Identifying Unintentional Touches on Handheld Touch Screen Devices

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ABSTRACT
Accidental triggering of unwanted interaction when using a handheld touch screen device is a problem for many users. Accidental touches on capacitive touch screen based mobile telephones were analyzed in a user test. Patterns that are characteristic of unintentional touches were identified. Layout guidelines to reduce the amount of unintentional touches are presented. Additionally, filtering criteria is defined that rejected 79.6% of unintentional touches whilst rejecting only 0.8% of intentional touches.

Author Keywords
Mobile phone, touch screen, touch UI, user study, unintentional touches, accidental touches, touch filtering.

ACM Classification Keywords
I.3.6 Methodology and Techniques: Interaction techniques; H.5.2 Interfaces and Presentation: User Interfaces - Interaction styles.

General Terms
Design, Experimentation, Human Factors.

INTRODUCTION
One of the main user pain points when using handheld capacitive touch screen devices is the frequency of making unintentional touches, and hence triggering unwanted behavior. This is particularly acute in a typical mobile usage context where the device is used one handed, i.e. the thumb of the hand holding the device is used for interaction. This problem is intensified by current device design trends that target to maximize screen size in small devices, and as a consequence minimize the device body area surrounding the screen.

This study focuses on one-handed device usage, and aims to identify patterns of unintentional touches that occur in problematic use cases.

Currently, leading touch screen controller manufacturers include features in their products that can filter some types of accidental touches [1]. However, we were interested to investigate if there are any benefits in introducing filtering at the UI level, where it can be applied according to the specific usage context.

Author's final draft version

RESEARCH CONTRIBUTION
This paper contributes by providing data and methods by which the user experience of a particular pain point of touch screen mobile device usage may be improved. We studied the problem from a practical UI design point of view, and aim to provide means to improve the UX.

The contribution of our research is two-fold. Firstly, to increase the understanding of the causes behind typical unwanted touch error cases. This data will provide device industrial designers and UI designers with information enabling them to avoid designs that have high propensity for unwanted touches. Secondly, we aim to propose filtering algorithms that may be applied in device UI to actively reduce the occurrence of unwanted touches, whilst having no effect on intentional user touches.

The majority of previous research in this area has focused on improving the accuracy of capacitive touch screens [2] [3] [4], the issue false-positives is relatively un-researched.

BACKGROUND
The main characteristic of capacitive touch screens that makes them particularly susceptible to unintentional activations is that they require zero-activation force. Physical buttons and resistive technology touch screens require the user to apply some level of force to trigger the interaction [5], and are hence more resilient to accidental activation. Although it is possible to augment capacitive touch screens with force sensing technology, this is currently not typical in commercial products [6].

DESIGN OF THE STUDY

Method
The test protocol used consisted of recording accidental screen interactions in 3 cases: swipe interactions in the home view, traditional phone call interaction i.e. placing device on ear and general device handling. Additionally, as a control, intentional touch events from each user were measured. The unintentional test cases were selected based on generally reported user feedback on the conditions in which accidental presses typically occur. Each test user conducted all the four cases in the test session.

Design of the Tester

A Nokia C7 device using Belle SW release was used as the test device. This was selected as a mid-size screen device (3.5” diagonal with 16:9 aspect ratio) that has a relatively thin device body area around the display. The screen has a pixel density of 210 pixels per inch.

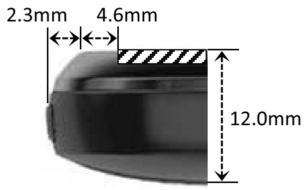


Figure 1. Profile of the test device vertical sides. Touchscreen is shown as hatched area.

The test application used was written in Qt. All touch events (press, move, release) were logged to a file in .csv format. The software was capable of recording 2 simultaneous touch points.

The proximity sensor on the device was not utilized, although in actual usage this plays a major part in filtering false presses in phone call interaction, in this study we wanted to focus on touch screen performance. The touch screen controller used in the test device had the standard parameter settings used in the commercial device, this includes a ‘cheek reject’ feature which rejects touch events above a certain size.

User Test Process

As the study focused only on ergonomic aspects of the usability, Nokia internal participants were used. All the participants were current capacitive touch screen device users that, in a screening interview, reported that they have faced issues with unintentional touches during their normal device usage. 17 study participants were used with ages between 28 and 56, with an average age of 43. Four of the participants were female and the remainder male.

In all the tests the users were instructed to use one handed operation, i.e. all interaction was using the thumb of the hand holding the device. If the user normally used both hands for operating their own device, they were instructed to repeat each test with their other hand.

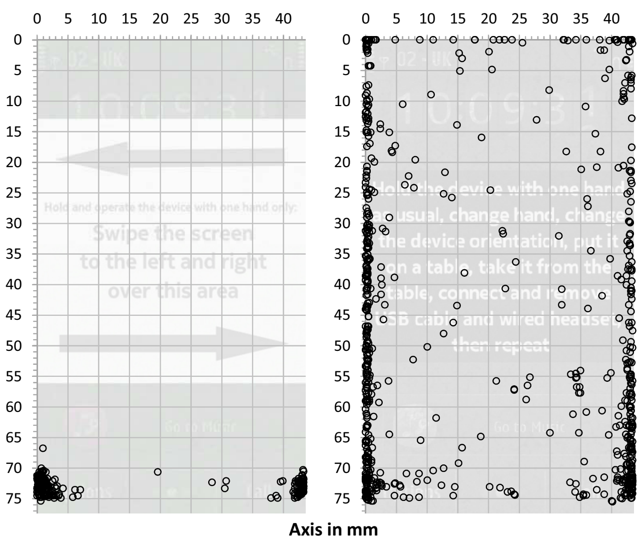
For the swipe interaction test users were instructed to swipe left and right in a defined central area on the screen (see figure 2a). In the handling interaction test case, users were instructed to transfer the device between their 2 hands, change the device orientation from portrait to landscape and vice versa, place the device on a table and then lift it from the table, connect and remove a USB cable, a wired headset and a charger. In the simulated phone call test case, users were asked to hold the device towards their ear for at least 3 seconds, and then change ear and hand.

Each test was repeated until the moderator visually identified that a minimum of 20 data points had been collected, or a maximum of 10 repetitions was reached.

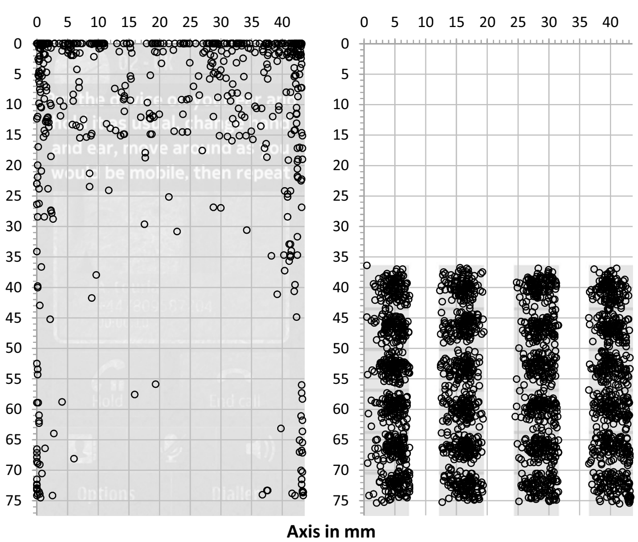
The control, intentional touches, test utilized a randomly presented sequence of square touch targets (see figure 3b). The size of the targets was chosen to represent the smallest size target that is typical in devices of the size used (7mm x 7mm). Some targets were located directly at the screen edges as this was identified as the area where the majority of unintentional touches occur. Each user completed this test using one handed operation, using only their dominant hand. Each target was presented 5 times giving a total of 120 touch events per user.

RESULTS

The total amount of touch event data samples collected in the study is 4188. Of those 1536 are unintentional touch events. The raw data recorded in each of the tests is shown in figures 2a to 3b, for clarity only the press points are shown.



Figures 2a: Unintentional touches during swipe test (the swiping area is indicated as the white background area) and 2b: during handling test (press events only shown).



Figures 3a: Unintentional touches during telephone test and 3b: Intentional touches test (press events only shown)

From figure 4 it can be seen that the touch time window for intentional presses is rather well defined. The majority of intentional samples have a touch time between 70ms and 400ms, with 99.7% of samples falling within this window. It can be noted that many unintentional presses have relatively short touch times.

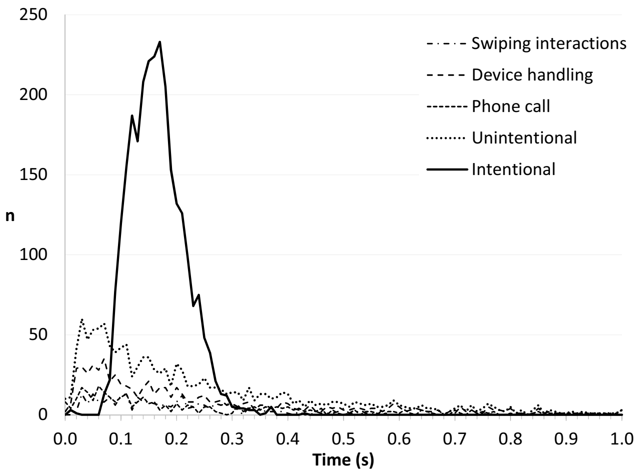


Figure 4. Touch time, press to release

Figures 5 and 6 show the distribution of touch events vs. distance from the screen edges.

In the horizontal direction there is a strong peak of unintentional presses occurring between 0.2mm and 0.8mm from the screen edges, with 36.0% of samples falling within this range. Analysis of the distribution of intentional presses showed roughly a normal distribution, centered slightly to the right of the visual target centers. This offset is due to the majority of the test subjects being right-handed, and has been reported in previous studies [3].

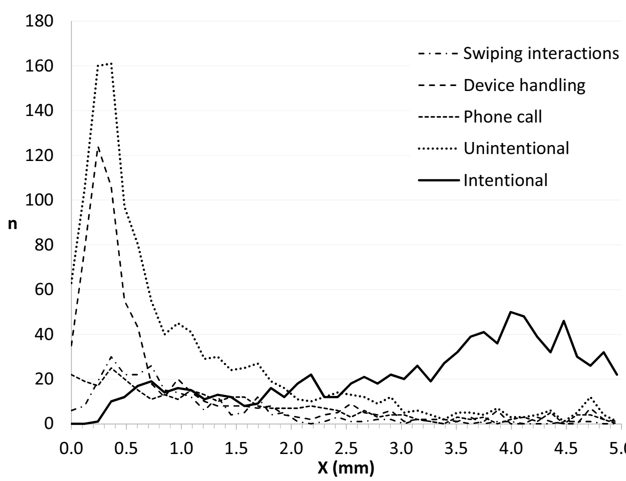


Figure 5. Distance from horizontal edge

In the vertical direction there is a peak of unintentional presses between 0mm and 0.2mm from the screen edge. No intentional presses occurred within this region.

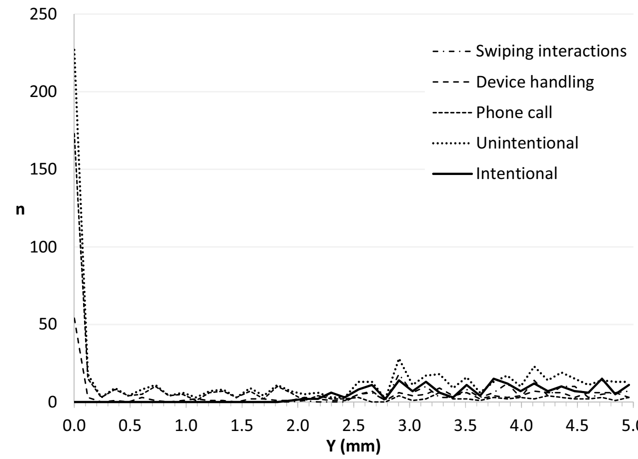


Figure 6. Distance from vertical edge

Figure 7 shows the travel path between press and release points for each touch event. The majority of all the touch events (84.6%) have zero distance. Almost all (99.8%) of intentional touch samples have a press-release travel path less than 6mm.

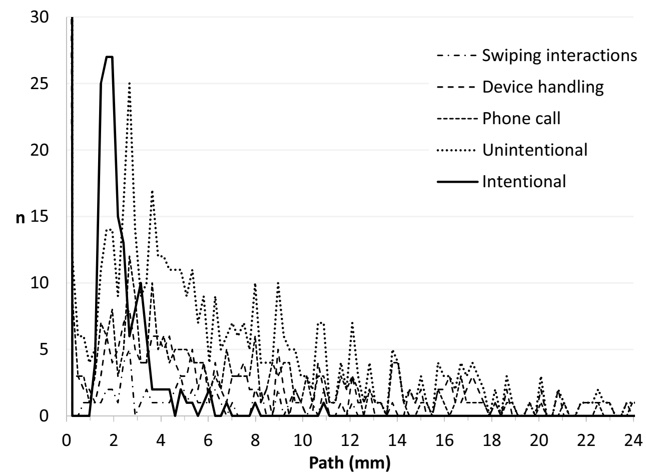


Figure 7. Press to release travel path

The gap in intentional touch events between 0mm and 1mm is unexplained, but assumed to be due to filtering in the touch screen controller.

Analysis was made to identify if the path of the touch point loops back towards the press point during a touch event. This is examined via the ratio of straight line press-release distance vs. actual travel path. This 'path looping ratio' is shown in figure 8. From the figure it can be seen that no intentional touch points have a ratio below 0.6, whilst a number of unintentional touch points have values below this.

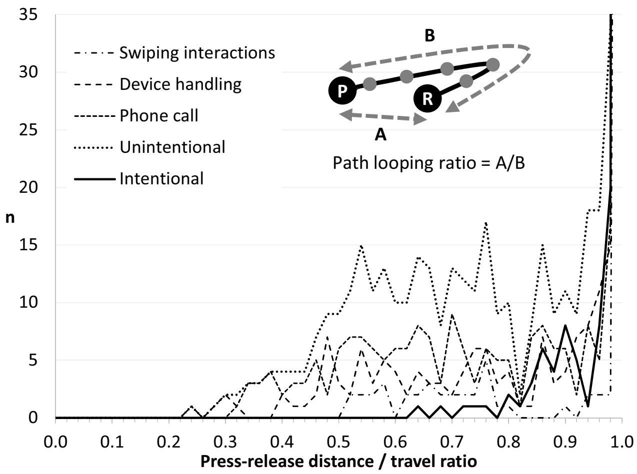


Figure 8. Ratio of press to release distance vs. travel path

Additionally, the speed of movement of the touch point during the touch was analyzed. However, it was found that this did not provide any useful differentiation between intentional and unintentional touches.

DISCUSSION AND CONCLUSIONS

Based on the results, a major reduction in unintentional presses can be achieved simply by not positioning button interaction touch targets within 1mm of the screen edges (see figure 5). In some UI layouts this will result in a reduction in button sizes and hence some minor reduction in intentional press performance. The button visual size must be changed correspondingly to be equal to, or smaller than, the active touch area of the button.

Table 1 proposes filtering criteria that aim to improve the user experience by removing unintentional presses, whilst having minimal effect on intentional presses. The effect of the criteria on the study data is shown in the table.

Filter window	Intentional rejected %	Unintentional rejected %
Time less than 70ms, more than 400ms	0.3	55.1
X distance less than 0.6mm from screen edge	0.4	31.8
Y distance less than 2mm from screen edge	0.0	21.8
Path distance press-release more than 6mm	0.2	16.2
Path loop ratio less than 0.6	0.0	6.9
Combined filter	0.8	79.6

Table 1. Proposed filtering criteria

The effect of a logical combination of all of the filtering criteria is also calculated and shown in table 1. Applying this combined filter would reject 79.6% of unintentional touches whilst having minimal effect on intentional touches, rejecting only 0.8%.

The target level for the acceptable percentage of intentional presses rejected is rather difficult to define. It will depend on the use case, and typically, based on visual and haptic feedback given by the UI users will adapt somewhat. A target value of around 1% was chosen, as being smaller than the acceptable error rate based on target size used in other studies [7].

The filter values will require tuning for different devices depending on their size and physical construction. For example, it is expected devices with narrower bezels than that of the test device will require a correspondingly larger 'distance from screen edge' value.

One proposal is that these filters are implemented as a component in touch UI frameworks, and application developers are provided with a simplified API to activate the filtering function. Developers could choose to activate the filtering in error critical use cases, or based on sensor derived information that the device is being used in one handed mode.

If the filters are used on components other than simple tappable buttons, modification of the filter parameters will be required. For example, if used on a scrollable list type UI component, then most likely movement based filtering criteria cannot be applied, as touch point movement is required to interact with the list component.

Analysis of time overlapping touch events is expected to be particularly beneficial in filtering device grip related accidental touches. This is a topic for possible future study.

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