Inaccurate input on touch devices relating to the fingertip

Paul Huber

Abstract— The fat-finger problem has emerged to a routine problem when interacting with especially small touch devices. Thereby, the target is smaller than the size of the finger contact area and interactions may result in incorrect input. Developers tried to respond to this and created new interfaces and tools. In this paper, I would like to present four approaches to address the problem. The stylus is a pen with a soft tip, which is used for interacting with touch surfaces. NanoTouch is a 6 centimeter large touch device, which can be controlled from its backside through a semi-transparent screen. Finally, the RidgePad has an integrated fingerprint scanner, which scans the user ID and fingerprints to save the special appearance of the fingerprints in certain finger positions. New technologies are on the rise where touch screen interactions without a touch screen are possible and the fat-finger problem will be a thing of the past.

Index Terms—fat-finger problem, touch imprecision, occlusion, RidgePad, nanoTouch, stylus, touch, fingertip, inaccurate input

1 Introduction

In recent years the number of touch devices has soared worldwide. This trend is unlikely to change in the coming years. Over time they have evolved in many facets, for example new form factors, touch-screens, many new functions etc. Touch devices seem to get smaller and more high-resolutioned every year. But nevertheless they allow to integrate input and screen into the same physical space, which allows advantageous compactness. But with these developments new problems come up. One of this problem is the so-called “fat finger problem”.
This paper is about the problem that a finger touch on a touch surface decreases the precision, because virtual targets are often smaller than a fingertip. In addition, occlusion by the finger or forearm prevents visual feedback. In the first section, I will discuss this issue in more detail, followed by three approaches to address it. The rest of the paper will deal with a comparison between the suggested solutions and gives an outlook into the future.

1.1 Inaccuracy by the fingertip

On first sight, the term may be a bit misleading. This problem emerges not only through „fat” fingers or fingertips, but by finger or fingertips of any size. When selecting targets on a touch device with a finger and the targets are smaller than the size of the finger contact area, users do not know if they hit the desired target *(see figure 1)*. Additionally, the lack of sensing precision can make precise touch screen interactions more difficult and error-prone [4]. In many interfaces touch targets are packed too close together. The result is that a wrong button is touched, which ends up in incorrect input. An example of the problem is using a non-mobile website on your mobile phone. When the interface is developed for a normal mouse interface, some buttons are often just a few pixels wide (e.g. closing windows). Without changing the zoom level it is almost impossible to hit for example the login field because the fingertip is too big to hit the field correct. Another example, that everybody knows who uses a mobile phone, is hitting the wrong character on the keypad while tipping in a message. This happens because the fields of the keypad are too close linked. Researchers have figured out that there is a minimum target size between 10.5mm and 26mm to reliably acquire targets [1]. The disagreement about minimum target size was probably caused by differences in study conditions. Designers must adhere to these specifications to reasonably guarantee accurate input.

- *Paul Huber is studying Media Informatics at the University of Munich, Germany, E-mail: paul.huber@campus.lmu.de*

- *This research paper was written for the Media Informatics Proseminar on "Interactive Surfaces", 2015.*

1.2 Inaccuracy by occlusion

There is another element of the fat finger problem: occlusion of the screen by the finger [5]. The occlusion problem is closely related to inaccuracy by the fingertip. Often the user’s finger tip occludes the target in the critical moment before touching the display. This prevents the target providing visual feedback and parts of the target are no longer visible. As a consequence, the user don’t know what part of the display he must touch and ends in an incorrect input.

> "There are different scenarios of occlusion. Occlusion gets worse the smaller the screen, the larger the finger, the more fingers and the further the fingers reach across the screen" *(see figure 1)* [5]

.

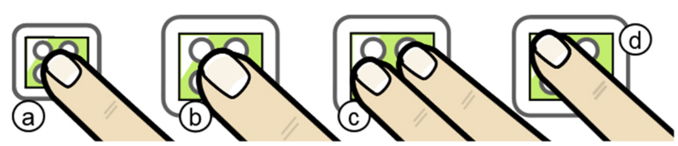

Figure 1. Occlusion impacting the fat-finger problem [5].

The inaccuracy by the fingertip, which can be also described as a precision problem and the inaccuracy by occlusion are most commonly referred to together as the fat finger problem.

2 The fight against fat fingers - three Approaches

There are several solutions to overcome the fat finger problem. Some researchers designed new interfaces, for example to scale a portion of the screen with the secondary finger while the primary finger performs the selection. Those precise dual finger selection techniques on multi-touch screens allow to select targets more accurate. Besides designing new interfaces, prototypes of new devices were created like nanoTouch or RidgePad. Studies showed, that with it touch accuracy is nearly doubled [1]. For designers, especially in designing mobile phones, it is a difficult task trying to show as much information as possible on a small screen, while increasing the accuracy of user’s touch. In the following paragraph, I would like to describe four techniques more precisely.

2.1 Keystroke Biometrics

Keystroke biometrics is used to describe individual typing behaviour. When it comes to touch input, every person has different procedures, for example different rythm or finger placement. Different temporal typing features are measured to collect data for individual typing behaviour (for example: hold time, flight time, exact touch locations, touch area size, pressure [2]). With this information a unique biometric template of the user’s typing pattern for future touch input can be developed. With this technique incorrect input can be reduced by 26.4 - 36.8 percent [2].

2.2 Stylus

Many immediately think of a stylus, whose tip is more accurate than a fingertip and defines a clear selection point [3]. It also removes the user's hand from the screen, which minimizes the occlusion. Its use is generally preferred in many interfaces that require precise interactions, for example navigating through an interface with small buttons. However, some disadvantages are associated. Using a stylus requires more time and a second hand. Especially for short interactions many therefore prefer using the finger, for example controlling a media player. Additionally, hand tremor can make the selection of small targets as difficult as using a finger.

2.3 NanoTouch

Promising is the project nanoTouch by Baudisch [5]. Because one's finger is not transparent and thus small targets are covered on the screen, nanoTouch pursues the concept to make the backside of a semi-transparent screen tactile. Thus a touch screen device can be controlled from its backside *(see figure 2)*. The display (6 centimetre) is pseudo transparent because an image of a "fake" finger appears behind the icons on the screen. A dot-shaped pointer corresponds to the touch location on the back and moves around in sync with the user's "real" finger *(see figure 2)*. To design the image of the finger as realistic as possible, the user's finger turns white when pressed. Tiny icons on the screen can also be dragged around.

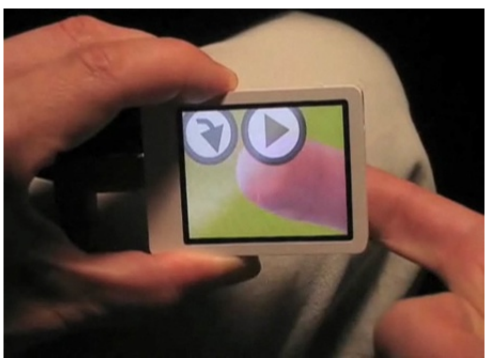

Figure 2. nanoTouch [5].

This technique allows to interact with very small screen devices, because it prevents fingers from occluding the screen and makes touch accuracy higher. According to a study by Baudsisch, 1.8 millimeters-sized targets were easy to hit. In this way nanoTouch allows building new types of devices, such as touch-capable electronic jewelry, smart watches or high-tech clothing. 8mm screens can be built that are still functional with this technology.

2.4 RidgePad

Another creative idea by Baudisch to address the fat finger problem is the so-called RidgePad [1]. Users are fundamentally different when it comes to touch input. For example users prefer to click a button with pad of a finger, others with the tip. Touchscreens have no way of telling which part of the finger is used, RidgePad does. It is a touch device with an integrated fingerprint scanner, which helps to scan the user ID and fingerprints to save the special appearance of the fingerprints in certain finger positions. In this way, it is possible to establish for each user a personal profile of the user's touch condition. It is important to extract the user ID because different users have different finger shapes and mental models which part of their fingertip they use to touch the target. Afterwards the fingerprint is compared with the database to calculate the finger's orientation and thereby to increase touch accuracy. Spatial information play an important role and is included in the calculation. The finger position is defined by two spatial information: pitch and roll *(see figure 3)*.

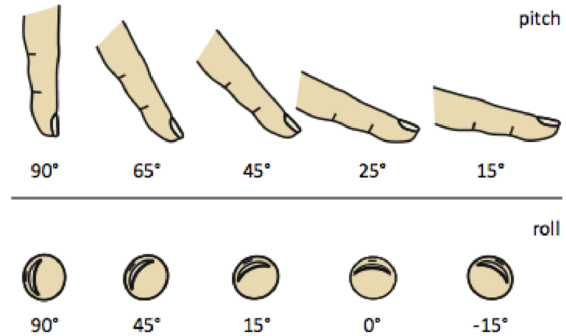

Figure 3. Pitch and roll of a finger [1].

The variable finger pitch describes in which angle the surface of a device is touched. The flatter the finger, for example 15 degrees, the more imprecise the touch input. An input with a finger pitch of 90 degrees would be most accurate, but it proves to be difficult because of the fingernail. Finger roll describes horizontal orientation of the fingernail *(see figure 3)*. Pitch and roll of the finger have a considerable impact on the touch accuracy.

The project is a promising approach because it nearly doubles the touch accuracy in contrast to traditional touch technology, accordingly smaller devices can be built. It has good chances to be implemented in some touch devices in the future. However, there are also disadvantages. The scanning process takes too much time and the components are too big to integrate them into portable devices such as phones. But with further development of this project, for example designing thin and cheap touch sensors with the technical feature to scan fingerprints, it will be able to realize it.

3 Discussion

A stylus proves to be an useful opportunity to obtain more accurate touch input. Additionally, it is also easy to use. But, especially on mobile phones, many short interactions are made. It is too complicated and time-consuming always to use a stylus for this. In my opinion this is a big disadvantage compared to nanoTouch and RidgePad. When a technical and a relatively cheap solution is identified to implement those techniques in touch devices, I think, nanoTouch and RidgePad will assert itself against styli.

4 Conclusion

My opinion in this issue is, that no solution has been found so far, which can solve the fat-finger problem completely. Especially on mobile phones with touch screen it is problematic. The smaller the touch screen, the greater the risk of incorrect input. Although, for example, mobile versions of websites with bigger buttons were designed, but the problem remains on other interactions like hitting the right character on the keypad. There are several good approaches to address the problem like new devices. But some of them aren't technically feasible until now like the RidgePad.

In the future, touch screens will may be replaced by new technologies and the fat-finger problem will be a thing of the past. For example, research is currently being performed on "imaginary interfaces" , whereby the screen disappears in space. This leads to a touch screen interaction without a touch screen. In a project called Imaginary Phone, the developed prototype has the functionality of a mobile phone. The user wears thereby a kind of brooch on his chest. In the left hand, he holds an imaginary mobile phone and operates it with gestures of his right hand. The camera on the chest spot the hands, which are illuminated by infrared light. The environment fades and the hands can be exempted.

Nor are such projects classified as visionary, but it is conceivable that software and camera technology will change the development of the interaction of human and machine in the next few years certainly.

REFERENCES

[1] Christian Holz and Patrick Baudisch. The generalized perceived input point model and how to double touch accuracy by extracting fingerprints. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '10, pages 581–590, New York, NY, USA, 2010. ACM.

[2] Daniel Buschek and Alexander De Luca and Florian Alt. Improving accuracy, applicability and usability of keystroke biometrics on mobile touchscreen devices. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, CHI '15, pages 1393–1402, New York, NY, USA, 2015. ACM.

[3] Daniel Vogel and Patrick Baudisch. Shift: A technique for operating pen-based interfaces using touch. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '07, pages 657–666, New York, NY, USA, 2007. ACM.

[4] Katie A. Siek and Yvonne Rogers and Kay H. Connelly. Fat finger worries: How older and younger users physically interact with pdas. In *Proceedings of the 2005 IFIP TC13 International Conference on Human-Computer Interaction*, INTERACT'05, pages 267–280, Berlin, Heidelberg, 2005. Springer-Verlag.

[5] Patrick Baudisch and Gerry Chu. Back-of-device interaction allows creating very small touch devices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '09, pages 1923–1932, New York, NY, USA, 2009. ACM.