Methods for Presenting Braille Characters on a Mobile Device with a Touchscreen and Tactile Feedback

Jussi Rantala, Roope Raisamo, Jani Lylykangas, Veikko Surakka, Jukka Raisamo, Katri Salminen, Toni Pakkanen, and Arto Hippula

Abstract—Three novel interaction methods were designed for reading six-dot Braille characters from the touchscreen of a mobile device. A prototype device with a piezoelectric actuator embedded under the touchscreen was used to create tactile feedback. The three interaction methods, scan, sweep, and rhythm, enabled users to read Braille characters one at a time either by exploring the characters dot by dot or by sensing a rhythmic pattern presented on the screen. The methods were tested with five blind Braille readers as a proof of concept. The results of the first experiment showed that all three methods can be used to convey information as the participants could accurately (91-97 percent) recognize individual characters. In the second experiment, the presentation rate of the most efficient and preferred method, the rhythm, was varied. A mean recognition accuracy of 70 percent was found when the speed of presenting a single character was nearly doubled from the first experiment. The results showed that temporal tactile feedback and Braille coding can be used to transmit single-character information while further studies are still needed to evaluate the presentation of serial information, i.e., multiple Braille characters.

Index Terms—Assistive technologies for persons with disabilities, haptic I/O, input devices and strategies, interaction styles.

1 Introduction

Interacting with mobile devices is challenging for the visually impaired. Getting proper feedback and information on the state of the device is especially problematic as the use of devices is currently based mainly on visual information. Recently, as the computational power of mobile devices has increased, screen readers coupled with speech synthesizers, e.g., [1], [2], have become available for a limited number of devices. However, speech output is not a private medium if used without headphones. In certain situations, such as public spaces, synthesized speech may be inconvenient or even impossible to listen to. The use of synthesized speech also causes disturbance to the environment. Headphones, on the other hand, may prevent one from hearing what is happening around, making it hard to observe the environment.

1.1 Braille Displays

Many blind mobile device users are accustomed to using their tactile sense for reading Braille; for them, it is one of the most common ways of acquiring information. Braille is a reading and writing system which transliterates traditional written letters into tactile characters. In six-dot Braille, each character consists of a rectangular array of two columns and three rows where individual dots are either raised or lowered (Fig. 1).

Braille is read by gliding the fingers over the dots forming the characters. Shapes outlined by individual dots are used for mentally constructing a geometric model of the layout of the Braille characters [3]. It has also been claimed that the reading of Braille is mainly based on variations in dot spacing and density [4]. This is the case especially when longer texts are read instead of individual characters.

Nowadays, mechanical Braille displays are used alongside traditional Braille, which is embossed on paper. Braille displays are devices that usually have up to 80 Braille cells. Each cell typically has six pins controlled by individual electromechanical actuators. Textual information, for example, in a document or in a menu, is transmitted via screen reader software to a Braille display. Although current Braille displays are widely used, two major drawbacks hinder the use of these devices in everyday life: their price and poor portability.

According to Roberts et al. [3], Levesque et al. [5], and Ramstein [6], the price of current Braille displays is a major obstacle for potential users. A standard Braille display for desktop computers typically costs between 5,000 and 15,000 USD. For this reason, there has been research on alternative approaches to cut down the cost of such devices. One common way has been to reduce the number of actuators. Instead of placing individual actuators for each dot, displays with fewer electromechanical parts have been built.

Roberts et al. [3] simplified the mechanical design by creating a Braille display which was based on a rotating wheel with the characters molded around its surface. Users

• *The authors are with Tampere Unit for Computer-Human Interaction, Department of Computer Sciences, University of Tampere, FIN-33014, Finland. E-mail: {jussi.rantala, roope.raisamo, jani.lylykangas, veikko.surakka, jukka.raisamo, katri.salminen, toni.pakkanen, arto.hippula}@cs.uta.fi.*

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