Usability Testing of the Interaction of Novices with a Multi-touch Table in Semi Public Space

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Abstract. Touch-sensitive devices are becoming more and more common. Many people use touch interaction, especially on handheld devices like iPhones or other mobile phones. But the question is, do people really understand the different gestures, i.e., do they know which gesture is the correct one for the intended action and do they know how to transfer the gestures to bigger devices and surfaces? This paper reports the results of usability tests which were carried out in semi public space to explore peoples' ability to find gestures to navigate on a virtual globe. The globe is presented on a multi-touch-table. Furthermore, the study investigated which additional gestures people use intuitively as compared to the ones which are implemented.

1 Introduction

Multi-touch is used more and more on many different devices and in many places, especially on handhelds but also on walls or tables in (semi) public space. Many people of all ages and experiences have access to multi-touch-devices. But it is not clear if all of them are familiar with ways to interact with such devices. Although many people commonly use virtual globes on their PCs to navigate the whole world, it is difficult for them to use a virtual globe on a multi-touch-table. This usability tests examined how a wide audience of untrained users in semi public space deal with a multi-touch-table on which a virtual globe is shown. We conducted the usability tests to introduce another form of human computer interaction. Especially for people who are not familiar with technical issues the multi-touch-devices could help them to interact with a computer. One could conjecture, the interaction is easier for them because it is very direct and they need not use other input devices such as mouse and keyboard. Hence, it is very important that the system works as they suggest and the gestures must be as intuitive as possible. Obviously, we chose novice users to do the usability tests because they are not familiar with other multi-touch-devices. We postulated that they do not know the gestures which are implemented in other systems nor could they infer gestures on our multi-touch-table from their previous knowledge. Because of this, they are most comparable to the mentioned user group which is not familiar with technical issues at all. We carried out our test not as a laboratory experiment but as a field study, because in this case we could ensure that the surroundings and the environment are similar as possible to the situation where such tables would be placed for the final usage.

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The used Software is a GoogleEarth multi-touch-version[1]. The main goal of the research is to examine if users of the table can find and use the gestures which are necessary for the use of the multi-touch table without any explanation. The following gestures are examined: One gesture to move the map (pan), one to enlarge or shrink the image (zoom) and one to change the inclination angle of the "camera" (tilt). These are the three basic operations which can be performed on a virtual globe. Furthermore, we investigated whether users perform other gestures to fulfill the task and how these gestures look like.

The first main test took place at the institute of political science of the University of Münster. In both tests the subjects were asked to fulfill a task on the multi-touch-table in which every gesture has to be executed. To determine the goal the user had while making a gesture, users were asked to talk about it.

In a second usability test, we investigated another group of possibly novice users: Children of a primary school in Rheine (Westphalia, Germany). We repeated our study with children, because we expected the children to be real novices with no previous experience in multi-touch. Furthermore, in pilot studies multi-touch-tables have been successfully used as learning devices in schools. The setting of the usability test had to be slightly adapted from the one with the adult user to meet the children's and the school's requirements.

Over the course of the paper the following issues are explained in detail: The second section introduces related usability studies with touch-sensitive devices in different settings. In the third section, we describe the technical background of our own study and the implemented gestures are explained. Furthermore, we report on our test results in the fourth section. Finally, we conclude with a discussion and give directions for future work.

2 Related Work

The usability of multi-touch-devices has been investigated in several studies previously. While our study was located in semi public space, many of the other usability experiments have been conducted as laboratory tests, such as Moscovich's et al. [9] and Wu's et al. [18]. In Moscovich's test, subjects could drag and manipulate easy geometric objects like squares and circles with one or two fingers. In Wu's test the subjects had to plan a room on a multi-touch-table with a special room planning software. To fulfill the task the subjects had to use gestures, but they were explained to the subjects before the test started. Only a few of the tests refer to virtual globes like they have been used in our research, e.g. the one of Tse et al. [16], which was rather an informal test with colleagues during the implementation of a set of gesture for navigating on virtual globes. Furthermore, the gesture set was complemented by speech recognition. In this test, panning and zooming, which have been the same as in this test, could be found easily. The expected tilt gesture, an upwards movement of the hand, a 3D gesture, could not be implemented on the used hardware. The implemented gesture was the usage of five fingers but this one was hard to find for the subjects.

[1] http://nuigroup.com/forums/viewthread/5422/

Other usability tests took place in public places as in this study, however in very different environments. One of them is conducted in the city center of Helsinki, Finland. A multi-touch-wall was installed by Peltonen et al. on which you can manipulate pictures from the Internet platform “Flickr” by using gestures. They mostly studied the group behavior of the users, so called multi-user approach and not a multi-touch single-user approach as we do. Furthermore, they studied the usage of gestures but this was done during the manipulation of pictures and not of virtual globes [10]. Also in a city center, Schöning et al. asked users of a multi-touch-wall about their behavior while using virtual globes. In this study emphasis was not put on the usage of the gestures although they were needed to fulfill the given task [15].

In exhibitions, field studies with multi-touch-tables and walls have been carried out already. During the exhibition “Deutschland, Land der Ideen” (“Germany, Land of ideas”) pedestrians were observed in a pedestrian underway in the city of Münster (Westphalia), Germany, while using a multi-touch-wall. The focus was on the spontaneous interaction with the shown virtual globe and the group behavior of the users and not on the used gestures [3]. In the “Museum of National History” of Berlin, Hornecker installed a multi-touch-table with so called “Tree of Life”-Software and observed how users approach the table and use the software which did not provide a virtual globe or a map. The shown content mostly was in question/answer form [7].

In all these works the interaction with the multi-touch-device is possible through various gestures but testing the ability especially of novice users to find and use them is very rare, e.g., Daiber et al. and Hornecker mention it in passing [3, 7].

Possible intuitive gestures were only investigated by using questionnaires or laboratory tests, but not by the use of the multi-touch-device on site [4, 17]. Only Daiber et al. ask for gestures to use virtual globes [3]. Hornecker describes gestures which are made in the situation of the usage but they are not used to navigate on a virtual globe [7].

With Children a few studies have been done, but none with virtual globes. Most of these studies analyzed the group behavior of the subjects and the cooperative usage of such a device [2, 11]. A usability test on a multi-touch-device was only done by Rick et al. [13] and Harris et al. [6]. They used learning software for children but mostly studied the differences between a single- and a multi-touch version of their software. Furthermore no gestures had to be used and the usage was explained to the children before. Many studies have searched for the best method to study children. They compared questionnaires, interviews and different “Thinking-Aloud”-Tests [5]. The result was that “Thinking-Aloud”-Tests and especially the “Constructive Interaction” Method, where subjects do a “Thinking-Aloud”-Tests in small groups, are the best methods [1]. Furthermore, the studies showed that questionnaires must not be too difficult and not have too many answering options [5]. Another point is that fun is important point for children in their rating [8]. Their findings strongly influenced our design of the usability test with children.

3 Fundamentals

3.1 Technical Background

The software used was a Google Earth plug-in for web browsers, which allows multi-touch-interaction with Google Earth. The software which detects the contact with the surface is Community Core Vision[2], an open source software of the NUIGroup. The hardware is a self-made multi-touch-table in which the technical equipment, like the used PC, the projector and infrared lights, is placed. The table has a width of 110cm, a depth of 60cm and a height of 79cm. The size of the display is 84x52 cm. To recognize the touches on the surface the rear diffused illumination technique is used. In this method the embedded camera recognizes the infrared light which is reflected by the touches on the surface in addition to the standard reflection of the frame.

3.2 The Gestures

The gesture to pan the map is done with one finger. The finger is placed on the surface, the map is anchored on this point and is paned when the finger moves.

There are two ways of performing the zoom gesture: With one hand and two of its fingers or with two hands and one finger of each. In both cases there are two points of contact with the surface. The two fingers are moved together to zoom in whereas they are moved apart to zoom out. In general this gesture is called “pinch to zoom”.

The gesture to tilt the camera perspective, e.g., to show differences in the terrain or 3D-buildings is a gesture with three points of contact. It can also be performed with one or two hands. Two contact points are not moved and the third is moved in vertical direction. With a contact from the front side of the table to the rear side the inclination of the camera becomes more horizontal and the contrary if the finger is moved from the rear side to the front side.

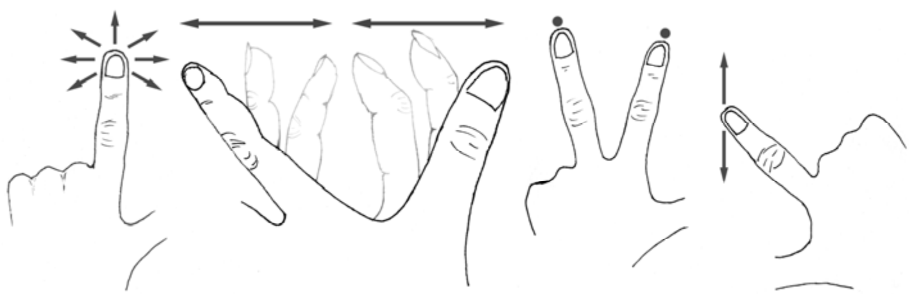

Fig. 1. The investigated gestures pan, zoom and tilt

4 The Tests

4.1 Main Test with Adult Subjects

The main-test took place in the lobby of the building of the institute for political science at University of Münster. The subjects were students with no background in computer science. The subjects were asked whether they want to fulfill a short task at the multi-touch-table right after their arrival. They were given the following task: *“Please navigate to a point of interest, show it in detail and tilt the camera to see if there are 3D-buildings.”*

[2] http://ccv.nuigroup.com/

It was not only observed whether the subjects found the gestures to operate the table and which ones they found but also how many tries the subjects needed to find it. We asked the subjects whether they found it easy to apply the gesture and whether they had problems to find the gesture.

While the subjects were doing the task they were observed by the interviewer whether they could find and use the implemented gestures. After the test the interviewer asked some statistical questions about age and gender followed by questions about the subject's experiences and feelings in the test. In addition video recordings were made to verify the found gestures and to recognize the gestures made intuitively in an analysis after the test.

In the case where a subject did not find a gesture the interviewer did not interrupt the subject. Most subjects stopped trying after three or four unsuccessful attempts. However, the right gesture was explained to the subject in two cases. On the one hand, if the subject asked for the right gesture after some time or on the other hand if the subject was thinking for about 30 seconds without operating the table.

A total of sixteen subjects participated in the test. Ten of them were female, six male. A female subject had to be excluded from the analysis, since she said to have quite a bit experience with multi-touch and could not be seen as a novice user. Her results have not been analyzed. Thirteen subjects were right-handed, two were left-handed and all of them were between 20 and 30 years old. Everyone knew the Google Earth software. Only two subjects said to have medium experience with multi-touch. Only 22.2% of experienced users and 13.3% in general had experiences with a large multi-touch-device.

73.3% of the users approached at the table when it was not in use while the other 26.7% entered it when somebody was using it. So it is possible that these subjects learned from the user who was at the table previously [14]. Every user found the gestures to pan. The zooming gesture was found 80%. The tilt gesture was only found 6.7%.

Seven subjects made unsuccessful attempts until they found the panning gesture. But everyone only had one unsuccessful attempt until finding the gesture. A remarkable fact is that some of them changed back to the wrong gesture although they had found the right one. The average of unsuccessful attempts was 0.47. Multiple uses of the same wrong gesture were only counted as one unsuccessful attempt.

While searching the zoom gesture, the subjects made more unsuccessful attempts. Seven subjects made one, one subject made two and two subjects made three unsuccessful attempts. On average the subjects made 1.25 unsuccessful attempts with a standard deviation of 0.92. The subjects that did not find the right gesture of course made unsuccessful attempts only. Also in this case every usage of the same wrong gestures was only counted once.

The subject who found the tilt gesture made one wrong gesture until he found the right one. Furthermore only two attempts to find the gesture were made. All other subjects said to have no idea how it could work and did not try to find out.

Also the duration until the subjects found the gesture was measured. It differs in the case of the panning gesture from one up to 33 seconds and for the zoom gesture from five up to 75 seconds.

Subjects that had medium experience made no mistake during the usage of the pan gesture. The number of unsuccessful attempts aggregates to seven, divided nearly similar to the other two groups.

Three subjects that almost had no experience with multi-touch were able to find the zoom gesture. But they had, on average, 2.33 unsuccessful attempts until they found it. This value is more than one attempt below general average. Subjects with a little experience or medium experience only had 0.86and 0.5 unsuccessful attempts respectively. So absolute novice users make more mistakes but half of them were able to find the zoom gesture.

Also the assessment of the simplicity was different in these user groups. Medium experienced subjects described the simplicity of finding the gesture easy or very easy, little experienced users said it was neither easy nor difficult. In both cases this is above general average. Only subjects with almost no experience assessed it on average as difficult. The results in simplicity of the usage of the gestures are similar. Again the medium experienced subjects assessed the gestures on average as easy to use, the subjects with little experience again said it was neither difficult nor easy, and although those with almost no experience gave the worst marks, they were still passable. But in this case one has to keep in mind that they only evaluate the gestures they have used and half of the subjects only found and used the zooming gesture.

The average duration until the subjects found the panning gesture was 9.6 seconds and the zoom gesture 29.1 seconds. In both cases the medium experienced were the fastest with 1.5 and 8.5 seconds respectively. The second fastest in finding the panning gesture were the inexperienced with 7.5 seconds and third were the little experienced with 13.7 seconds. The reason for this surprising result could be that the inexperienced touched the table much more carefully and so did not use the whole for panning first. The results for the zoom gesture were 8.5, 24.6 and 53.3 seconds in the expected order.

The Spearman Rho correlation analysis shows that the experience of users is strongly correlated to the success of finding and using the gestures. Also these two questions are strongly correlated to each other. Furthermore strongly correlated are the number of mistakes and the duration until the finding of the zoom gesture. This variable is also strongly correlated to the two simplicity questions. Not as strongly connected as the just mentioned variables, are the experience to the mistakes and duration of the zoom gesture. Other variables are not correlated.

4.2 Main Test with Children

Following previous studies [1, 5, 8] mentioned already in the related work, we adapted our study design for the main test with children. We invited children in small groups to test the multi-touch-table. Besides the constructive interaction method, a short questionnaire was used. The children were asked about their experience with computers and especially multi-touch. Furthermore, they were asked if they had fun in using the table and whether they found it easy or difficult. All these questions were only separated in two answer possibilities but in the simplicity question the children gave three different answers. Additionally, statistical notices about the grade, the gender and the found gestures of the children were made. Because of the group situation it was too difficult to count mistakes while searching the gestures. But the duration until a group found the right gesture was measured.

42 children in nine groups took part in the test. 23 were female and 19 male, 36 right-handed and six left-handed. All of them had experiences with computers and had fun in fulfilling the exercise.

20 children said they had no experience with multi-touch, 21 said they had experience, one said “a little”. The devices on which the children had collected their experiences were very different and not all are comparable to the used multi-touch-table. The simplicity was judged easy by seven subjects, “middle” by 26 subjects and difficult by eight subjects. One child made no statement.

In all groups the panning gesture was found by at least one child, all together by 25. The zooming gesture was found by three experienced children in three different groups, who had different experience on average. Nobody found the panning gesture and not many attempts were made to find it. The duration until the gestures were found in the groups differs between 10 and 185 seconds for the panning gesture and between 48 and 195 seconds for the zooming gesture.

Experienced children judged the table a bit better than the inexperienced but if you do a correlation analysis between these two variables you can see that they are not significantly connected. This counts for the cases subjects and groups. Also the duration until the finding of the gestures and if the zoom gesture was found is not connected to any other variable.

So it can be said that for children it seems not to be very important as for adult subjects to have experiences to work with the table properly, although all children who found the zoom gesture had experiences.

4.3 Results and Analysis of Additionally Used Gestures

For the analysis of additionally used gestures we included all subjects in the analysis, i.e., the subjects of our pretest, main test and those who were excluded from the analysis due to their previous knowledge or since they did not agree to participate but still used the table.

Our analysis of additional gestures showed that many users prefer to pan the map by using multiple fingers instead of one finger (seventeen (adult), twenty (children)). Moreover, somebody tried to rotate the globe by snapping his finger over the surface and it was tried to move the globe itself when the zoom level was low and not the whole display was covered.

When zooming, there were two gestures that have been mainly used in addition to the implemented ones. This is the known double click of the desktop version (eighteen, fifteen), and the use of all fingers of the hand in opposite to the thumb instead of just one finger (thirteen, twelve). Two users who made the gesture implemented it as a two-hand gesture, but not with one finger per hand, but with two fingers. In addition one subject attempted to click on the “stars” which mark the towns in GoogleEarth, another one attempted to press on the surface for a longer time and as well people searched for buttons and commands in the menu bar on the right hand side of the display.

For the tilt of the camera mainly the whole hand or several fingers were tipped over the surface (three). Moreover many gestures were used only once or twice: The turn of all fingers on the surface, a sliding movement with more than one finger and the back of the hand. Furthermore, the implemented gesture was one time used “inverse”, i.e., one finger attached and two fingers moved. Even for this gesture buttons were searched.

In particular, for panning and zooming there were gestures which have been used intuitively very often. An implementation of these would simplify the handling of the table. Especially the gesture double-clicking or double-touching in this case and pinch to zoom with more than one finger for zooming, and the possibility to move the map with more than one finger for panning would be helpful. Based on our usability test we could not find a set of intuitive gestures for tilting and suggest providing users with additional information on this functionality. We believe that the reasons for the usability problems are caused by the dimensionality: Tilting of the map is a 3D action, but the surface allows only for 2D gestures.

For the tilt gesture it is notable that many users of the table, who have not been given the task, were not even aware that there is the possibility of tilting the image. They only noticed it when they had accidentally tilted the image. But after that they did not try to restore it but left the table quickly or pressed the "Reset Position"-button.

In the children test we found similar results with respect to additionally used gestures. However, interesting differences were discovered regarding the behavior of children: Children tried out many more different gestures per subject, except for the tilting operation. For this operation the most used gesture was the sliding of a flat hand over the surface. While adults spent more time on thinking, children were quicker to test numerous different gestures. Children obviously had fewer reservations to touch the table (however this might be influenced by the slightly different group setting). Another interesting finding is that children tried out the same gestures not only for one but for different operations. These were sliding of the whole hand over the table, the rotation of the fingers on the table and a parallel sliding of some fingers from different hand over the table. All three were tried for zooming and tilting. A correlation analysis of the experience of the groups and their additionally used gestures showed that more experienced children tried more gestures than inexperienced ones. The reason of this result could be seen very well throughout the tests. Inexperienced children were more afraid to touch the table than experienced ones and so they did fewer gestures. The children's judgment of the simplicity is not correlated to the number of additionally used gestures.

5 Conclusion and Future Work

The tests show that many but not all young people aged between 20 and 30 years know intuitively how to operate a multi-touch-table even if they have no experiences. Especially panning and zooming is no problem for most of them. They find the needed gestures and are able to use them. Some other gestures like the double click or the panning with more than one finger which have been done by some subjects should be implemented and tested in future.

Only some of the subjects were able to find the tilt gesture. So this one does not seem to be intuitive but our test results did not reveal other alternative gestures which could be implemented instead. In further developments the gesture should not be used without an explanation.

Although children interact faster and more frequently with the table, it is more difficult for them to find the right gestures and they should be provided with more explanations. It does not matter if the children have a bit of experience or not.

The present study tested users who are up to 30 years old. In future work older user groups, so called digital immigrants [12], should be studied. In addition, people without experiences with multi-touch and without experiences with GoogleEarth should be studied. In another study of children the groups should be smaller or at least only one child should be studied because too many hands are confusing for the table and the study as a whole.

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