Gesture Tracking And Recognition In Touchscreens Usability Testing

Kamil Cichoń
Faculty of Computer Science and Management
Wroclaw University of Technology
Wyb. Wyspiańskiego 27
50-370 Wrocław, Poland
197440@student.pwr.wroc.pl

Janusz Sobecki
Jerzy M. Szymański
Institute of Informatics
Wroclaw University of Technology
Wyb. Wyspiańskiego 27
50-370 Wrocław, Poland
janusz.sobecki@pwr.wroc.pl
jerzy.szymanski@pwr.wroc.pl

Paper presented at MIDI 2013 Conference, 24-25.06.2013, Warsaw, Poland.

Abstract
In this paper we present a tool for gathering touchscreen data for usability analysis. Touchscreens are becoming the most popular input/output device mainly because of increasing number of smartphones and tablets. As the interaction with touchscreen differs from interaction using standard devices such as mouse or touchpad it is necessary to deliver special tools for data gathering and methods for usability analysis.

Author Keywords
Touchscreen, Gestures recognition, HCI, TUIO, Usability

ACM Classification Keywords
H.5.2. Information interfaces and presentation: Input devices and strategies, Interaction styles, Theory and methods

Introduction
Touchscreens are nowadays one of the most popular devices used in interaction with different types of mobile systems, such as smartphones, tablets or GPS devices. Despite of the mobile devices touchscreens are applied also in stationary devices such as ATM's (Automatic Teller Machines) or POI (Point Of Information) or POS (Point of Sale).

The popularity of touchscreens is a consequence of their functionality, they are both an input and output devices that enable control of any application using different gestures and presenting information in a graphical form. However touchscreens have been known over 40 years already, it is only about 10 recent years that have brought the great increase of their popularity. During that time touchscreens have been built using several different technologies such as: resistive, capacitive, infrared, surface acoustic wave (SAW), strain gauge, optical imaging and others. Depending on the type of the device mobile or stationary the size of the touchscreen may vary from 3” to over 50” of the screen diameter accordingly. Quite often they for different sizes different technology is used, for example the capacitive touch screens are the most popular in mobile devices and infrared touchscreens are usually applied in bigger format screens.

One of the most important quality measure of interactive system is its usability. Usability is defined in quite many different ways. Taking only into account the ISO norms we may find several definitions. For example in the norm ISO/IEC 9126: Software engineering — Product quality, it is defined as a collection of attributes that the product should bear and are needed for the assessment of the use of the product, they are the following: understandability, learnability, operability, explicitness, customizability, attractivity, clarity, helpfulness and user-friendliness. In the norm PN-EN ISO 9241: Ergonomic requirements for office work with visual display terminals (VDTs) [3], usability is defined as an extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. Where effectiveness is an accuracy and completeness with which users achieve specified goals, efficiency stands for resources expended in relation to the accuracy and completeness with which users achieve goals, satisfaction is a freedom from discomfort, and positive attitudes towards the use of the product and finally context of use contains users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used. Finally the norm ISO 13407: Human-centered design processes for interactive systems, that have been revised by ISO 9241-210:2010 defines the process of user centered design that contains the following phases: user centered planning, specification of the context of use, user and organization requirements specification, product development and product evaluation according to the defined requirements.

The interaction using the touchscreen is different to other standard input devices such as keyboard or mouse, so as a consequence we should work-out different ways of the usability verification [7] and methods for comparing different usability evaluation techniques [1]. In this paper we present the ways of gathering touchscreen input data in form of gestures and its application of the interactive system usability analysis. From the gesture data we can see not only where and when the user touches the screen but also what kind of gesture was made. For the data analysis we can use standard statistics as well as heat maps, which are often used in an interactive systems usability testing.

User Interaction Using Touchscreens

User interaction with computer system is such a type of communication between users and a computer systems in which users gives some commands to the computer systems and users may observe their results and further react accordingly. It is a subject of research of the scientific domain of Human-Computer Interaction (HCI) that considers methods of design, development and analysis of interactive systems with special interest given to the human factor, especially psychological and sociological aspects [10].

The methods of user interaction with computer systems are called within HCI domain the interaction styles [8]. We can distinguish the following classical interaction styles [8]: key-modal, linguistic and direct manipulation. Nowadays we can add the following styles: multimodal, natural and virtual reality [12]. In the key-modal interaction style the user interaction is conducted by using a set of keys that depending on the specific context may have different functionality (modality). The direct manipulation style displays several objects (i.e. icons) in the same time and the user is able to manipulate them, as an effect of this manipulation the object changes its appearance. The following style is called linguistic, in the standard mode the user enters text using a keyboard in form of a formalized commands or natural language. The multimodal interaction style is characterized by the constant user monitoring his or her intentions by means of capturing of different physical phenomena, such as EEG, eye movements, gestures, body movements, speed of breath, etc. This interaction style is have also quite many similarities to the natural user interface, in which users interact with the computer system in similar ways as with the real objects using gestures or movements made by their hands, legs, head, whole body or the specific elements such as eyes, lips or fingers. Finally the style of virtual reality (VR) is an environment for visualization, manipulation and user interaction with complex data that gives user the feeling of being: intensive, interactive, immersive, illustrative and intuitive.

One of the most specific feature of touchscreen interaction is possibility to use different gestures. They are described in the following section in more details. Touchscreens may be used in implementation of the graphical direct manipulation, which is the subtype of the direct manipulation style, or natural user interface because of the possibility of application of different gestures. They are also used in the application of Augmented Reality systems, which have some properties of the VR interaction style. The touchscreen can be operated using either stylus or fingers, however the most popular capacitive technology need application of a conductive object [11].

The interaction with the touchscreens may result in quite many specific usability problems. One of these is the acceptable size of a displayed object, the experimental research has proven that reduction of the size of the interactive screen object from the nearly ideal 22 mm to 7.2 mm results in a negative performance impact of 25% [2]. The consequence of this is also 6-7% increase of necessary corrections. The usability of a mobile systems using touchscreens according to the recent research can be improved by providing the tactile feedback [4]. It was verified experimentally that on average, participants could complete the tasks 22% faster when provided with tactile feedback.

System for gestures recognition

In order to gather the touchscreen data a special application has been built. The application is designed to work with OpenSoundControl/TUIO (A Protocol for Table Based Tangible User Interfaces) touch events [5]. The main advantages of the application of OpenSoundControl/TUIO are following: ease of use, high speed, sources that are publicly open and reliability (at least for a UDP protocol). The protocol delivers all the information that are needed to prepare solid usage information and statistics for touchscreen data gathering. TUIO delivers information about coordinates, touch type, acceleration etc., and it also supports touch ID, so when two fingers happen to touch the screen at the same time, one of them would have an ID 0 and the other 1 to distinguish them [13].

To organize all types of interactions with the touchscreens successive TUIO protocol versions are being developed. The basic version of the TUIO protocol is 1.0. In order to ensure low latency communication TUIO uses UDP. There could be loss of some packets during communication using UDP. Version 1.1 of this protocol is an extension of the previous version. It has been designed to enable the use of multi touch gestures. The protocol defines the format for encoding messages and adds some attributes to the message. Currently version TUIO 2.0 is being developed. It will enable the encoding and determining the geometry of the touched object and controlling of the interactive surface.

Touch gestures are movements performed with a finger or an object (stylus) on the touch screen. Nowadays, the touch interaction between the human and the computer (especially handheld devices) usually is done using touch gestures. We can distinguish three types of gestures due to the number of fingers used [13]. Table 1 summarizes all the basic gestures, indicating which of them may be implemented using one, two or more fingers. The set of gestures which recognition is implemented in the presented solution are shown in Figure 1. Based on the characteristics of selected gestures we proposed a simple mechanism to identify gestures. Flip is recognized when the time between pressing a finger detachment is less than 351ms, and slide of the finger is larger than 100 pixels vertically. Dragging is identified when the finger moved at least 50 pixels in either direction. Double tapping is detected

Gesture	Single touch	Double touch	Multi touch
Tap	•		
Double tap	•		
Press	•		
Drag	•	•	•
Flick	•		
Press and tap		•	
Pinch		•	•
Spread		•	•
Press and drag		•	
Rotate		•	
Press, tap, then drag			•

Table 1. Touch gestures summary due to the number of fingers used.

when the first finger was pressed in less than 501ms, and slide of the finger is not more than 50 pixels.

Figure 2: Main screen and corresponding heat map of analyzed application.

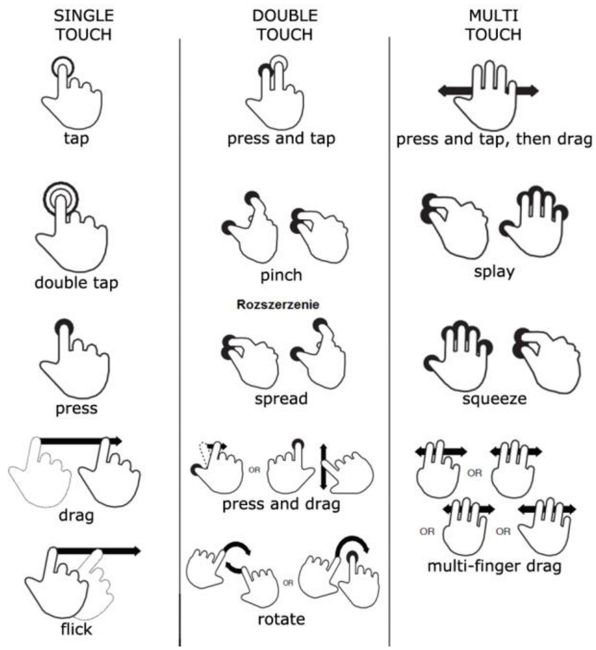

Figure 1. Gestures recognized by the presented system (graphics based on [12]).

Tap gesture is identified when the finger touches the screen for less than 1 second, and when did not move for more than 50 pixels. The last single touch gesture press is detected as the previous, except that the time of touching the screen, must be longer than 1 second. For the two fingers the following gestures are possible: press and tap, pinch, spread, press and drag and two kinds of rotation with two fingers. For the three and more fingers, it is possible to detect gestures such as squeeze, splay, press and tap, then drag and multi touch drag. To recognize more complex gestures such as pinch or squeeze standard mathematical formulas were used, i.e. area of triangle, quadrilateral field, and for the rotation gesture trigonometric function.

The goal of obtaining our data is to perform usability testing. For this reason we created a simple tool that generates a heat-map of a subset of a chosen portion of data. Its basic functionality is to load the image file, which provides the background for the generated heat map and load the interaction data from database. The time range, covered by the file is automatically determined. There is also a possibility to manually narrow range of time taken for further analysis. Heat maps indicate areas in which the greatest number of interactions were made, which often can be understood as the most interesting areas for users [9]. In the case of interactive applications, increased activity in a particular area may indicate problems encountered in using the particular object [6].This tool takes the x and y coordinates of every message sent within a user-defined time period, and represents these points as semi-transparent blobs (Figure 3). Overlaying these blobs results in varying degrees of saturation. The resulting heat map is an image displaying the touch data with colored heat intensity (blue/black - low intensity, red/white - high intensity) in relative position.

Figure 3. Color palette and blobs as a base to generate the intensity of the heat maps.

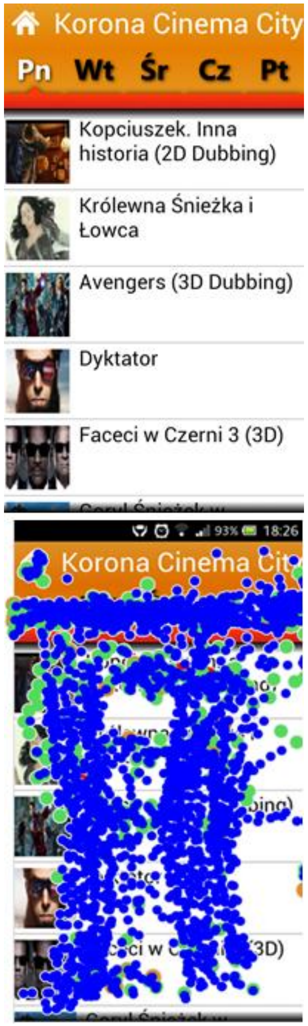

Figure 4: View of the scrollable list and corresponding heat map of analyzed application.

The experiment

The experiment participants have been asked to test the chosen mobile application. The research goal was to detect and recognise all of the movements (gestures), analyse them and verify the overall usability. The main issue was to find out what gestures are more common and easy for users and what gestures are not, during realization of given tasks.

The group consisted of twelve persons. Primary requirement to participate in the experiment was the daily use of a mobile phone equipped with a touch screen. The participants of the study were five women and seven men, aged from 24 to 31 years.

The research have been conducted on an individual basis with each participant. Participant was accompanied by the moderator. His role was to record the type of errors made and difficulties encountered by users. User tests is based on tasks in the checklist. It is used in order to effectively carry out the test and examine the usability in a reproducible way. Method based on click tracking will be used for data collection purposes.

It is a method that involves the recording of the touched areas. With this it was possible to track the gestures made by the user on the touch panel. Gestures made with one, two, and more fingers have been detected.

At the beginning of the test, each user could refer to the application, go through all the screens, and then start doing the tasks. Tests have been performed on the mobile phone model Sony MT27i Sola. It is equipped with 3.7 inch touch screen and Android operating system, version 2.3.7. In order to register the information about the touch of a special method has been implemented, and then integrated with the application.

The basis to perform research is the application called "Mobile Cultural information for Wroclaw". The purpose of this application is to allow the user to obtain information on cultural events in Wroclaw (one of the biggest cities in Poland).

To properly carry out the tasks it is necessary to start from the main screen of application. Users carried out twelve tasks directly related to the intended application and its content, for example finding cinema repertoire for specific day, checking the details visible in the image or to verify price of tickets.

In the application we can distinguish three main views (layouts) in which all content is presented. Main menu view consists of six icon categories such as: cinema, opera, art, theatre, children and concerts. By pressing the corresponding image a new window on the appropriate category will open.

After selecting one of the categories window opens showing a scrollable list of items / events. Selecting a specific item takes user to the detailed view. The screen contains basic information about the event. It includes a thumbnail image, the start time, address, a brief description, price and average rating. It is also possible to insert own assessment. Pressing the image causes enlargement of the picture and allows to perform operations such as increase, decrease and rotation.

Figure 5: Detailed view screen and corresponding heat map of analyzed application.

Experiment and results

In general all participants were able to accomplish all the tasks and had no difficulties with using the application. Obtained data made it possible to verify the mechanism of registration and recognition of touch gestures. The following table (Table 2) summarizes the number of each type of gestures made by all users in all tasks.

Gesture type	Number of realizations
Tap	608
Drag	199
Flick	33
Spread	17
Pinch	10
Double tap	8
Rotate	7
Press	3
Press and drag	1

Table 2. Number of recognized gestures made by all users during experiment.

As can be seen from the above table and participants were gesturing with only one or two fingers. It should be added that the developed application have not detected only ten out of nearly a thousand gestures made by all users during all tasks. The most commonly used were gestures tap, drag and flip, it is justified because they are used to confirm a selection or to scroll through lists. It is interesting that some performed double tap, it can indicate about the application or something that she could not read or participants could not press any interface element. Another important aspect is that the performance of gestures with a few fingers is much more difficult. When making such gestures like pinch, extension or rotation, less trained people lie down phone on the table and with both hands performed gestures. However, the rest of the group kept up with one hand and the other performed gestures.

The Figure 2 presents the number of users that have tried to touch every possible element of the interface, even the inscription with the name of the program. Most of them were used the tap and drag gestures. This is due to the fact that the window is scrollable list of interface elements called the tabs. In Figure 4 there are clearly visible three lines, which are grouped touch points. They are places where participants drag the screen or have made other actions. Two vertical lines may indicate the length or range of the thumb, because it is usually used for scrolling the screen. It may also make possible to assume about using phone in the right or left hand. On the view with detailed information about selected event (Figure 5) tap gestures were made most often. Drag and flip occurred twice in the use of gesture extension. It may reflect the fact that someone tried to enlarge the whole text. The hardest part is to identify gestures, which need to use several fingers. Unfortunately, a large part of the users were not always able to touch all the elements of the interface or even make properly complex gesture.

Often users too quickly or clumsily tried to perform a variety of gestures, leading to confusion. There have been cases of pressing each item or use interface interactions that have not been implemented. This may indicate that advanced users are already accustomed to the use of the known gestures, not necessarily knowing whether they are implemented.

Conclusions

In this paper we presented a tool for gathering the touchscreen interaction data. We also presented a case study how these data may be used in the usability verification. We analysed both the types of gestures used during the use of the application and we used also heat maps for analysis of the touchscreen input data, to identify the most active regions. We are planning to do some research that will gather data from hundreds or even thousands of users, then we will be able to draw conclusions concerning the usability that will be statistically reliable. In this case however we should also consider to develop more sophisticated tools for data analysis, such as for example neuro-fuzzy expert systems or complex networks analysis.

Acknowledgements

The research was partially supported by Grant no. N N519 444939 funded by Polish Ministry of Science and Higher Education (2010-2013) and the European Commission under the 7th Framework Programme, Coordination and Support Action, Grant Agreement Number 316097, ENGINE - European research centre of Network intelliGence for INnovation Enhancement (http://engine.pwr.wroc.pl/).

References

[1] Chynał P., A method for comparing efficiency of the different usability evaluation techniques. Information systems architecture and technology: Web Engineering and High-Performance Computing on Complex Environments, Wrocław: Oficyna Wydawnicza Politechniki Wrocławskiej, 2012

[2] Glavinic V, Ljubic S, Kukec M, Model of a Touchscreen Interaction Benchmark Test Supporting Usability Awareness in Mobile Application Development Process. LNCS 6389, 2010, pp. 505–508.

[3] International Standard ISO 9241-11. 'Ergonomic requirements for office work with visual display terminals (VDT's) – Part 11: Guidance on Usability'. ISO 1997.

[4] Kaaresoja T, Hoggan E,, Anttila E, . Playing with Tactile Feedback Latency in Touchscreen Interaction: Two Approaches. LNCS 6947, 2011, pp. 554–571.

[5] Kaltenbrunner M., Bovermann T., Bencina R., Costanza E. TUIO: A protocol for table-top tangible user interfaces. In Proceedings of Gesture Workshop 2005. Gesture Workshop, 2005

[6] Kasperski M., Boguska-Torbicz A., Web Design. Usability in practice (original title in Polish: Projektowanie stron WWW. Użyteczność w praktyce). Wydawnictwo Helion, 2008

[7] Klos A., Saltarski R., Sobecki J., Szymański J. M., Touchscreen data gathering and analysis applied in usability testing. Multimedia and Internet Systems, Wrocław, Wydawnictwo TEMPO, 2012. s. 15-24.

[8] Newman WM, Lamming MG, Interactive System Design. Addison-Wesley: Harlow 1996.

[9] Pearrow M., Web Site Usability Handbook, Charles River Media, 2000

[10] Preece J, Rogers Y, Benyon D, Holland S, Carem T, Human-computer interaction. Addi-son-Wesley: Harlow 1996.

[11] Sikorski M., Human-Computer Interaction (original title in Polish: Interakcja człowiek-komputer). Wydawnictwo Polsko-Japońskiej Wyższej Szkoły Technik Komputerowych, 2010

[12] Sobecki J., Ant colony metaphor applied in user interface recommendation. New Generation Computing. vol. 26, no 3, 2008, pp. 277-293.

[13] Villamor C., Willis D., Wroblewski L., Touch Gesture, 2012, http://static.lukew.com/TouchGestureGuide.pdf.