THAW: Tangible Interaction with See-Through Augmentation for Smartphones on Computer Screens

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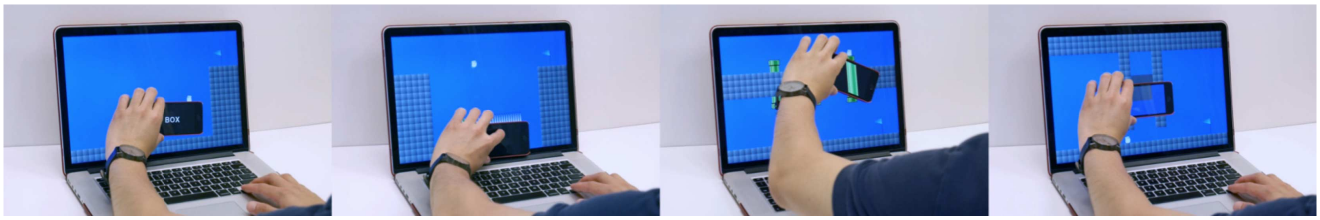

Figure 1: A smartphone screen can be used as a user interface intervening into the display space of a computer screen.

ABSTRACT

In this paper, we present a novel interaction system that allows a collocated large display and small handheld devices to seamlessly work together. The smartphone acts both as a physical interface and as an additional graphics layer for near-surface interaction on a computer screen. Our system enables accurate position tracking of a smartphone placed on or over any screen by displaying a 2D color pattern that is captured using the smartphone's back-facing camera. The proposed technique can be implemented on existing devices without the need for additional hardware.

Author Keywords

Multi-device Interaction; Tangible Magic Lens;

ACM Classification Keywords

H.5.2 User Interfaces: Input devices and strategies (e.g., mouse, touchscreen)

INTRODUCTION

A growing number of people own a smartphone in addition to their computer. The collocated interaction with those devices poses the question of how to seamlessly connect the different display spaces and their afforded interactions.

The physical body of the smartphone affords tangible manipulation, while the screens on both devices can display virtual graphics that augment or interact with each other. If the interaction between the devices happens in close proximity, the graphics on each device and the phone's physicality in combination with our strong visual-motor skills bridges the gap between spatial reality and the digital.

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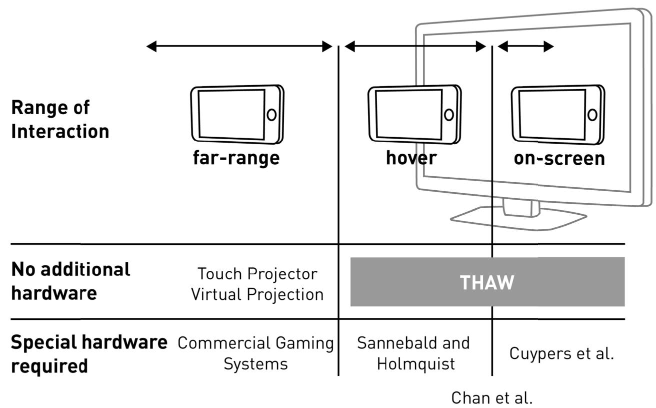

Figure 2. Systems based on tracking of handheld devices

Prior Augmented Reality (AR) styled interaction systems explored interactions between a phone and a computer screen over a distance, however, none thoroughly explored near surface (on-screen) interactions. This is mainly because the proposed tracking techniques require a certain distance between the devices to work properly [1, 2] or special tracking hardware / setups as seen in [3, 4, 5]. (Figure 2)

In this paper we present THAW (Tangible, Handheld, and Augmented Window), a system that enables near-surface interaction with ordinary computer displays and smartphones without any necessary hardware modifications. We also present a framework that explains and classifies possible interactions.

IMPLEMENTATION

The very close distance from the smartphone to the screen (< 2cm) makes conventional feature-based tracking impossible due to the camera's lack of near-focusing capability and limited field of view (FOV). In our system, a computer screen displays a distinct color pattern. The phone's back-facing camera detects the pixels' color shown on the screen behind the phone. Sampled points are used to infer the phone's position from the RGB values through linear transformation. Calibration needs to be performed only once per device (Figure 3). Additionally, by comparing two frames' color delta we can measure the smartphone to screen distance reliably up to 15 cm.

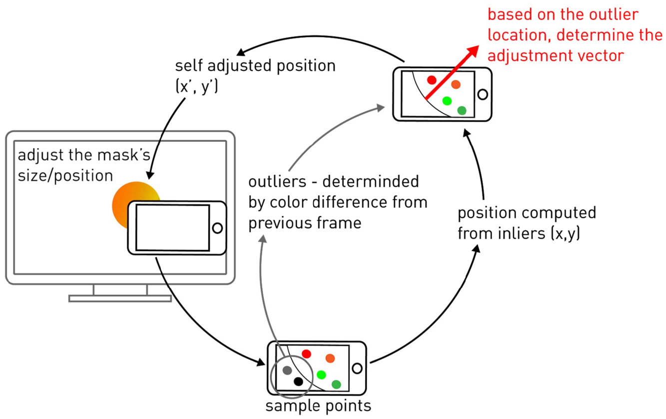

Figure 3. Sequence diagram of the tracking algorithm

Non-invasive Tracking

One advantage of using a dynamically displayed tracking pattern is its adjustability. It is sufficient for the pattern to only be visible in the camera's FOV to achieve continuous tracking. Therefore, we can hide the pattern in the area occluded by the phone, which allows tracking without sacrificing valuable information space.

INTERACTION

Here we present a framework for classifying possible interactions with our system (Figure 4). The phone can be used as a physical token to directly interact with digital entities based on their relative positions (Figure 4(a-b)). It can act as a lens for controlling or augmenting objects on a computer screen (Figure 4(c)) and also offers an additional space to be used for extended control or as a physical clipboard. (Figure 4(d)). The presented interactions can be used in combination or interchangeably, thus enabling variable combinations of tangible interaction and see-through augmentation.

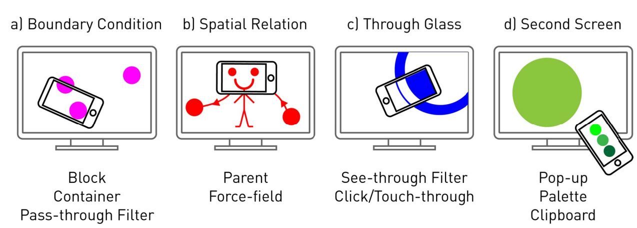

Figure 4. Categories of interaction

DEMO APPLICATIONS

See-through Mouse

We use the phone as an advanced see-through mouse tool. The phone serves both as a tangible clipboard and a see-through touch tool, enabling intuitive drag/drop or copy/paste of digital content (Figure 5). This largely extends the modality of a conventional mouse, enabling more sophisticated functionality such as opening a web link on the mouse or performing kinetic gestures.

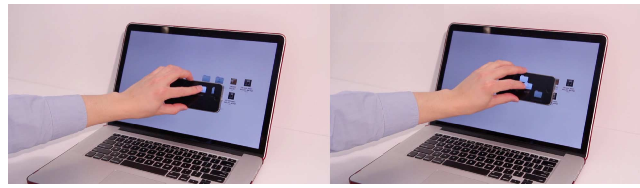

Figure 5. Seeing and touching through the smartphone

Game

We developed a simple game in which the goal is to help the character reach the flag. The smartphone acts as an active controller that can be used to physically intervene in the gameplay (Figure 1). Players have to choose different strategies to clear each stage, which is designed to showcase a specific interaction or a mix of interactions of our framework. It is notable that, in each stage, the phone is perceived to have versatile physicality through showing different uses of visual augmentation and interactions. This potentially promises countless more novel gaming scenarios than the ones presented here.

CONCLUSION

In this paper, we proposed an easy to deploy technology as well as interaction scenarios to better utilize the near-range interaction space on and above computer screens with smartphones. The combination of AR and Tangible User Interfaces (TUI) enables versatile user interfaces for context-aware seamless interactions. As a growing number of people own these two complementary devices, we believe that our system can unlock the potential of those collocated technologies in the immediate future and contributes an easy to deploy near surface interaction technology.

REFERENCES

1. Baur, D., Boring, S. and Feiner, S. Virtual Projection: exploring optical projection as a metaphor for multi-device interaction. In Proceedings of CHI'12. ACM.
2. Boring, S. et al. 2010. Touch projector: mobile interaction through video. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (New York, NY, USA, 2010), 2287–2296.
3. Chan, L.-W., Wu, H.-T., Kao, H.-S., Ko, J.-C., Lin, H.-R., Chen, M. Y., Hsu, J., and Hung, Y.-P. Enabling beyond-surface interactions for interactive surface with an invisible projection. In Proc. ACM UIST '10 (2010), 263–272.
4. T. Cuypers, Y. Francken, C. Vanaken, F. V. Reeth, and P. Bekaert. Smartphone localization on interactive surfaces using the built-in camera. In Proc. Procams, pages 61–68, 2009.
5. Sanneblad, J. and Holmquist, L.E. Ubiquitous Graphics: Combining Hand-held and Wall-size Displays to Interact with Large Images. ACM AVI Conference on Advanced Visual Interfaces 2006.