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. At the basic level, AR faces challenges in terms of display technology, registration and rendering [2]. The display technology used determines the complexity of registration and rendering. *Traditional AR* relies on mobile displays carried by the users (retinal, HMDs, smartphones and handheld projectors), allowing the augmentation of virtually any object within the display's field-of-view but requiring complex operations for registration (e.g. 3D location, object recognition) and rendering (e.g. field-of-view calculation, perspective correction). Further, mobile displays present limitations in terms of resolution, focus, lighting and comfort. On the other side, *Spatial AR* (SAR) relies on displays fixed in the environment (projections, transparent LCDs); requiring simpler operations for registration and rendering and offering solutions to the limitations of traditional AR, 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 AR that is mobile. The basic tenet of cAR is a *mobile device* with a *portable transparent display* (e.g. TOLED) that augments a physical object when *directly overlaid on top of it*. 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.

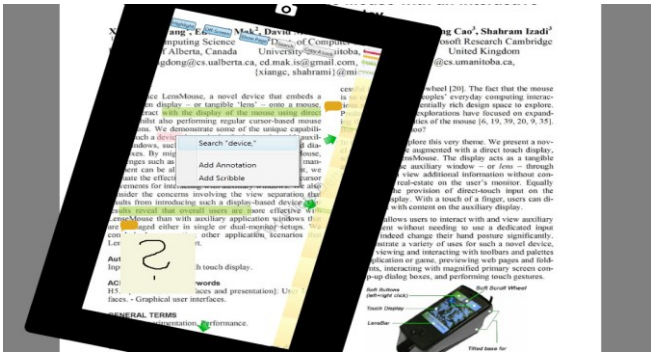

Figure 1: tPad screen capture showing highlights (green) , text and free-hand annotations, and off-screen pointers (arrow).

By following an iterative and user-centric design approach, and taking Active Reading [1] 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 devi-ces: contact-based (e.g. annotations, scribbles), content-aware (e.g. UI orientation, content lookup), and off-contact (e.g. flipping, stacking).

Our final prototype is a mobile device called the *tPad*. The tPad addresses registration with 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 on top of another one. We implemented the ActiveReade, a tPad application that allows users to underline, high-light, 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

[1] Active reading is an activity which has been discussed as better performed in paper and that can benefit from digital augmentation for which several technologies have been proposed [REFERENCE].

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 [1 PAGE]

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 content-aware interactions, third we rely on transparent display technology.

CONTACT AUGMENTED REALITY – cAR [1/2 PAGE]

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

How is cAR different than traditional 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) Simplified rendering

4) Operation both as a mobile device, and as a augmented lens.

Why does it need a transparent display: 1) because it preserves the appearance (texture, colors, lighting, age, wear) of the object being augmented.

2) Because if maintains visible the physical modifications done in that object.

APPROACH [1/2 COLUMN]

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 [1 PAGE]

Contact-based

Content-aware

Off-Contact

TABLETOP PROTOTYPE [1 PAGE]

Implementation Details: registration, display and render details.

Features

Feedback

Limitations

tPad PROTOTYPE [1 PAGE]

Implementation Details: registration, display and render details.

Features – features that are not contact, reinforce the need of paper

Feedback

Limitations: LCD and light-table, FPS, single-side touch input, attached to the computer

DISCUSSION [1 PAGE]

Transparent displays on mobile devices – perhaps not for mobile phones, but convenient for cAR.

Model-based registration: model creation and distribution

Model-based –vs– ad-hoc registration

CONCLUSIONS [1/2 PAGE]

Actual conclusions

Future work

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