TOWARDS THE TABLETOP INTERACTION WITH FINGERS AND HAND

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Abstrakt

Článok prezentuje vývoj dotykovej, viacdotykovej a stolovej interakcie. Predstavená je základná idea dotykovej interakcie vzhľadom na paradigmu priamej manipulácie a popísané sú dva spôsoby akým je možné dosiahnuť rozšírenie pôvodnej paradigmy priamej manipulácie. Neskôr je dôraz kladený na stolové dotykové zariadenia, kde je vysvetlená dôležitosť a výhodnosť použitia infračerveného svetelného spektra pre rozšírenie interakčných možností na týchto zariadeniach. V závere sú prezentované idey pre budúcu prácu v oblasti dotykovej interakcie.
Kľúčové slová: interakcia človek počítač, interakcia na dotykových stoloch, multidotyková interakcia

Abstract

We present an evolution timeline of touch, multi-touch and tabletop interaction. We show the basic idea of touch-based interaction in respect to a direct manipulation paradigm as well as different approaches to enhance this direct manipulation paradigm. Furthermore we focus on tabletop devices and show the main advantage of usage of near infrared light spectrum in order to augment the interaction of tabletop devices. Finally, we present ideas for our future research aims in the field of touch interaction.
Keywords: human computer interaction, tabletop interaction, multi-touch interaction
Classification: HCI design and evaluation methods, Interaction devices:Touch screens

1 Introduction

Multi-touch interaction is the most promising and today one of the most researched areas in the field of Human Computer Interaction. Multi-touch user interface paradigm spread across numerous hardware devices ranging from the small mobile devices up to large conference displays or presentation tabletop displays.

The entire multi-touch interaction and its main idea is based on the direct manipulation paradigm as defined by Shneiderman[11], which is the most common user interface paradigm used by millions of people every day. In the former standalone systems users have been using an input device, like a mouse or a keyboard in one space and the feedback was given in an entirely different space as shown in Figure 1.

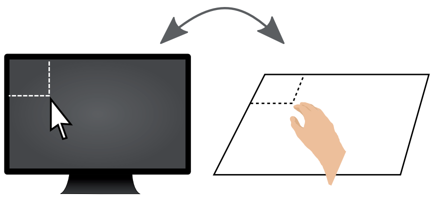

Fig. 1. Former system's users have been using an input device in a physically different space than the output device.

2 Review of our Contribution

There are two approaches to integrate input and output spaces into a single one. In the first approach, the output space is moved into the same space where the input of the user has taken place. Such systems usually employ a haptic feedback devices, where either a tactile [3] or kinesthetic feedback is used [6] as shown in Figure 2.

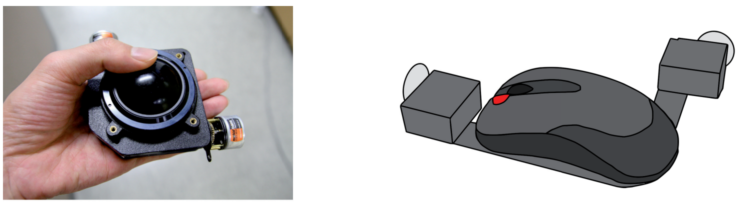

Fig. 2. Haptic feedback devices. Left a Touchball tactile feedback device from [3], right a kinesthetic feedback mouse, where two servo motors controls the movement of the mouse [6].

The second approach is to integrate the input interaction space into the output interactions, which is the basic principle of touch devices. The touch paradigm has been perfected by enabling the usage of multiple touch points or even gestures defined by the movement of these touch points.

The proposed multi-touch device used for tabletop interaction provides even more interaction possibilities by simply scaling the interaction space to larger dimensions. Because of the larger dimensions, it is profitable to use an optical implementation of proposed touch detection, which brings a lower costs of implementations and, what is more, some extra interaction possibilities.

The majority of optical implementations, as described in [2], use a near infrared light spectrum[1], which is not visible to a human beings, but clearly visible for most standalone computer cameras placed usually beneath the touch surface. By using only the near infra red part of the spectrum there is a significant increase in a signal to noise ratio, thus making the detection of touch points very straightforward, as shown in Figure 3.

The large scale of tabletop touch sensitive displays, usage of the near infrared light spectrum and the straightforward detection algorithms lead to the enhancement of the interaction with physical objects. For example The reacTable [8] make use of such physical objects that are used as a passive haptic devices called "props". The individual props are recognized by special markers known as fiducials as shown in Figure 4.

The usage of fiducial markers on physical objects together with the multi-touch input might be viewed from two different perspectives. Firstly, from the perspective of the interaction paradigms, where a touch interaction paradigm is coupled with the tactile user interface paradigm or eventually an integration of two different direct manipulation paradigms. Secondly, a 2D touch interaction (like touching a button) is combined with a 2.5D physical object interaction (manipulating with an actual physical object) resulting in higher dimensionality (4.5D) user interaction.

[1] Light with wavelengths from 800 nm up to 1400 nm.

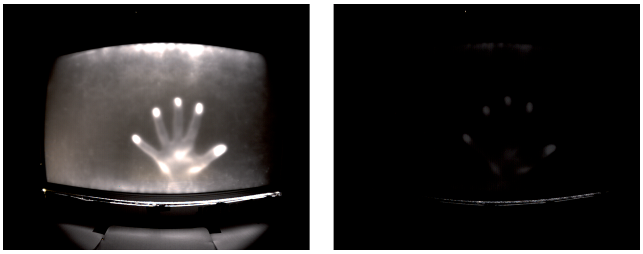

Fig. 3. Touched display with five fingers and the hand above the display giving 3 dimensions in total. A comparison of camera image in visible and infrared spectrum (left image), and image of only infrared spectrum (right image), from [7].

Fig. 4. An example of fiducial markers used in the implementation of The reacTable [8].

Going even further, a trivial extension is a combination of touch input interaction with a 3D user interaction above the actual touch interaction space as proposed by [5]. Here a 3D gesture interaction was proposed to be used for three-dimensional spatial object manipulation, whereas two-dimensional touch input defined the temporal characteristics of the resulting animation. The actual implementation by [4] enhanced the proposed solution by adding a shutter glasses and stereoscopic display technology to render three-dimensional output above the tabletop display.

3 The Future of the Tabletop Interaction

Although it might seem that there is no further research to be done in tabletop human computer interaction, we believe there is still a room for some enhancements.

Firstly, the integration of physical objects with touch interaction seems to be very promising unfortunately, the number of possible fiducial markers is limited. An extension to fiducial markers is the use of QR codes, that are trackable in real-time [12] but also the amount of coded information is substantially increased. Specifically, the large QR code is able to store about 4000 alphanumeric characters. Moreover, there is another essential property of QR code, which is its error correction, where up to 30% data lost can be restored [12].

Secondly, there is still a lack of interaction semantics. The entire touch interaction is based on either the static touch inputs or dynamic gesture inputs, where the semantic of the input is determined by either the touch target or the type of the gesture executed. This semantics determination is done after the actual user's input. Our improvement in this phase is the identification of the semantics after as well as before the specific user input. Trivial example of before touch input semantics is usage of special keyboard switches changing the type of the interaction that is about to take place. On the other hand, since the tabletop device is using hands and finger, it is very convenient to use either hands[2] or finger identification or even the combination of both.

There are several approaches to solve the finger identification problem on tabletop devices. Firstly,

[2]Hand identification as defined in bimanual interaction introduced by [9].

an identification by computing the sum angles to the adjacent finger has been published by [1], where a standalone capacitance touch device has been used, thus before the actual interaction user has to touch with all the five fingers to register the hand model. On the other hand, in [10] a Kinect depth map has been used for detection of user's fingertips and the kinematic human hand model was matched to the detected fingertips.

Fig. 5. In the left picture a camera's view of optical tabletop implementation and sufficient brightness difference between the fingertips, hand shadow and background scene. In the center picture a processed image is shown. In the right image contours of hand and detected finger touches are depicted.

Our proposed solution uses optical tabletop implementation based on frustrated total internal reflection [2], where an ambient infra red light provide sufficient brightness difference between the fingertips, hand shadow and background scene from the camera's point of view as shown in Figure 5 along with an entire image processing process. Using a frame division, morphology, threshold and contour finding algorithms the actual contour of the user's hand is found along with the contour of individual touch points. We propose to count the angle difference of fingertips adjacent to the actual touch point, that is enough to identify the actual touch finger. Such algorithm will be successful only in case of the hand with all five fingers visible. It is unnatural for the user to always work using hand with all five fingers spread, we propose further user testing and analysis in order to sufficiently define the touch interaction techniques using different fingers. This analysis will help to create much successful algorithm for finger identification without the need for spreading the fingers.

4 Conclusion and future work

We have shown that there is a bright future for the tabletop and multi-touch interaction. To go little bit further we see a responsive tabletop interaction, where the tabletop system is aware of its presence in respect to the user performing the interaction. Giving a multimodal feedback might be useful to navigate the user in the tabletop interface and coupling the 3D user interface with actuators to rotate the entire tabletop. By this way we create 360 degree 3D input around the entire tabletop. Since, the optical tabletop implementation usually uses near infrared spectrum a various infrared pointers or even an infrared data communication is possible far away from the touch sensitive device.

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