Contact Augmented Reality: Exploring its Design and Implementation

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ABSTRACT

We present Contact Augmented Reality (cAR), an approach to augmented reality where the display is mobile and on direct contact with the augmented object.

Author Keywords

ACM Classification Keywords

General Terms

INTRODUCTION

Augmented reality (AR) enhances the real world by embedding digital content onto it. In AR, the display type used determines the possibilities for interaction. Traditional AR relies on mobile displays carried by the users (retinal, HMDs, smartphones), allowing the system to augment virtually any object within the display's field-of-view. On the other side, spatial augmented reality (SAR) relies on displays fixed in the environment (projections, transparent LCDs), offering solutions to traditional AR problems such as resolution, focus, tracking, lighting and cumbersomeness, but limited to non-mobile applications [2].

In this paper we present Contact Augmented Reality (cAR), an approach to augmented reality which builds on the strengths of SAR while preserving the vision of an augmented reality that is mobile. To achieve this, cAR uses portable transparent displays (e.g. TOLED) to render the digital content, and requires the cAR device to be on direct contact with the augmented object. This direct contact provides spatial alignment at a very short distance between the digital content and the augmented object, thus simplifying registration and rendering: registration is reduced to finding the *relative* 2D location and orientation of the cAR device on-top of the augmented object; rendering no longer requires perspective corrections.

By following an iterative and user-centric design approach, and taking Active Reading as a sample application area [1], we built a series of prototypes which helped us identified and explore a series of interaction techniques for cAR devices. We divide such techniques into contact-based (e.g. annotations, scribbles), content-aware (e.g. UI orientation, content lookup), and off-contact (e.g. flipping, stacking) interaction techniques.

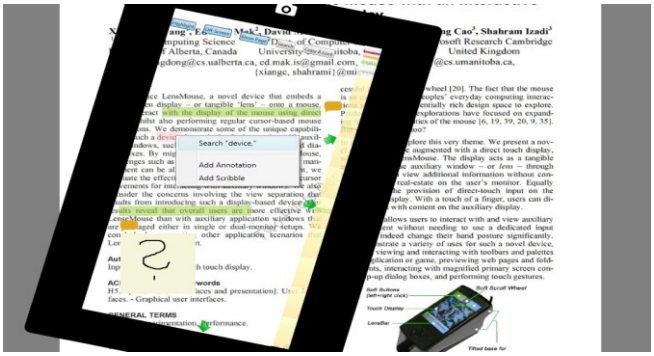

Figure 1: tPad screen capture showing highlights (green) , text and free-hand annotations, and off-screen pointers (arrow).

Our final prototype is a mobile device called the tPad. The tPad addresses the registration problem by using a camera-based feature tracking approach, and uses a capacity-overlay for touch input; a controller board detects the tPad's flipping or whether it's stacked with another one. We implemented the ActiveReader (see Figure 1), a tPad application that allows users to underline, highlight, scribble comments, search content, and look-up references (see Figure 1). Users access special information by flipping the tPad, and two tPads can share content when staked-up.

We studied the ActiveReader tPad application with users in active reading tasks. The tasks required using all the tPad features like touch, flipping and staking. Initial feedback shows that using the tPad is highly intuitive and learn-able. Moreover, users highlighted the value of reading on paper, having the digital features when needed, and being able to access their annotations digitally.

Our contributions are at the conceptual, interaction design, and technical levels. First, we introduce cAR and differentiate it from existing AR approaches. Second, and propose a series of interaction techniques for cAR. Finally, we present a device prototype called the tPad and show how the tPad and the CAR notion can be applied to and benefit an everyday task such as active reading.

RELATED WORK

Augmented Reality
HMDs and Handheld

Spatial Augmented Reality
Fixed in relation to the object

Projectors, transparent displays

Virtual Lenses
Mackays ABook – say that we were inspired by this work and we generalize this initial exploration into the concept of cAR. However, we depart in several ways: first we use a camera based registration, second we explore off-contact and transparent interactions, third we rely on transparent display technology.

CONTACT AUGMENTED REALITY - cAR

Definition: mobile device which augments when coming in close contact (overlay) with the augmented surface.

How is it different than normal or spatial: 1) Activated upon contact, else the device works as a normal mobile device → it is not handheld as it needs the surface.

2) Spatially aligned -> registration problem is reduced to finding the location of the device in relation to the surface, no need to track the user.

3) Interaction techniques that are contact-based, content-aware, and off-contact (like a normal mobile device).

APPROACH

We used Active Reading as an application scenario and an inspiration tool to brainstorm and elicit features and interaction techniques.

Design sessions

Prototype 1 - Tabletop

Prototype 2 - tPad

cAR INTERACTION TECHNIQUES

Contact-based

Content-aware

Off-Contact

TABLETOP PROTOTYPE

Implementation Details: registration, display and render details.

Features

Feedback

tPad PROTOTYPE

Implementation Details: registration, display and render details.

Features – features that are not contact, reinforce the need of paper, talk about on-the-fly model generation

Feedback

DISCUSSION

CONCLUSIONS

Actual conclusions

Future work

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