist as a tactile body location produces significantly better results than using the wrist or ankle. Once a set of crossmodal parameters has been established, it will be possible to include crossmodal icons in various mobile applications.

6. REFERENCES

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