

Evaluating Touchscreen Interfaces of Tablet Computers for Elderly People

Martin Burkhard, Michael Koch

CSCM Cooperation Systems Center Munich, Bundeswehr University Munich

Abstract

The AAL project SI-Screen focuses on providing an innovative user interface for elderly people enhancing their access to awareness streams of Social Networking Services by using tablet computers. As part of our attempt to investigate the acceptance of the newly developed user interface, we assessed the display size and touch input accuracy of multi-touch tablet computers in a multi-directional tapping task as proposed by the ISO 9241-9 standard. In this paper we present our methodology for evaluating touchscreen interfaces with elderly people and discuss our initial findings obtained in Germany and Spain.

1 Introduction

The core innovation of the Ambient Assisted Living (AAL) project Social Interaction Screen (SI-Screen) is the creation of an easy-to-use solution for supporting social interaction of elderly people via Social Networking Services (SNS). The users should be supported in maintaining social bonds to family and friends as well as in taking part in local activities where they can meet peers of same age and similar interests (also see Burkhard 2012).

Based on our preliminary interviews in Germany and Spain, we found personal computers and their conventional user interfaces as major obstacles for elderly people to benefit from SNS (Burkhard et al. 2012). As a consequence, we decided to create the *elderly interaction and service assistant (elisa)* as a portable tablet computer equipped with a multi-touch screen. To overcome the obstacles, we are currently re-configuring the look and feel of existing tablet hardware, customizing the graphical user interface according to the needs of elderly people, and creating new ways to interact with and in different SNS via a new Social Software Integration Layer.

For designing the hardware we had to find which kind of tablet computer would fit best for our target group. To do so, we did an evaluation of tablet devices with elderly users.

In this paper, we present the methodology and initial results of our tablet evaluation in Germany and Spain. In Section 2, we introduce the applied ISO 9241 part 9 (2002) standard for testing non-keyboard input devices, and describe our evaluation method. Our initial results and observations are presented in Section 3. Finally, in Section 4, we conclude with a discussion of our findings.

2 Methodology

The guiding questions for the touchscreen evaluation were: (1) What are the acceptance factors of elderly people for multi-touch tablet computers? (2) On what tablet computer do elderly people achieve high touch accuracy? And (3) what is the minimum size of a touchable element to ensure high hit rates ($> 75\%$) on the newly designed user interface?

While Question (1) was mainly covered by interviews, the challenge for answering questions (2) and (3) was to find an applicable approach to compare the touch accuracy on tablet computers differing in screen size, display resolution and physical dot density. Consequently, we reviewed similar studies evaluating touch interfaces in particular with regard to older adults (Greenwood et al. 2006; Holzinger 2002; Umemuro 2004). We came to the conclusion to follow the multi-direction tapping task (MDTT) proposed by the ISO 9241-9 standard (2002), and to apply Fitts' law equation $ID = \log_2 \left(\frac{D}{W} + 1 \right)$ to compare the results of different tablet computers.

2.1 ISO 9241-9: Evaluating Non-Keyboard Input Devices

The ISO 9241-9 (2002) standard proposes a range of performance tests to evaluate the *ergonomic requirements for non-keyboard input devices*. The focus of the standard lies on measuring the accuracy of computer mice, joysticks, trackballs, pens as well as touchscreens (Douglas et al. 1999; Soukoreff & MacKenzie 2004).

Figure 1 shows the configuration of the multi-directional tapping task (MDTT) as proposed by DIN EN ISO 9241-9 (2002). During the test, participants have to tap on circles in order of the predefined sequence (Figure 2). The position and size of every circle is calculated according to Fitts' logarithmic algorithm (Fitts 1954).

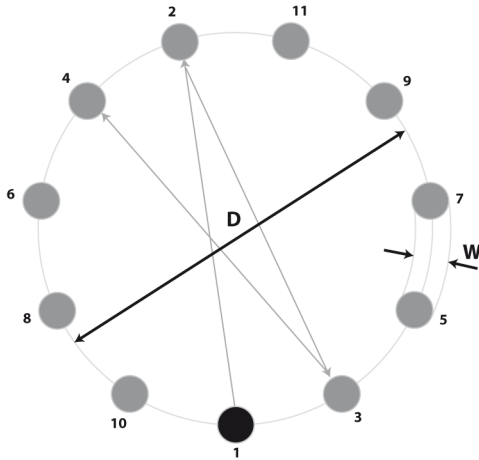


Figure 1: Multi-directional tapping task (ISO 9241-9 2002). Illustration adapted from Soukoreff & MacKenzie (2004).



Figure 2: Elderly person performing Multi-directional tapping task on Android tablet (Lux et al. 2012).

2.2 Participants

The MDTT has been evaluated with 30 elderly participants in Germany and Spain. 15 elderly people have been tested in Spain and 15 in Germany. As Table 1 shows, while the average age of 65.7 was quite similar in both countries, the gender distribution was differently unbalanced (Barberà et al. 2012). Additional characteristics, including previous experience of the participants with touch devices, are being analysed and will be presented in future publications. For the tests the elderly participants were instructed to focus on tapping accuracy.

		Gender		Age			
		Woman	Man	Minimum	Maximum	Average	SD*
Country	Spain	66.7% (10)	33.3% (5)	57	91	65.87	8.975
	Germany	86.7% (13)	13.3% (2)	58	76	65.53	5.527
Total		76.7% (23)	23.3% (7)	57	91	65.70	

Table 1: Distribution of participants by country, gender and age ($n=30$). *SD = Standard Deviation
Source: (Barberà et al. 2012)

2.3 Tablet Computers

Table 2 presents the four tablet computers employed during evaluation, with focus on different form factors, materials, mobility and customizability. Every chosen tablet has a resistive touchscreen and varies in shape, display size, weight, grip zone for resting the fingers and

either has a plastic or metal housing (also see Lux et al. 2011). In our test we concentrated on Android™ tablets as their hardware components are available as tablet manufacturing kit creating a fully customized *elisa* tablet. In contrast the Apple iPad™ is inappropriate for replacing the hardware housing and standard graphical user interface.

The tablets were tested in random order to avoid influence on tablet rankings by participants in the subsequent interviews (Section 3). Each tablet differs in display size, screen resolution and pixel density. Accordingly, based on the ISO movement distance D derived from the screen height and the ISO difficulty index ID , the comparable ISO element width W of every circular element (Figure 1) could be determined by Fitts' law.

		Samsung Galaxy Tab 7.0™	Samsung Galaxy Tab 10.1N™	Sony Tablet S™	Sony Tablet P™
Display size (in inch)		7,0"	10,1"	9,4"	2x 5,5"
Screen resolution (width x height in Pixel)		1024 x 600	1280 x 752	1280 x 752	1024 x 912
Pixel density (in DPI)		168.9	149.8	161.3	206.5
ISO D (in mm)		63,42	101,40	92,28	86,80
ISO W (in mm)	ISO ID = 2.5 / 3.0 3.5 / 4.0	13,53 / 9,02 6,01 / 4,21	21,70 / 14,41 9,83 / 6,61	19,84 / 13,07 8,82 / 6,14	18,62 / 12,33 8,38 / 5,67

Table 2: Comparison of the four Android tablet devices and the ISO values calculated by the test application.
Source: (Lux et al. 2012) based upon product specifications.

2.4 Test Application and Measurement

The Android™ test application by Lux, Müller & Burkhard (2012) performs a total of twelve MDTTs for every participant per tablet. In order to identify the minimum element size for high hit rates (>75%) four difficulty indexes (ID) ranging from *very easy* ($ID = 2.5$) to *very hard* ($ID = 4.0$) are tested. Depending on the ISO ID and ISO D the diameter (ISO W) and the position of the 11 circles in test (Figure 1) are calculated (Table 2) by Fitts' equation. Each of the four ID s are randomly repeated three times to ensure the results are statistically valid.

Every MDTT task starts at the same start position (circle nr. 1 in Figure 1) and ends at the last element (circle nr. 11 in Figure 1). Consequently, eleven single taps have to be carried out. While a MDTT task is in progress, the test application records every single tap on the touch screen measuring the exact position of the finger, distance from the position to the active circle's centre and the movement time between each touch. Every time the test candidate taps outside of the active circle, the test candidate has to repeat the tap for the same

element again. Consequently, the *error rate (ER)* for every MDTT is defined by the *amount of taps (N)* and the *number of circles* divided by the *number of circles*: $ER = \frac{N-11}{11}$.

3 Initial Results

Overall elderly participants had the lowest MDTT error rate of 37.6% (SD = 8.05) on the Galaxy Tab 10.1NTM (Table 3). In contrast, the majority of the participants had difficulties in performing the test on the Galaxy Tab 7.0TM resulting in a high error rate of 55.9% (SD = 35.99). Comparing the results of the two countries, elderly Germans performed better in terms of tap accuracy. However, this result is non-significant as factors like age (Bakaev 2008), gender and motor skills have not been respected.

		Error Rate of Multi-directional Tapping Task			
		Galaxy Tab 7.0	Galaxy Tab 10.1N	Tablet S	Tablet P
Country	Spain	61.8 % (SD = 44.11)	38.3 % (SD = 9.01)	47.5 % (SD = 21.18)	46.9 % (SD = 24.91)
	Germany	50.1 % (SD = 24.27)	36.8 % (SD = 7.17)	43.1 % (SD = 15.17)	41.6 % (SD = 14.45)
Total		55.9 % (SD = 35.99)	37.6 % (SD = 8.05)	45.3 % (SD = 18.81)	44.2 % (SD = 20.58)

Table 3: Recorded MDTT error rate of evaluators in Spain and Germany (n=30). SD = Standard Deviation
Source: (Barberà et al. 2012)

Table 4 lists the tablet rankings of the elderly participants based on their placements after all tests were completed. The results show that tablet computers with the largest screen size were placed first. While Spanish participants favour the Tablet STM, the German interviewees prefer the Galaxy Tab 10.1NTM. Overall, the Galaxy Tab 10.1NTM came in first with 82 points according to the applied 4-Point ranking (see Table 4).

		Tablet Computer Ranking			
		Galaxy Tab 7.0	Galaxy Tab 10.1N	Tablet S	Tablet P
Country	Spain	3 rd place (32)	2 nd place (38)	1 st place (42)	2 nd place (38)
	Germany	2 nd place (37)	1 st place (44)	4 th place (34)	3 rd place (35)
Total		Place 4 (69)	1 st place (82)	2 nd place (76)	3 rd place (73)

Table 4: Consolidated tablet rankings based on placements by interviewees in Spain and Germany (n=30).
4-Point Ranking: 1st place = 4 points. 2nd place = 3 points. 3rd place = 2 points. 4th place = 1 point.
Source: (Barberà et al. 2012)

4 Discussion

In the interviews a majority of elderly participants in Germany and Spain reported overall acceptance of using touch and their preference for large screen sizes and light tablet weight. However, there is no common opinion on the favourite tablet computer. Eventually, the Galaxy Tab 10.1N™ placed first according to the measured touch accuracy and by point ranking. Accordingly, a 10.1 inch touchscreen will be used for the elisa tablet computer. Moreover, based on the hit rates the touchable elements of the graphical user interface should have a minimum diameter of about 9 mm. To get a clearer picture, a future publication will combine the results presented in this paper with the technical affinity and finger movement time of each participant. Moreover, the conducted interviews after every tablet computer was tested will be consolidated and related to the tablet rankings.

From our initial findings, Fitts' law equation helps in comparing the measurement results of different tablet devices. However, factors of age (Bakaev 2008) and gender as well as dry finger skin and different age-related cognitive-motor skills should be considered. In particular, our observations indicated that elderly people with dry or wrinkled fingertips had a significant higher touch recognition error rate on some tablets (Lux et al. 2012). This could also be related with the layer types of the resistive touchscreen technology. We also discovered that elderly people mainly used their forefingers during test and rarely adopted their tap strategy to the predefined touch sequence.

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Contact

Martin Burkhard, Michael Koch
Bundeswehr University Munich
CSCM Cooperation Systems Center Munich
Werner-Heißenberg-Weg 39, D-85577 Neubiberg, Germany
E-Mail: {martin.burkhard, michael.koch}@unibw.de
WWW <http://www.kooperationssysteme.de>