

cAR: Contact Augmented Reality with Transparent-Display Mobile Devices

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Motivation



[digitalsignage.net]



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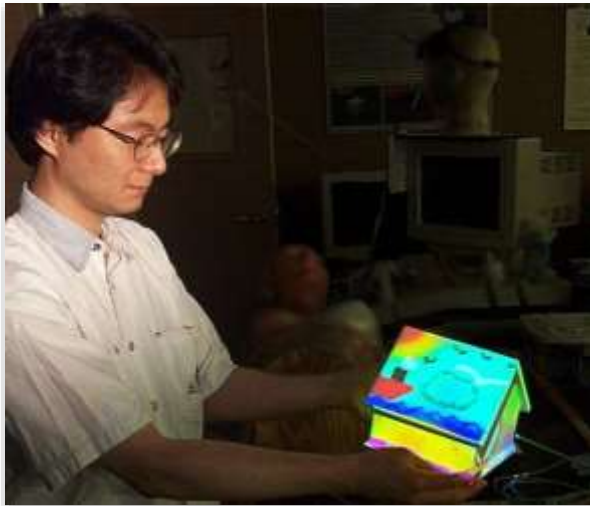
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Motivation

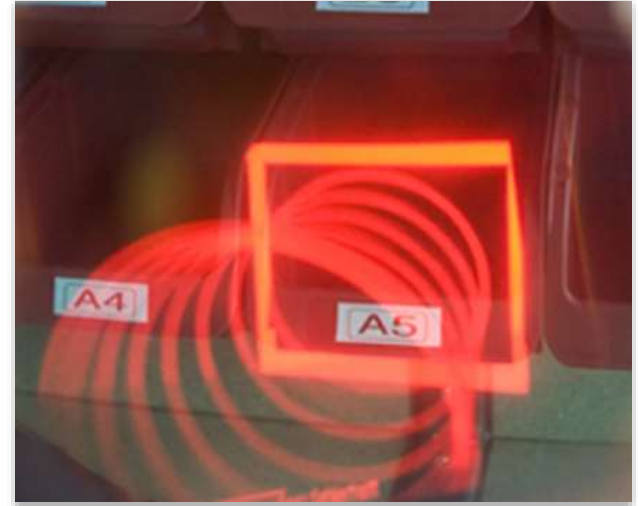
- To bring both worlds together: Augmented Reality
- Can be distant projections, handheld lenses, or also head mounted displays/smart glasses



[Bandyopadhyay et al. 2001]
Dynamic Shader Lamps



[Wagner et al. 2005]
Invisible Train

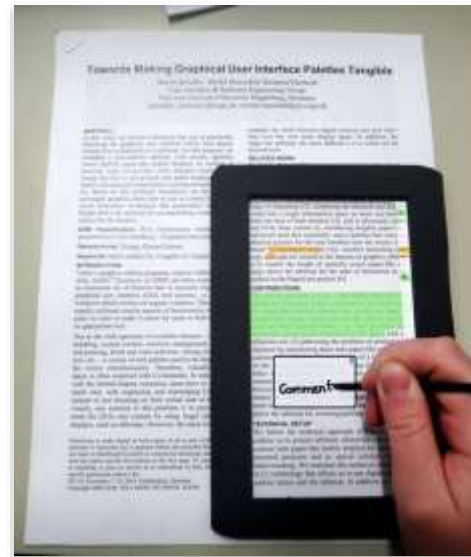
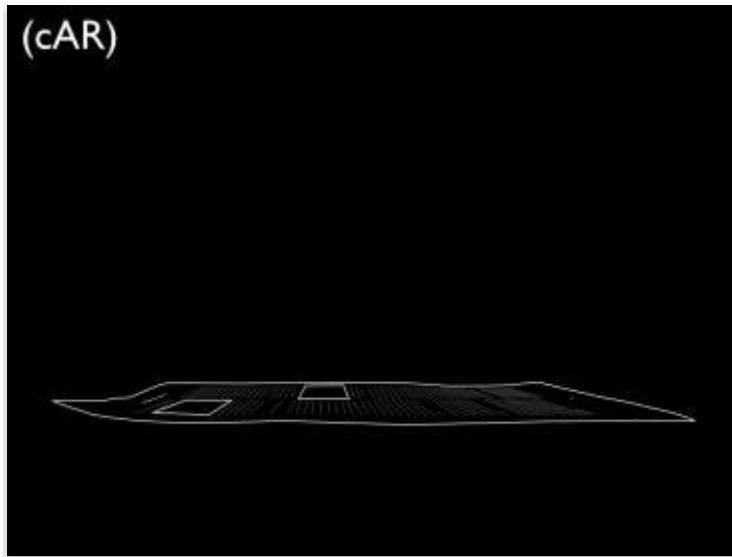


[Schwerdtfeger and Klinker 2008]

- Our approach: Contact Augmented Reality (cAR)

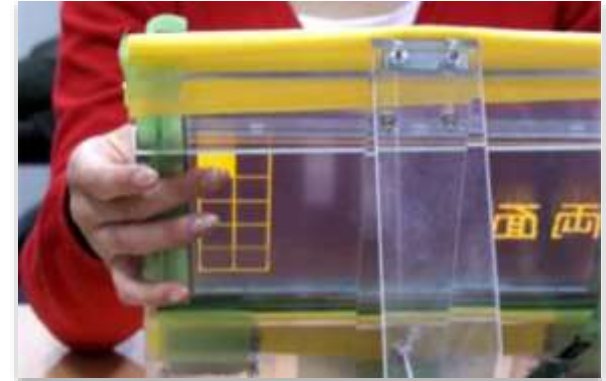
Contact Augmented Reality

- Concept: Mobile Device with transparent screen rests on top of an augmented object or surface



Contact Augmented Reality

- Transparent displays already exist in both research prototypes and consumer products
- But many challenges for AR:
 - Binocular parallax
[Lee et al., 2012]
 - Object tracking



[Ohtani et al. 2011] – LimpiDual



[@darwinpogi.tumblr.com] – Lenovo S800

Contact Augmented Reality

- Contact Augmented Reality minimizes the distance between object and augmentation...
- ... simplifying registration to 2D
- ... and reducing visual parallax

Contributions

We present Contact Augmented Reality (cAR) and contribute:

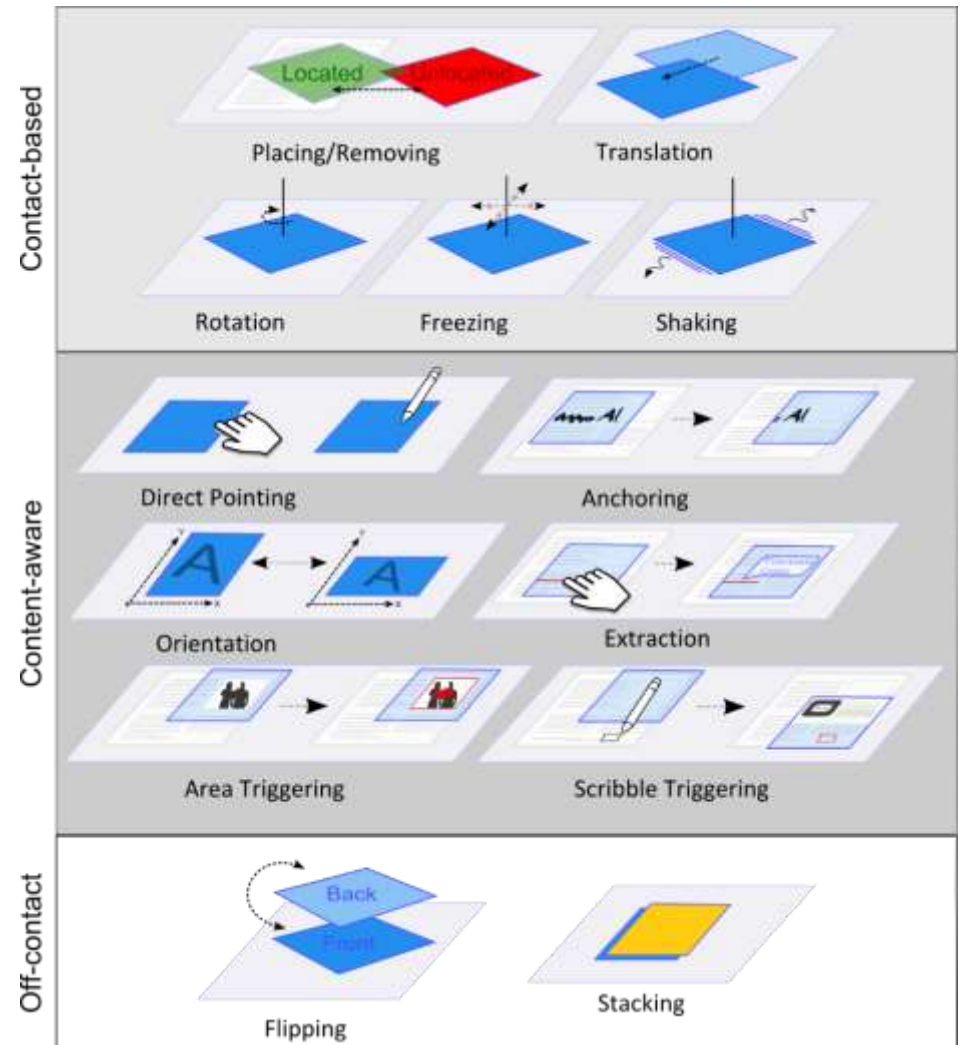
- Categorization of different interaction techniques for Contact Augmented Reality
- Two cAR prototypes implementing a subset of these features
- How cAR can be applied to the area of active reading

Introducing the

cAR Interaction Vocabulary


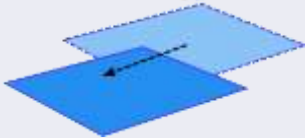
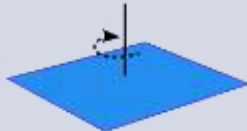
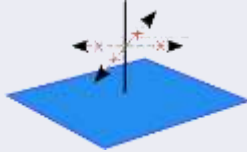
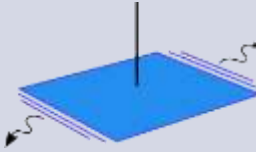
Interaction Vocabulary

- 3 categories of cAR interaction techniques:
 1. Contact-Based
 2. Content-Aware
 3. Off-Contact






Interaction Vocabulary: 1. Contact-Based

- Manipulation of device *in relation* to underlying object

Technique	Usage	
Placing/ Removing	Starting & stopping of registration and accessing information	
Translation	Move viewport into augmentation, browse virtual content	
Rotation	Rotate viewport, change display mode Also: Input for continuous values (zoom, opacity,...)	
Freezing	Ignore translation/rotation, preserve current view	
Shaking	Symbolic gesture to trigger functionality, e.g., Undo/Deselect	




Interaction Vocabulary: 2. Content-Aware (I)

- Leverage *knowledge about* the underlying object

Technique	Usage	
Direct Pointing	Touch or pen based interaction with spatially-aligned digital content	
Anchoring	Add digital content (annotations) fixed at the physical object	
Orientation	Adjust orientation of user interface in relation to coordinate system of augmented object	

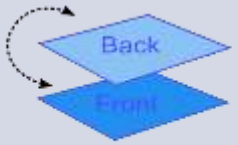

Interaction Vocabulary: 2. Content-Aware (II)

- Leverage *knowledge about* the underlying object

Technique	Usage	
Extraction	Select items of digital model, e.g., select words and look up their definition	
Area Triggering	Statically defined zones on the object that trigger functionality, e.g., a video that is connected to a printed picture	
Scribble Triggering	Hand-drawn glyphs on the physical object trigger functionality on the device, e.g., launch an application	

Interaction Vocabulary: 3. Off-Contact

- Techniques that *break the direct contact* with the augmented object

Technique	Usage	
Flipping	Make use of both display sides, allow mode switches or perform visual changes	
Stacking	Transparency allows digital content of two stacked devices to be visible at once, support content sharing	

Presentation of the cAR

Prototypes

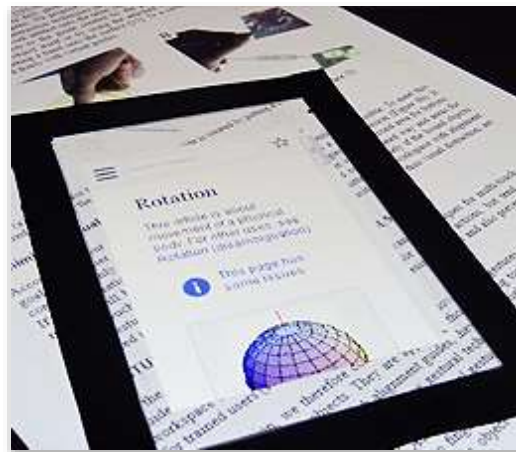
Prototypes

- We built two prototypes
 - Low-Fi tabletop prototype
 - Hardware prototype using a semi-transparent display (tPad)
- Use case: Active Reading
 - Reading used to self-inform, cross reference or support discussion
 - Used as an example application setting for cAR
 - Basic features include highlighting, searching, annotations, note-taking and content sharing



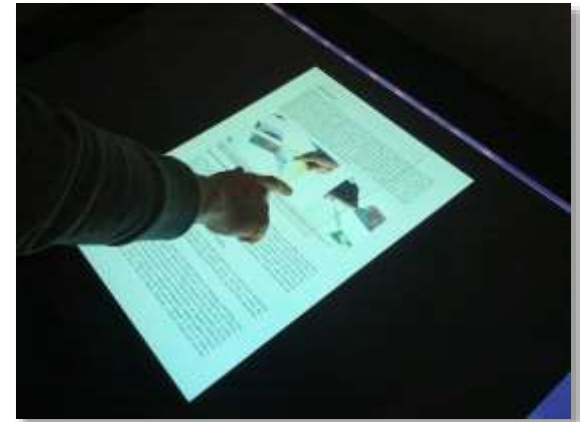
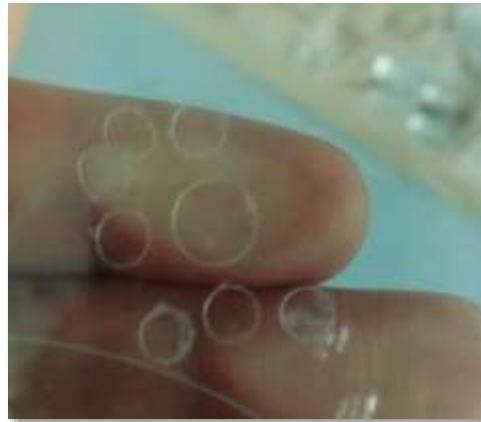
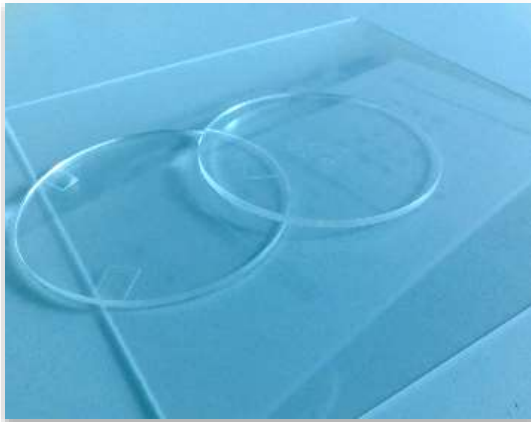
Tabletop Prototype

- Use transparent tangible as mockup for device
- Multitouch tabletop:
 - Simulates real documents
 - Tracks tangible
 - Registers touch input



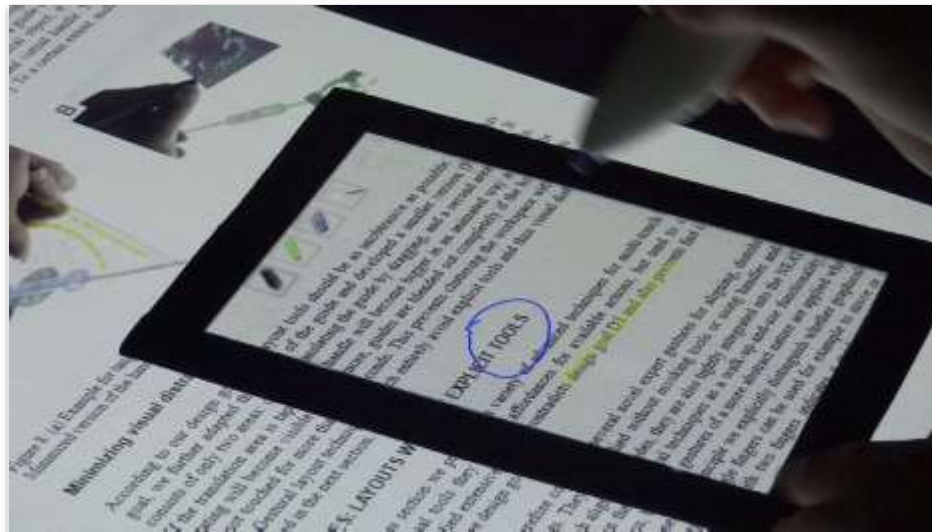
Tabletop Prototype: Implementation

- Samsung SUR40 tabletop
- Tangible construction [Büschel et al., AVI 2014]
 - 7" acrylic glass plates
 - Microsoft ByteTags cut from IR reflecting foil allow tracking
- Supports touch and IR pens



Tabletop Prototype: User Feedback

- Early user feedback from 8 participants (2 female, avg. 28 years)
- Structure:
 - Individual sessions
 - Brief introduction, time to try out the prototype, discussion in form of semi-structured interviews (~30 minutes)



Tabletop Prototype: Results

- Participants appreciated the cAR concept for active reading
- Mentioned value of additional information not included in the text
- Valuable insight for second prototype:
 - Mixed feedback for individual techniques
 - E.g., highlighting and free-hand annotations most important for 3 participants, others did prefer conventional techniques
 - Looking up word online/in a dictionary essential to most
 - Shows how diverse users are

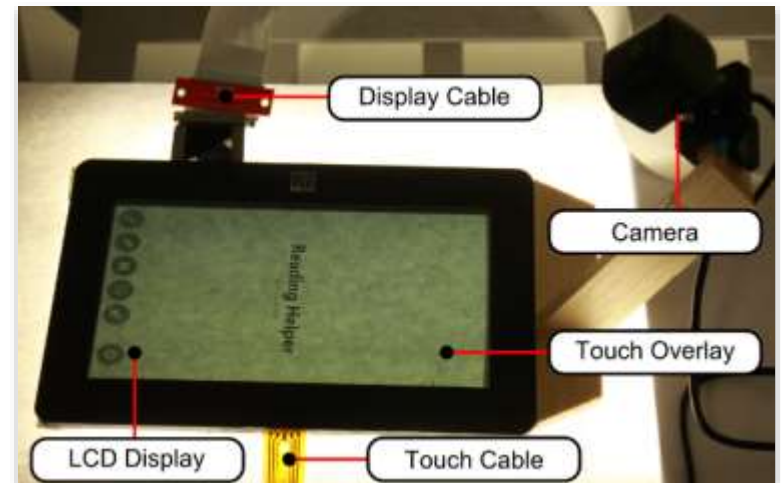
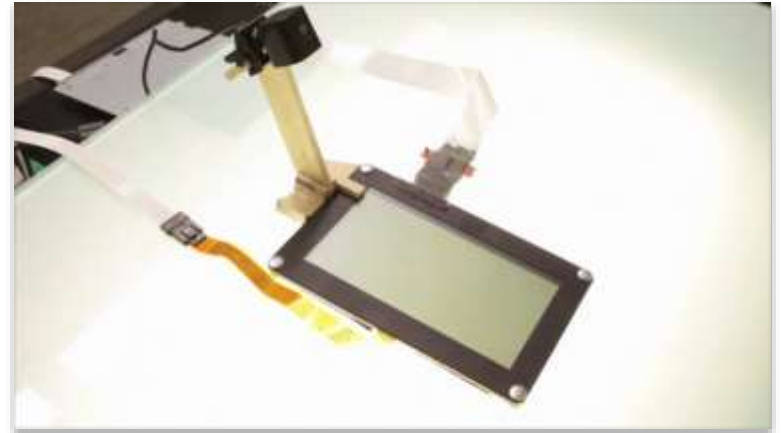
tPad Prototype

- High-fidelity prototype
- Semi-transparent 7" LCD, touch/pen capable
- Placed on a light table



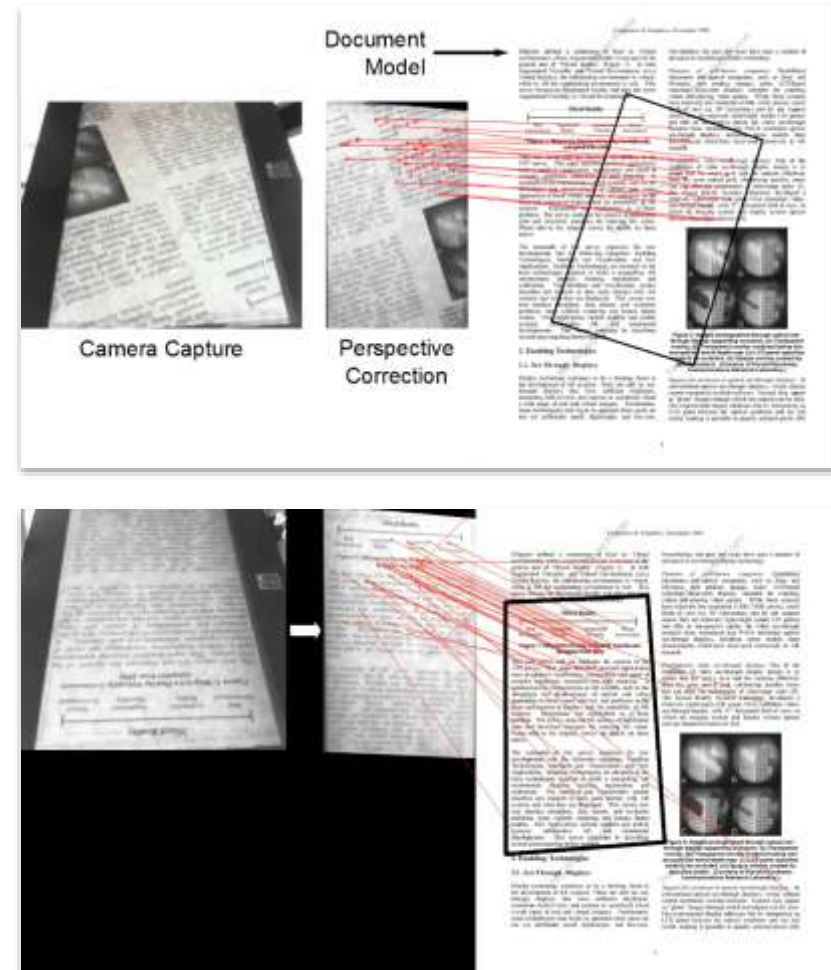
tPad Prototype: Hardware

- 7" LCD, removed backlight/diffuser
- Resistive touch overlay
- Includes sensors for flipping and stacking
- Attached overhead camera for registration



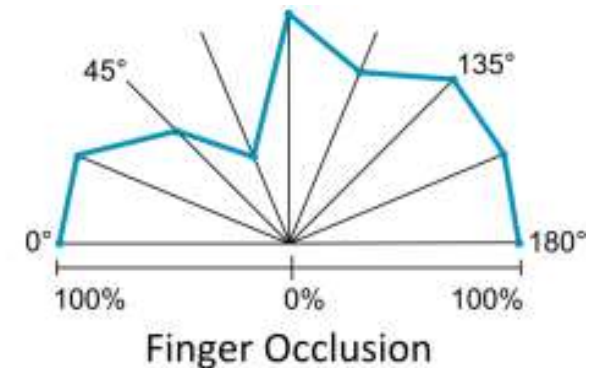
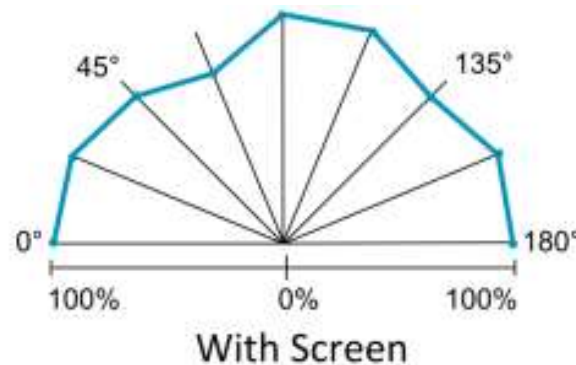
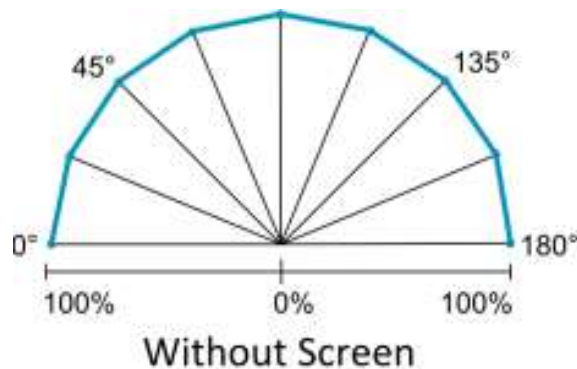
tPad Prototype: 2D Registration

- Based on surface capture & feature matching
- Image processed against known documents
- Keypoints detected by FAST corner detector
[Rosten and Drummond 2006]
- Matching uses Fast Retina Keypoint (FREAK) descriptor
[Alahi et al. 2012]



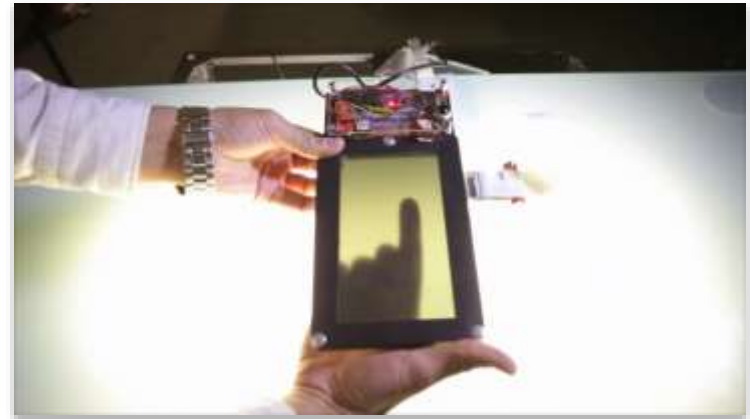
tPad Prototype: Evaluation

- Tested tracking on 10 different sample pages
- 9 different viewing angles
- 3 conditions:
 - Without screen
 - With (empty) LCD attached
 - With screen and partial occlusion (finger)



tPad Prototype: Limitations & Future Work

- Limited by need of light table
➔ use transparent OLED in the future
- Registration at approx. 10 FPS, attached camera needed
➔ explore other tracking technologies, e.g., built into frame
- More info about tPad,
including a new prototype:
[Hincapié-Ramos et al., DIS 2014]



Thank you



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Association for
Computing Machinery



SIGCHI
special interest group: computer human interaction

References

Alahi et al. 2012	Alahi, A. and Ortiz, R. and Vandergheynst, P. (2012). FREAK: Fast Retina Keypoint. In Proc. CVPR '12. IEEE
Bandyopadhyay et al. 2001	Bandyopadhyay, D., Raskar, R., and Fuchs, H. (2001). Dynamic shader lamps: Painting on movable objects. In Proc. ISAR '01. IEEE.
Büschel et al. 2014	Büschel, W., Kister, U., Frisch, M., Dachzelt, R. (2014). T4 – Transparent and Translucent Tangibles on Tabletops. In Proc. AVI '14. ACM.
Hincapié-Ramos et al. 2014	Hincapié-Ramos, J.D., Roscher, S., Büschel, W., Kister, U., Dachzelt, R. and Irani, P. (2014). tPad: Designing Transparent-Display Mobile Interactions. In Proc. DIS '14. ACM.
Lee et al. 2012	Lee, J., Bae, S., Jung, J., and Choi, H. (2012). Transparent display interaction without binocular parallax. In UIST Adjunct Proceedings '12. ACM, New York, NY, USA.
Ohtani et al. 2011	Tomoko Ohtani, Tomoko Hashida, Yasuaki Kakehi, and Takeshi Naemura. (2011). Comparison of front touch and back touch while using transparent double-sided touch display. In ACM SIGGRAPH 2011 Posters (SIGGRAPH '11). ACM, New York, NY, USA.
Rosten and Drummond 2006	Rosten, E. and Drummond, T. 2006. Machine learning for high-speed corner detection. In Proc. ECCV '06. Springer Berlin Heidelberg.
Schwerdtfeger and Klinker 2008	Schwerdtfeger, B. and Klinker, G. (2008). Supporting order picking with Augmented Reality. In Proc. ISMAR '08. IEEE.
Wagner et al. 2005	Wagner, D., Pintaric, T., Ledermann, F., and Schmalstieg, D. (2005). Towards massively multi-user augmented reality on handheld devices. In Proc. PERVASIVE'05. Springer-Verlag, Berlin, Heidelberg.