Evaluation of Touch Screen Vibration Accessibility for Blind Users

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ABSTRACT

In this demo paper, we briefly present our experimental prototype, entitled *EVIAC* (EValuation of VIbration Accessibility), allowing visually impaired users to access simple contour-based images using vibrating touch screen technology. We provide an overview of the system's main functionalities and discuss some experimental results.

Categories and Subject Descriptors

H.5.4 [Hypertext/Hypermedia]: *Navigation,* K.4.2 [Social Issues]: *Assistive technologies for persons with disabilities*, H.5.3 [Group and Organization Interfaces]: *Web-based interaction.*

General Terms

Measurement, Performance, Design, Experimentation, Human Factors.

Keywords

Touch screens, vibration, accessibility, EVIAC, Contour-based images, Blind subjects, Blindfolded subjects.

1. INTRODUCTION

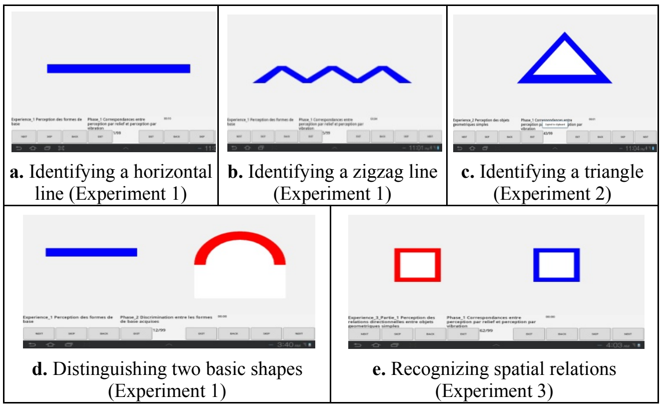
Accessing visual information nowadays becomes a central need for all kinds of tasks and users, namely visually impaired users. Existing accessibility tools like screen readers, Braille terminals and talking browsers are increasingly helping persons suffering from visual incapacities to access and manipulate information, and perform various kinds of activities previously deemed unfeasible for the visually impaired. Yet, these techniques are effective when accessing text-based contents [1, 2, 5, 10, 27], but remain fairly limited when handling visual contents. Most studies, in this field [14, 15, 20, 28, 31] focus on low-vision users by providing visual aids and image enhancement techniques like applying image filters (image contrast manipulation [22], spatial filtering [19], adaptive thresholding [21], and compensation filters [6]) to adapt image quality to the user's visual deficiency. Some techniques utilize 3D modeling [7, 17, 18] and tactile image printers [12, 14, 25], yet remain very expensive for everyday use, and are of limited use (single-purpose) and limited portability (where bulky equipments are usually needed). Other studies have investigated haptic feedback, using a force feedback mouse [30], or piezo-electric pins [23], in order to access mathematical charts and geographic maps [13]. Yet haptic-based approaches generally suffer of the same shortcomings mentioned earlier, namely cost, and lack of multi-purpose application [16].

Original studies in [4, 8] have addressed accessibility of simple visual representations (basic shapes and contours) on vibrating touch screens ([8] supports vibration and audio, whereas [4] investigates vibration-only), highlighting the potentials of touch screen technology.

The goal of our work is to provide an accessible and affordable (i.e., cost-efficient) means of presenting simple (contour-based) pictures for (totally) blind users. To do so, we build on the study in [4], investigating the usability of vibrating touch screens, as a low-cost solution providing a contour-based presentation of simple images for visually impaired users. This could be very useful in allowing blind people to access geographic maps [13, 29], to navigate autonomously inside and outside buildings [11, 26], as well as to access graphs and mathematical charts [3, 23]. We also aim to provide a low-cost, portable, and multi-purpose solution for digital presentation of simple images, in contrast with existing expensive, single-purpose and less portable techniques. Our main motivation is that the *potentials of touch screen vibration-based feedback ought to be fully understood prior to integrating other modalities* (such as audio or human speech). Initial experiments (in [4]) were performed only on blindfolded candidates (as an initial step) and yielded encouraging results. Hence, we extend our evaluation study to blind people, covering two kinds of testers: blind since birth and blind after birth candidates. In the following, we briefly describe our system and discuss some experimental results.

2. PROTOTYPE & EXPERIMENTAL SETUP

In our experiments, we aim to prove that *a properly formed contour-based image can be effectively perceived by the visually impaired when presented on a vibrating touch screen.* In order to confirm this hypothesis, we developed the *EVIAC* (EValuation of VIbration ACcessibility) prototype system (initially described in [4]), consisting of three main experiments: i) Recognizing basic shapes (lines, curves, zigzags), ii) Recognizing simple geometric objects (square, triangle, rectangle, and circle), iii) Recognizing spatial relations between simple geometric objects (directional, metric, and topological relations). Each experiment consists of 4 consecutive phases, testing if a blind person is capable of: a) Mapping the correspondences between shapes presented on an embossed paper, and their counterparts presented on a vibrating touch screen (this is also considered as a learning phase, providing the *tester* with the correct answers in order to allow the blind person to learn the right correspondences), b) Distinguishing between the basic shapes acquired in the previous phase, presented as doublets on a vibrating touch screen, c) Identifying, via multiple choice interrogations, the basic shapes already acquired in the previous phase, presented on a vibrating touch screen, and d) Identifying, without any additional indications (i.e., without multiple choices), the basic shapes already acquired in the previous phases, presented on a vibrating touch screen. Experimental procedures for each testing phase are described in detail in [4].



a. Identifying a horizontal line (Experiment 1)
b. Identifying a zigzag line (Experiment 1)
c. Identifying a triangle (Experiment 2)
d. Distinguishing two basic shapes (Experiment 1)
e. Recognizing spatial relations (Experiment 3)

Figure 1. Prototype snapshots.

The *EVIAC* protocol was implemented in a prototype system running on a mobile computer tablet (Samsung Galaxy Tab 10.1), with an android operating system. The prototype allows storing personal information about each test subject (name, age, sex, type of blindness, familiarity with touch screens, etc.), as well as tester answers, and finger path contours for each tested image (to be used in later studies for correlation and statistical analysis concerning user behavior). Note that there is only one vibration motor embedded in the device, hence the tester is asked to use one finger in touching the screen, and vibration is generated as the finger is moved over the stimulus. Note that existing studies using touch-enabled devices have found that use of only one finger was sufficient for vibro-tactile line tracing [9, 24]. Prototype snapshots are shown in Figure 1.

3. EXPERIMENTAL EVALUATION

A battery of experiments was first conducted on normal (blindfolded) candidates [4]. Here, we extent the experimental evaluation to cover blind candidates, categorized as: i) blind since birth, and ii) blind after birth, as well additional parameters such as information overload and fatigue. Experiments were performed on a total of 29 candidates, aged between 20 and 30, all of whom are familiar with personal computers and tablets: i) Six blind since birth testers (5 males and 1 female), ii) Seven blind after birth testers (2 males and 5 females), iii), Sixteen blindfolded testers (8 males and 8 females). Note that prior to executing the experiments, an *environment familiarization and discovery* step is required, in order to explain for each test candidate: the experiments to be conducted, the nature of each experiment, the tasks to be completed, as well as how to handle the vibrating screen (prototypical) environment.

In the following, we present the results obtained when conducting Experiments 1 and 2 of *EVIAC*. Note that phase 1 (Mapping between embossed paper and vibrating touch screen tactile perceptions) of each experiment is considered as a learning phase, allowing the subjects to correctly identify the mappings (correspondences) between objects presented on embossed paper and the touch screen. Figure 1 compiles the percentage of correct answers for each experiment. Results show a 79.58% average ratio of correct answers for the blind since birth testers, 62.11% average ratio of correct answers for blind after birth testers, and 86.61% average ration of correct answers for the blindfolded testers. Thus, results show that our accessibility method based on vibrating touch screen seems feasible for accessing simple contour-based images. However, we note that blindfolded testers performed better: with 8.11% more correct answers than blind since birth testers, and 28.29% more correct answers than blind after birth testers. Hence, we are currently further adjusting our prototype system, tuning vibration frequency, intensity, and variation (increasing/decreasing frequency/intensity based on the tester's finger position and its distance from the object on screen) in order to maximize the blind testers' performance. As an ongoing work, we are currently studying the finger path trails automatically recorded for each tester regarding each test phase, in order to analyze the different testers' groping strategies (by correlating the finger paths and the shape/object contours) when sweeping the touch screens.

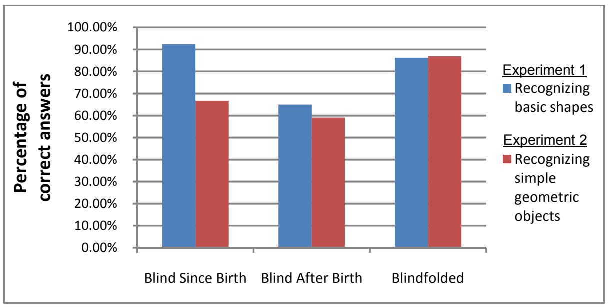


Figure 1: Percentage of correct answers presented for each category of testers, for experiments 1 and 2.

In the demonstration of *EVIAC*, we will provide an overview of the various components and functionalities of the system, and show how it enables contour-based image accessibility.

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