Design of Web-based Tools to Study Blind People's Touch-Based Interaction with Smartphones

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Abstract. Nowadays touchscreen smartphones are the most common kind of mobile devices. However, gesture-based interaction is a difficult task for the majority of visually impaired people, even more for blind people. This difficulty is compunded by the lack of standard gestures and the differences between the main screen readers platforms available in the market. Therefore, our goal is to investigate the differences and preferences in touch gesture performance in smartphones among visually impaired people. During our study, due to the constraints of the allocated resources and the availability of the participants, we implemented a web-based wireless system to facilitate the capture of participants' gestures. In this paper we present an overview of both the study and the system used.

1 Related work

In a previous study by the authors on touch-based interaction in smartphones, we noted that people with different types of visual impairment performed some gestures with more or less difficulty [1]. This motivated us to further study how visually impaired people perform touch gestures. Touch gestures are characterized by a set of attributes called descriptors, which can be geometric and kinematic (e.g., number of fingers, path length, velocity, etc.), and that are used by gesture recognition systems [2]. The differences in these descriptors influence the qualitative aspects of the gestures, like discoverability, ease-of-use performance, memorability, and reliability [3]. For instance, finger count, stroke count, and synchronicity have an important effect on perceived difficulty [4]. However, accessible computer-based interfaces across a myriad of available platforms is a complex challenge [5], particularly due to difficulties in recruiting users with disabilities for research studies [6]. For this reason, studies sometimes use sighted participants which are blindfolded or that are blocked from seeing the screen [7, 8]. However, blind people have difficulties in learning touch gestures [9]. For this reason, a study with blind people suggest not using print symbols, to reduce location accuracy demand, to use familiar layouts, to favor screen landmarks, and to limit time-based gestures [10].

2 Methodology

For our study, we recruited 36 participants (14 female, 22 male) from four different local centers for blind and low-vision people in Tuscany. The mean age of the participants is 45 years for females (SD=14.3) and 50 years for males (SD=16.8). We classified the 36 participants in four categories: severe low vision (11), blind since birth (7), blind since adolescence (6), and those who became blind in adulthood (12). 26 of the participants had previously used some kind of touchscreen mobile, like smartphones, tablets, and music players. In addition, more than half of the participants reported to have used iOS, with the rest using mostly Android.

We selected 25 gesture types, mostly from those used and Android's screen reader TalkBack, and iOS screen reader VoiceOver. The authors suggested other gestures in the set. Gesture selection was based on three main characteristics: pointer count (or finger count), stroke count, and direction. Also based on these characteristics, we classified the gestures in seven groups: swipes, letterlike shapes, taps, rotors, angled shapes, and to and fro swipes. When we described the gestures to the participants, we described a given gesture by its shape or by how it is performed; we did not give a semantic to the gestures.

We experienced difficulties for the capture of the participants' gestures with touchscreen smartphones. We needed to capture a set of gestures performed by visually impaired participants who were on tight schedules and were spread across geographically distributed local centers. Also taking into account the project's time and budget constraints, we needed to optimize the capture sessions. Therefore, we decided to work with multiple participants at the same time, using identical Android smartphones. In addition, to facilitate the data collection, we developed a Web-based system aimed at capturing the user gestures.

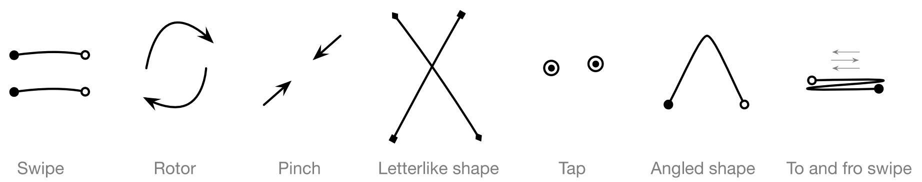

Fig. 1. Reference gesture groups and examples.

3 The gesture capture system

To capture participant's gesture, we used three identical Nexus 5 smartphones with a 4.95 inches display. All of our devices had Android v4.4 as the operating system. We developed a web-based client-server architecture to capture the participant's gestures. Up to three clients (smartphones) can connect simultaneously to a web server (a laptop) through a Wi-Fi local network. The connection was via WebSockets, which allowed interactive sessions between the server and the smartphones. Gesture data and capture parameters were transmitted as JSON and serialized within an SQLite database.

From the server dashboard, we could select the gesture type and start or cancel a given capture session. These commands would be sent to all the connected smartphones, so the participants could perform their gestures with minimal interruptions. We could also visualize each gesture as it was performed, using the canvas API. In addition, we integrated automated and manual mechanisms to mark a participant's gesture in case their gesture did not match the gesture type characteristics (e.g., number of fingers, strokes, direction, etc.).

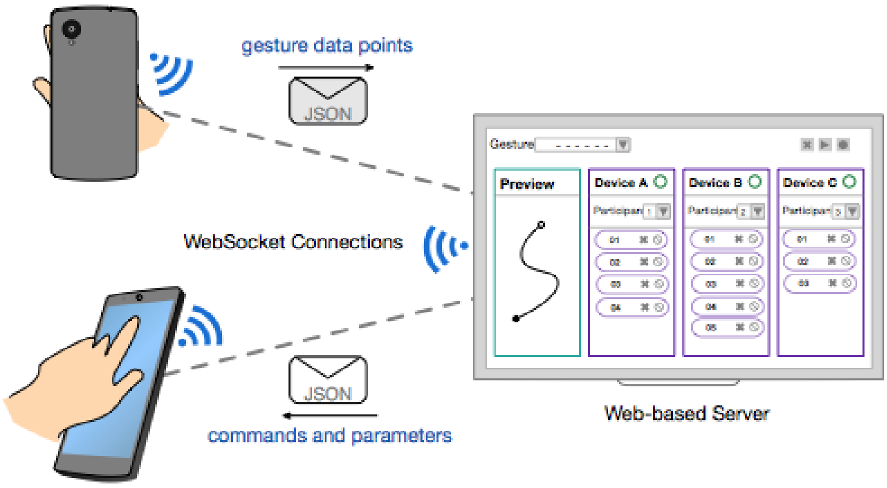

Fig. 2. Wireless client-server architecture used to capture participants' gestures.

4 Procedure

We arranged four different sets of capture sessions, each for every local blind association. In each location, we had one, two or three participants per session, according to their availability schedule. Additionally, we sorted the set of gesture types by increasing difficulty, according to our perception, in order to avoid participants' frustration. Each session lasted approximately 75 minutes and it consisted of two parts. The first part consisted in capture of the gestures per se, and the second part consisted on a questionnaire in which we collected data about the profile, mobile devices use and gesture preferences of the participants.

The 36 participants were asked to perform each of the 25 gestures six times, with the goal of having 5400 gesture samples. For every gesture type, we initially told the participants the name of the gesture, how to perform it, and then we recorded if they already knew or had done the gesture or not. We also asked them to rate its difficulty, using a five-point scale, from 1 (very easy) to 5 (very difficult). We had cardboard cutouts of most of the gestures in case any of the participants needed a tactile representation. To manage the session, a researcher would use the web-based server to visualize each participant capture and record the data for each gesture. We also implemented an automated mechanism to mark captures with an incorrect number of simultaneous pointers or consecutive strokes, according to the reference gesture.

5 Results and discussion

In general, participants perceived a low level of difficulty of most of the gesture types (mean=1.49, median=1). The most difficult gestures, as perceived by the participants, were to and, and rotor, while the easiest gestures were simple swipes with one finger, one stroke, and one direction. However, we noted a slight increase in perceived difficulty in longer gestures with similar descriptors. Concerning gesture shape preference, half of the participants preferred rounded gestures, six steep-angled gestures, two right-angled gestures, and ten reported having no preference. In addition, the majority of the participants also preferred gestures with one finger (22 participants, and one stroke (19 participants). Regarding differences among the visually impaired groups, we found noteworthy variations, and in one gesture, the vertical chevron, the difference in sharpness was significant.

We would like to note that despite the issues solved by our solution, we had other issues to capture the gestures. For instance, the average age of our participants, 48 years (SD=15.8), means younger visually impaired people are underrepresented. In addition, participants would sometimes perform a gesture outside the boundaries of the screen due to the lack of tactile edges. Other times, participants' fingernails would make contact with the display, and the gesture was not recorded as intended, especially in women with long fingernails. In the first location, an issue we had inherent to wireless capture system was multipath propagation [11]. This kind of interference occurred when the signals sent by the mobile devices to the web server, and vice versa, arrived by more than two paths or canceled each other. The construction materials used in the room where we perform the sessions caused this interference. Therefore, we relocated the equipment and participants, and in subsequent locations we did a preliminary signal strength test. Despite these issues, in the end, thanks to our capture solution we were able to make effective use of our limited time with the participants.

6 Conclusions

More research is needed in regards to accessible and mobile touch-based interaction for visually impaired people, especially for those who are blind. In this paper we presented an overview of a study on gestures preferences and differences among visually impaired people. We also presented how the use of wireless and web based technologies can solve some of the problems that might arise during such studies. Given that we mainly used web technologies, similar research tools could be implemented across different mobile platforms with relative ease, compared to native solutions [12].

7 References

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