Evaluating Touch-Screen Vibration Modality for Blind Users to Access Simple Shapes and Graphics

Joe Tekli , Youssef Bou Issa , Richard Chbeir

PII: S1071-5819(17)30147-7
DOI: 10.1016/j.ijhcs.2017.10.009
Reference: YIJHC 2161

To appear in: *International Journal of Human-Computer Studies*

Received date: 5 January 2017
Revised date: 9 August 2017
Accepted date: 23 October 2017

Evaluating Touch-Screen Vibration Modality for Blind Users to Access Simple Shapes and Graphics

Joe Tekli*
E.C.E. Dept., School of Engineering
Lebanese American University
36 Byblos, Lebanon
joe.tekli@lau.edu.lb

Youssef Bou Issa
Faculty of Engineering
Antonine University
40016 Baabda, Lebanon
youssef.bouissa@upa.edu.lb

Richard Chbeir
LIUPPA Laboratory
Université de Pau et des Pays de l'Adour
64000 Anglet, France
richard.chbeir@univ-pau.fr

Abstract—**Accessing visual information becomes a central need for all kinds of tasks and users (from accessing graphics and charts in news articles, to viewing images of items on sale on e-commerce sites), especially for blind users. In this context, digital tools of assistance, using adapted software (screen readers, talking browsers, etc.), hardware (force feedback mouse, piezo-electric pins, etc.), and more recently touch-screen technology (using smart phones or smart tablets) have been increasingly helping blind persons access and manipulate information. While effective with textual information, yet existing solutions remain limited when handling visual information. In this context, the goal of our study is to shed light on how the *vibration* modality can be perceived by blind users when accessing simple contour-based images and visual graphics on a touch-screen. In this paper, we target the vibration-only modality, compared with audio-kinesthetic or multimodal vibro-audio solutions. Our main motivation is that the potentials and limitations of touch-screen vibration-only feedback need to be fully studied and understood prior to integrating other modalities (such as sound, human speech, or other forms of haptic feedback). This could prove very useful in a range of applications: allowing blind people to access geographic maps, to navigate autonomously inside and outside buildings, as well as to access graphs and mathematical charts (for blind students). To achieve our goal, we develop a dedicated experimental protocol, titled EVIAC, testing a blind user's capacity in learning, distinguishing, identifying, and recognizing basic shapes and geometric objects presented on a vibrating touch-screen. Extensive tests were conducted on blindfolded and blind candidates, using a battery of evaluation metrics including: i) accuracy of shape recognition, ii) testers' average response time, iii) number and duration of finger strokes, iv) surface area covered by the testers' finger path trails, as well as iv) finger path correlation with the surface of the target shape. Results show that blind users are generally capable of accessing simple shapes and graphics presented on a vibrating touch-screen. However, results also underline various issues, ranging over: prolonged response time (e.g., blind users require 1 minute and 22 seconds on average to recognize a basic shape), reduced touch-screen surface coverage, and low correlation between the surface of the target shape and the tester's vibration trails. The latter issues need to be further investigated to produce optimal recipes for using touch-screen technology to support image accessibility for blind users.**

Keywords—**Blind users, data and image accessibility, tactile image, vibrating touch-screen, paper embossing, experimental evaluation protocol, empirical study.**

1. Introduction[1]

In the dawn of the 21th century, visual media tools and contents become ubiquitous, saturating our modern society (ranging over web pages, mobile applications, e-books, e-commerce, etc.). Accessing visual information becomes a central need for all kinds of tasks and users (e.g., from accessing data representative graphics and charts in news articles, to viewing images of items on sale on an e-commerce site), namely for blind users. According to its latest statistics produced in 2014, the World Health Organization (WHO) estimates at 285 million the number of people affected by visual impairments, among whom 39 million are totally blind; and these numbers are expected to double by 2020 (World Health Organization, 2014). In this context, and thanks to adapted tools of assistance (e.g., screen readers, digitalized Braille terminals, and screen magnifiers), computerized solutions are increasingly helping blind or visually impaired persons to access and manipulate information, and perform various kinds of activities previously deemed unfeasible for the visually impaired.

However, while effective with textual contents, (ANSI/NISO, 2005; Cooper M. *et al.*, 2008; Guillon B. *et al.*, 2004; Stephan F. and Miesenberger K., 2008), yet existing solutions remain limited when accessing visual contents and images. The most prominent studies in this context focus on low-vision users (i.e., users who are not totally blind) by providing visual aids and image enhancement techniques (Dolphin, 2016; Kennedy J.M., 1993; Lawton T.B., 1992; Peli E., 1994; Tang J. *et al.*, 2004; Zubair J., 2008), adapting image spatial frequency, or applying dedicated filters in order to adapt image quality to the user's visual impairment. Other approaches have exploited tactile imaging (Kennedy J.M., 1993; Shiose T. *et al.*, 2008) and 3D models (Oouchi S., 2004; Oouchi S. *et al.*, 2010) in order to reproduce graphics and images in an embossed representation, highlighting the senses of depth and distance in an image with superimposed layer structures. Some approaches have investigated haptic feedback: using a force feedback mouse (Yu W. and Brewster S. A., 2002), or piezo-electric pins (Pietrzak T. *et al.*, 2009), in order to access images (Abu Doush I. *et al.*, 2012) as well as mathematical charts and geographic maps (Kaklanis N. *et al.*, 2011).

* Corresponding author.