MMI 2: Mobile Human-Computer Interaction

Small and Large Display Interaction

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Lectures

#	Date	Topic
1	19.10.2011	Introduction to Mobile Interaction, Mobile Device Platforms
2	26.10.2011	History of Mobile Interaction, Mobile Device Platforms
3	2.11.2011	Mobile Input and Output Technologies
4	9.11.2011	Mobile Input and Output Technologies, Mobile Device Platforms
5	16.11.2011	Mobile Communication
6	23.11.2011	Location and Context
7	30.11.2011	Mobile Interaction Design Process
8	7.12.2011	Mobile Prototyping
9	14.12.2011	Evaluation of Mobile Applications
10	21.12.2011	Visualization and Interaction Techniques for Small Displays
11	11.1.2012	Mobile Devices and Interactive Surfaces
12	18.1.2012	Camera-Based Mobile Interaction
13	25.1.2012	Sensor-Based Mobile Interaction 1
14	1.2.2012	Sensor-Based Mobile Interaction 2
15	**8.2.2012**	**Exam**

Aktuelles

- Klausur am 8.2.2012
  - Anmeldung
- Fragen zur Klausur
  - jeweils zu Beginn der nächsten Vorlesungen (ab 18.1.)

Review

- How to visualize the relevant of a POI to a query?
- Why is screen navigation important for small displays?
- Mechanisms to indicate objects beyond the screen?
- How to improve touch screen accuracy?

Preview

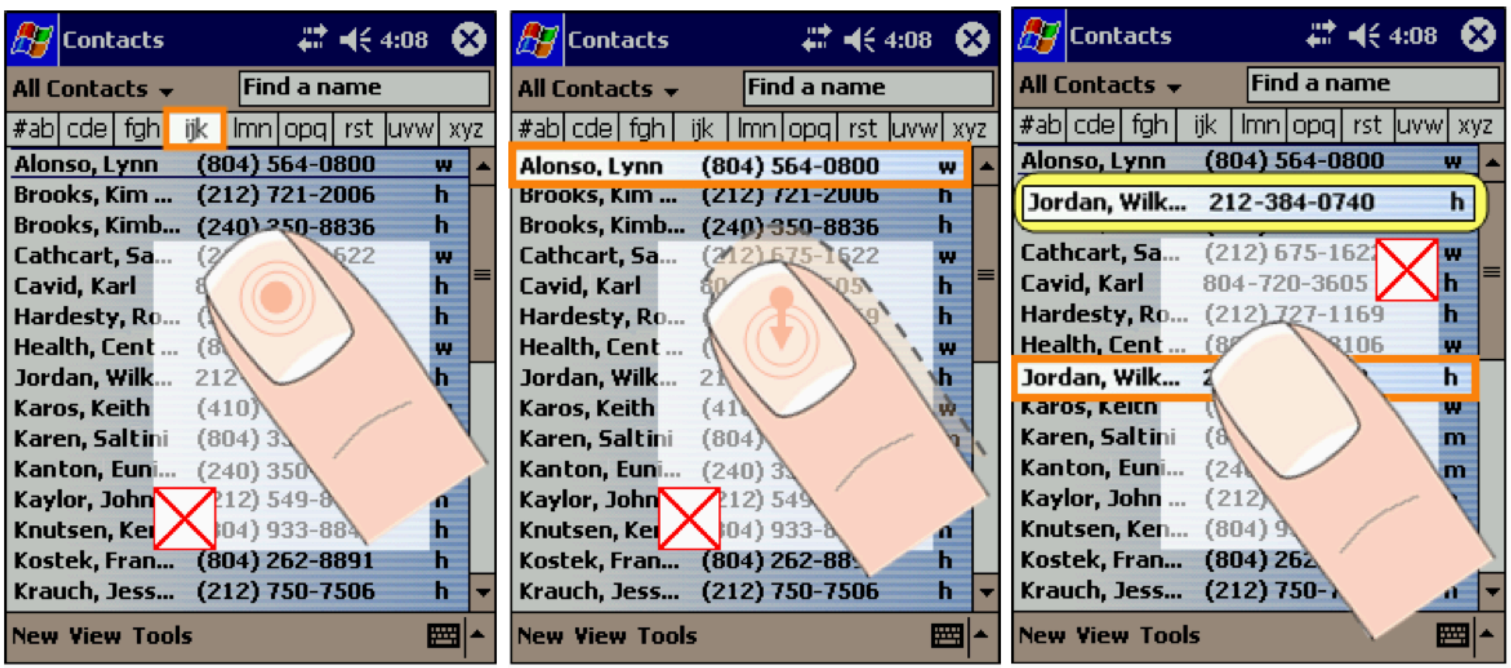
- Touch Screen interaction techniques
- Behind-the-device interaction
- Mobile devices and interactive surfaces

TOUCH SCREEN INTERACTION TECHNIQUES

Precision Touch Input: ThumbSpace

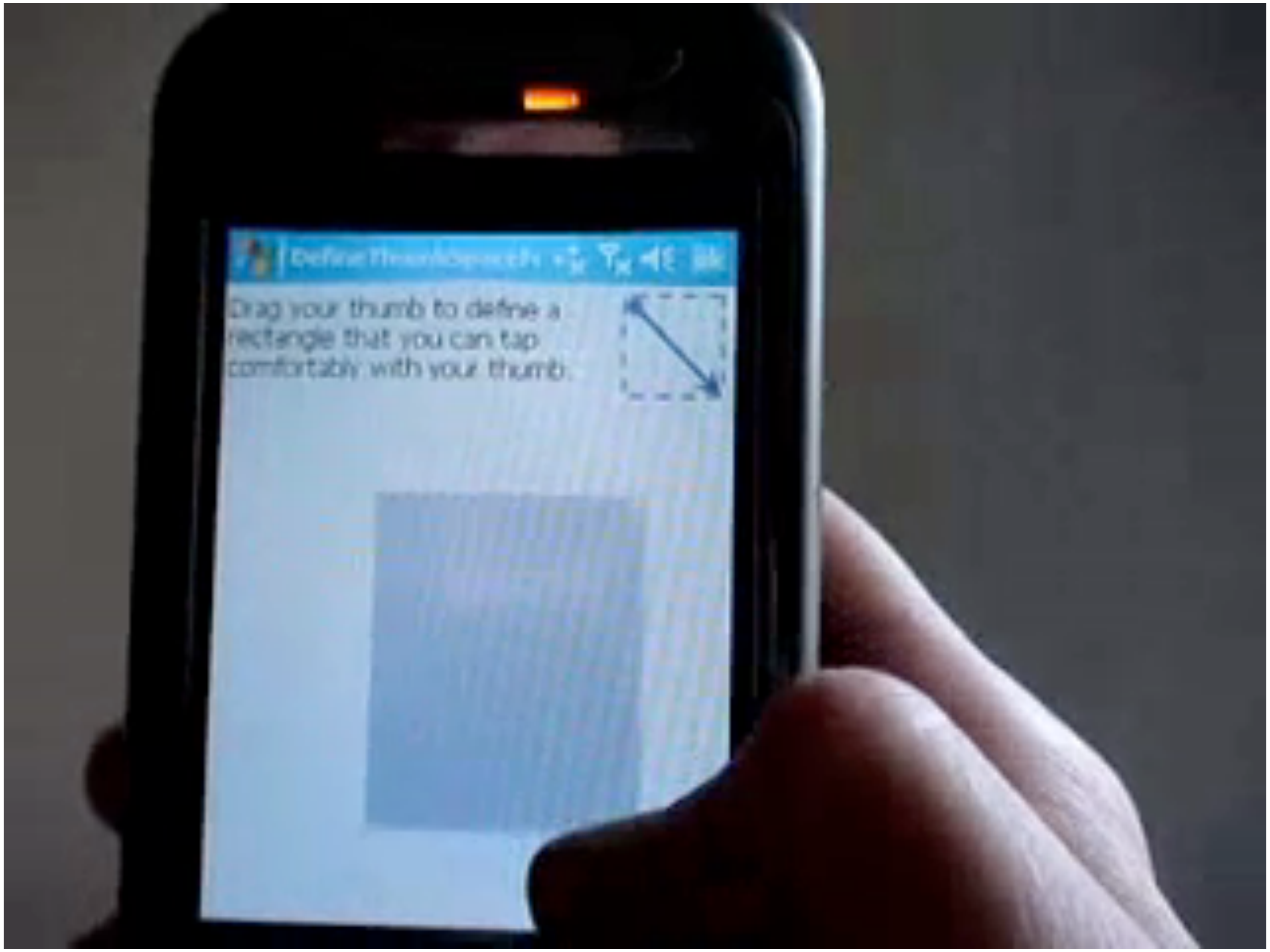
ThumbSpace: User-defined space which thumb can reach

- One-handed thumb operation of handheld touch interfaces
- Not all of screen reachable → reduce thumb interaction space
- Selection on lift-off (as with Offset Cursor)



Karlson, Bederson. ThumbSpace: Generalized One-Handed Input for Touchscreen-Based Mobile Devices. Interact 2007.

Precision Touch Input: ThumbSpace

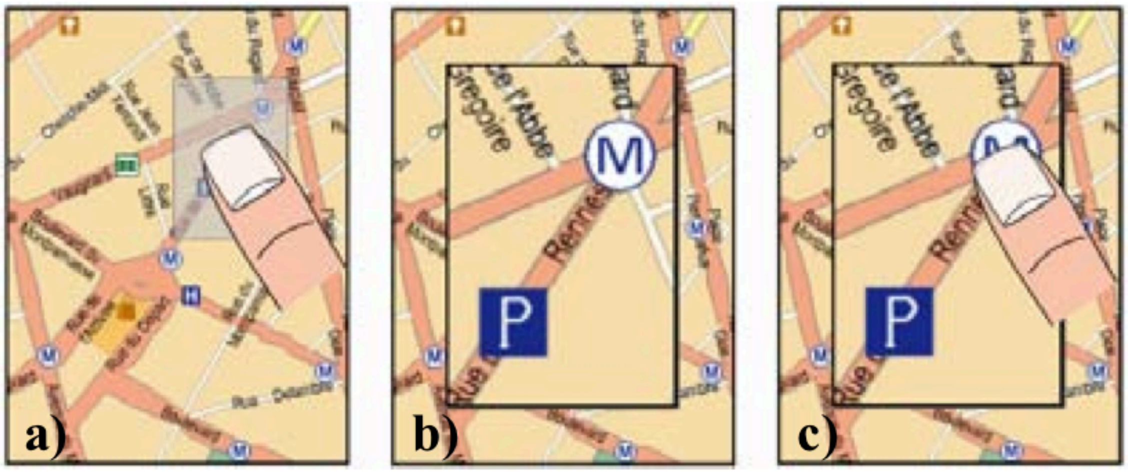


Karlson, Bederson. ThumbSpace: Generalized One-Handed Input for Touchscreen-Based Mobile Devices. Interact 2007.

Precision Touch Input: TapTap and MagStick

TapTap: Tapping the screen twice

- tap 1: select area of interest
- area zooms in, centered on screen
- tap 2: select magnified target
- zoomed target typically close to screen: fast selection
- works in border areas (c.f. Shift)



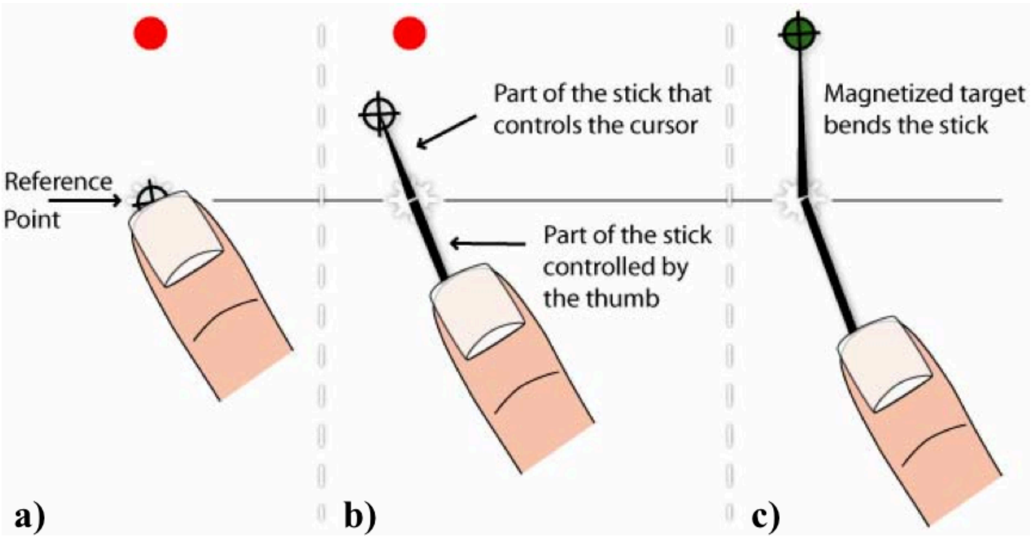
How to distinguish single touch?

Roudaut, Huot, Lecolinet. TapTap and MagStick: Improving one-handed target acquisition on small touch-screens. AVI 2008.

Precision Touch Input: TapTap and MagStick

MagStick: “magnetized telescopic stick”

- Initial touch position is reference point
- Moving away from target extends stick in opposite direction
- End of stick is “magnetically” attracted by target

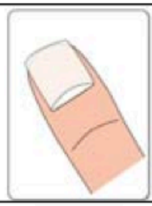
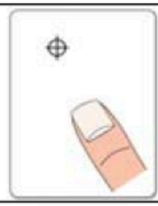
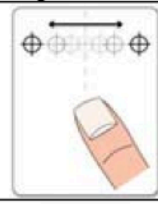
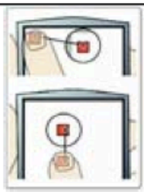
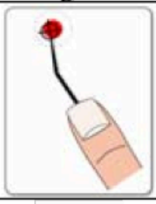
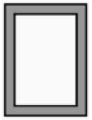
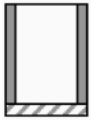
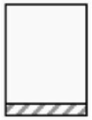
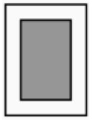
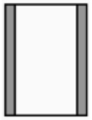
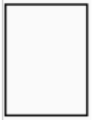


Is moving away from the target intuitive?

Is MagStick better than simple Offset Cursor?

Roudaut, Huot, Lecolinet. TapTap and MagStick: Improving one-handed target acquisition on small touch-screens. AVI 2008.

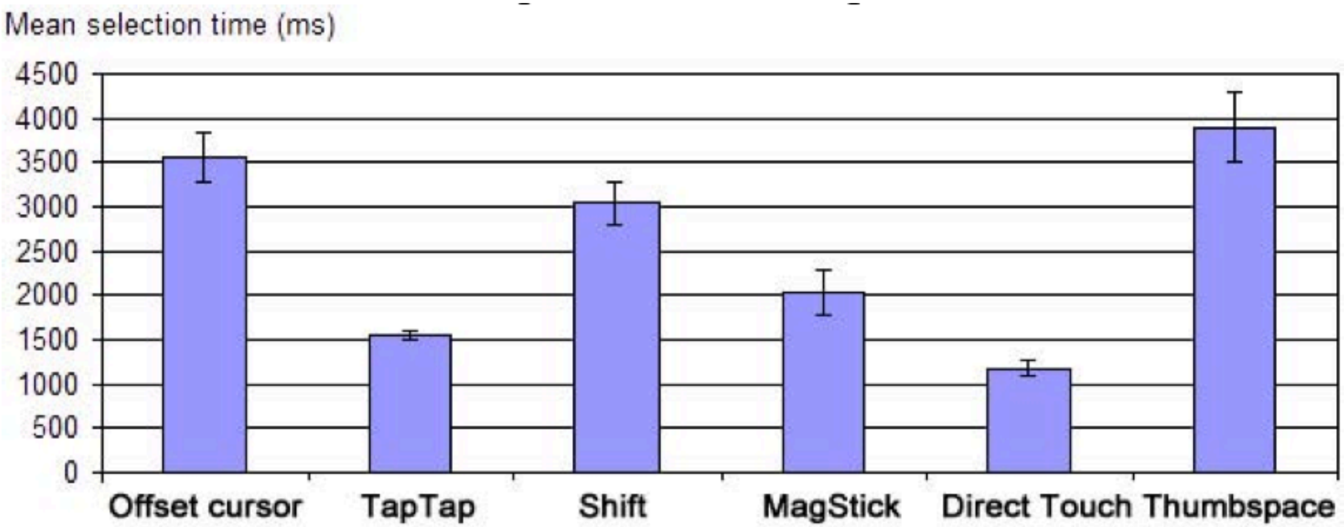
Precision Touch Input: Comparison Experiment

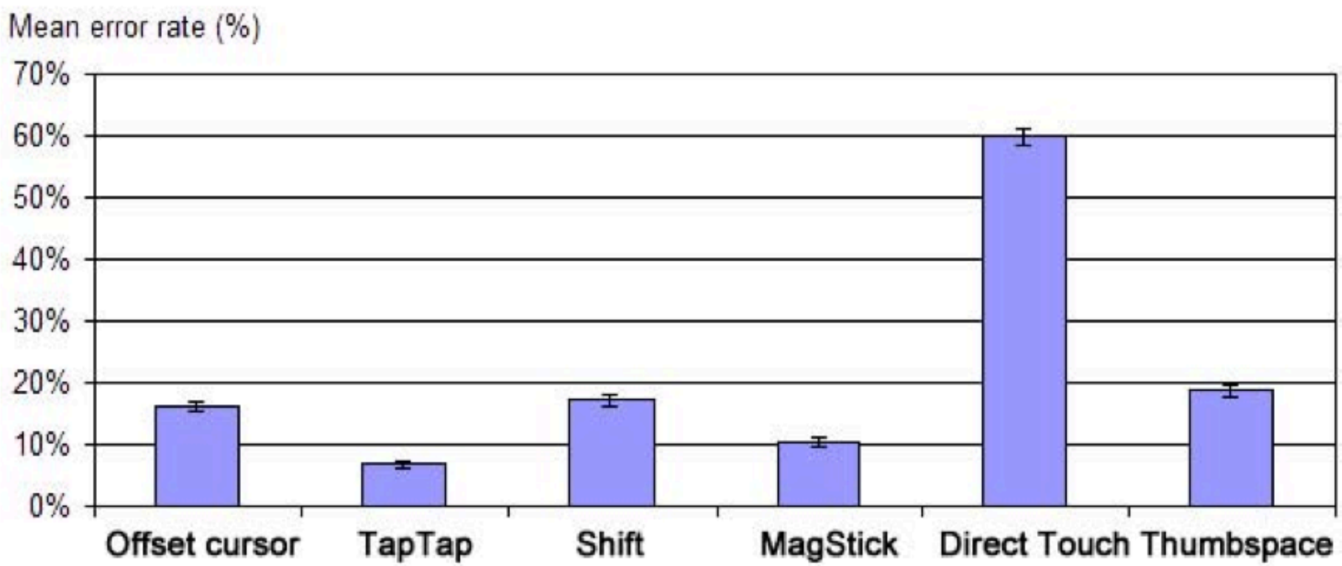
	Direct Touch	Offset Cursor	Adaptive Offset	Thumbspace	Shift	TapTap	MagStick
Overview							
Target Accessibility							
	Grayed areas are difficult to reach – Hatched areas are impossible to reach						
Thumb Occlusion	Everywhere	None	None	Center (if same relative and absolute positions)	On top left	None	None
Pointing Accuracy	Coarse	Medium (net correction distance time)	Medium (net correction distance time)	Fine (facilitated by Object Pointing)	Medium (small targets) and coarse (large targets)	One coarse and one fine (increase target size)	Fine (facilitated by Semantic Pointing)

- Dependent variables
  - Time
  - Error rate
  - Questionnaire results
  - Ranking of techniques

Roudaut, Huot, Lecolinet. TapTap and MagStick: Improving one-handed target acquisition on small touch-screens. AVI 2008.

Precision Touch Input: Comparison Experiment

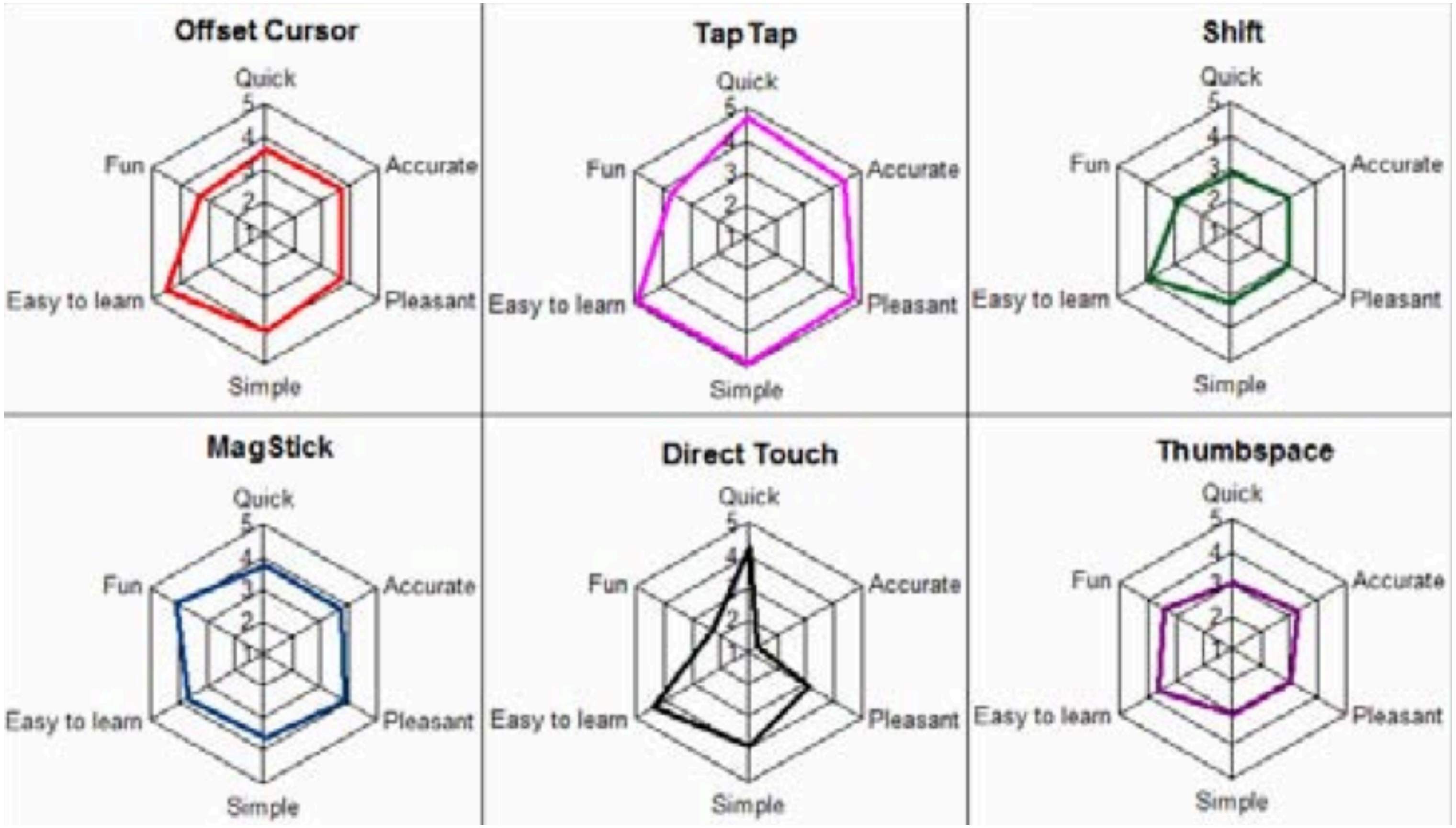




Roudaut, et al. TapTap and MagStick: Improving one-handed target acquisition on small touch-screens. AVI 2008.

Precision Touch Input: Comparison Experiment

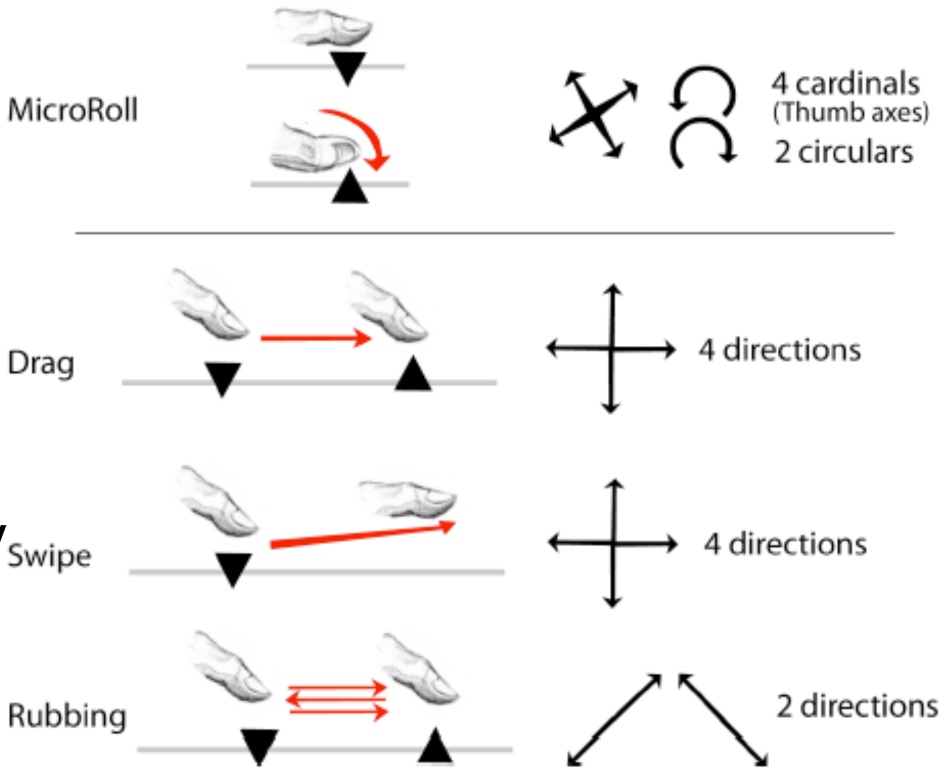
- Ranking (first to last): TapTap, MagStick, Shift, Offset Cursor, Thumbspace, Direct Touch



Roudaut, et al. TapTap and MagStick: Improving one-handed target acquisition on small touch-screens. AVI 2008.

MicroRolls: Expanding Touch-Screen Input by Distinguishing Rolls vs. Slides of the Thumb

- Input vocabulary for touchscreens is limited
- MicroRolls: thumb rolls without sliding
  - Roll vs. slide distinction possible
  - No interference
- Enhanced input vocabulary
  - Drags, Swipes, Rubbings and MicroRolls



Roudaut, Lecolinet, Guiard. MicroRolls: Expanding Touch-Screen Input Vocabulary by Distinguishing Rolls vs. Slides of the Thumb. CHI 2009.

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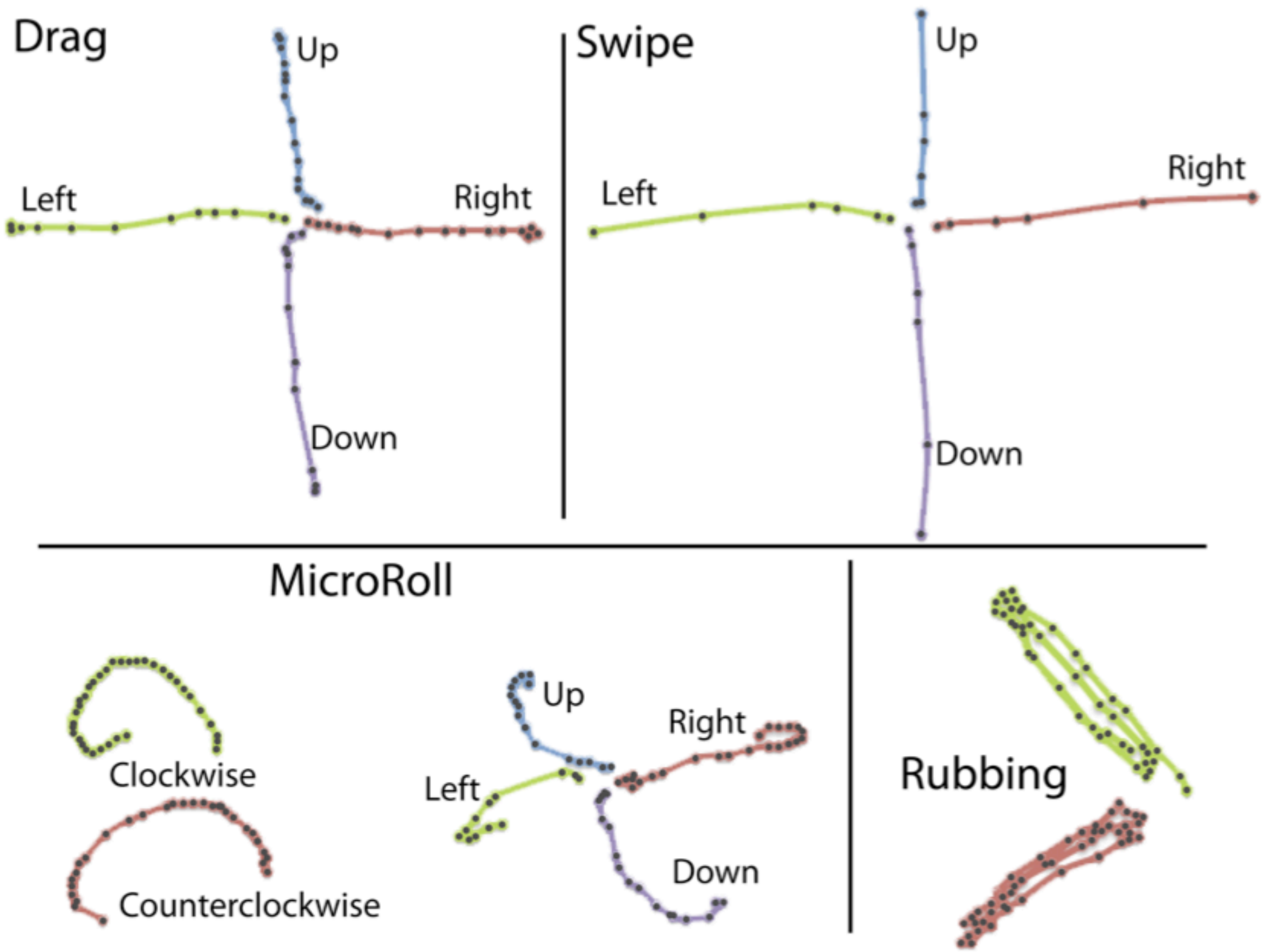
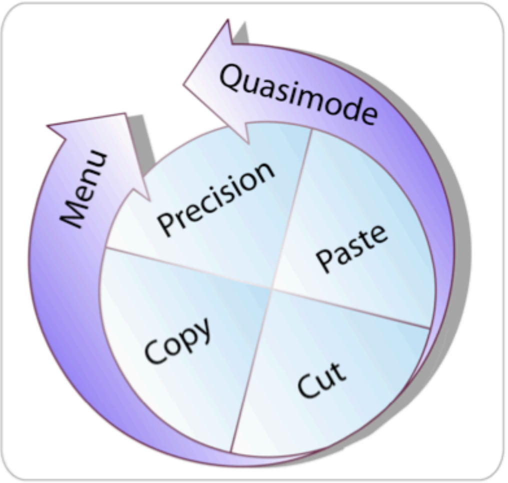
Kinematic Traces of Different Touch Gestures

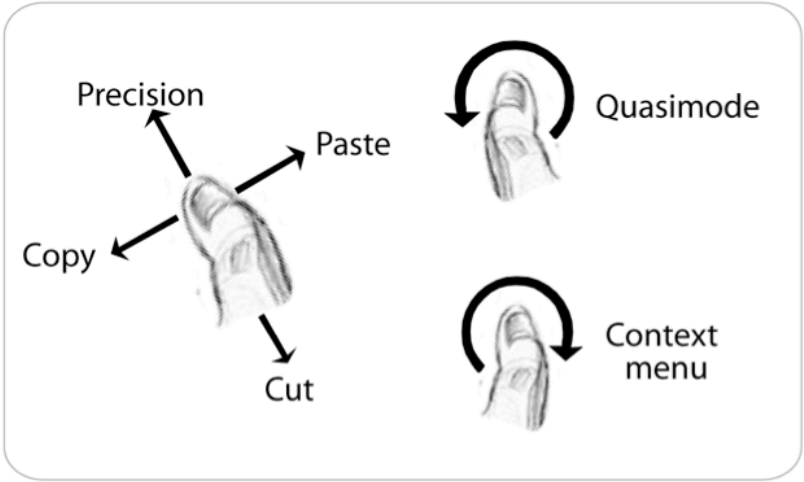


Roudaut, Lecolinet, Guiard. MicroRolls: Expanding Touch-Screen Input Vocabulary by Distinguishing Rolls vs. Slides of the Thumb. CHI 2009.

Mapping MicroRoll Gestures to Actions



Menu (300ms timeout)



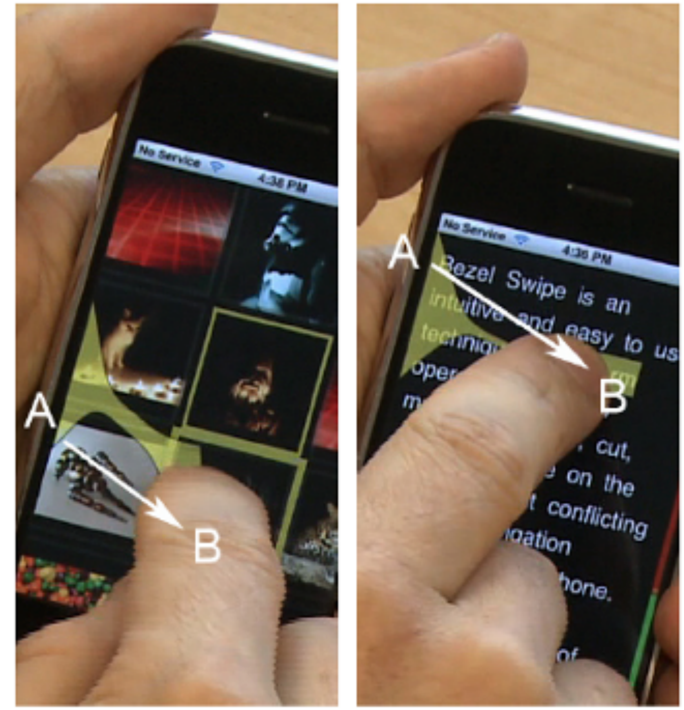
MicroRoll gestures

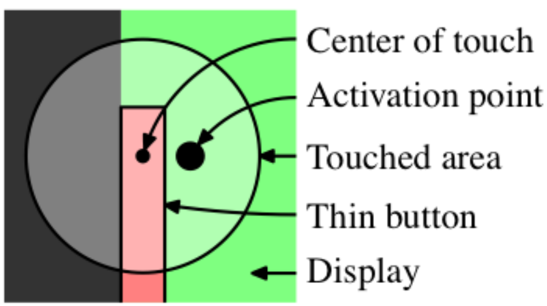
- Menu supports gesture learning
  - Menu only appears after 300ms timeout
  - Experts execute gestures immediately
- Precision: selecting small targets
- Quasi-mode: modify subsequent operation

Roudaut, Lecolinet, Guiard. MicroRolls: Expanding Touch-Screen Input Vocabulary by Distinguishing Rolls vs. Slides of the Thumb. CHI 2009.

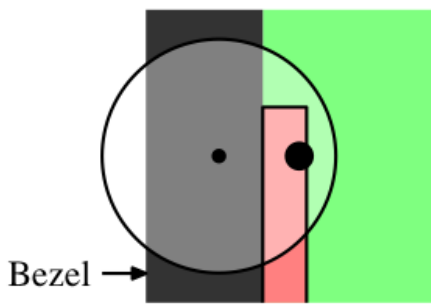
Bezel Swipe: Conflict-Free Scrolling and Selection on Mobile Touch Screen Devices

- Drag from screen edges through thin bars
- Edge bar encodes command
- Multiple commands without interference
  - Selection, cut, copy, paste
  - Zooming, panning, tapping





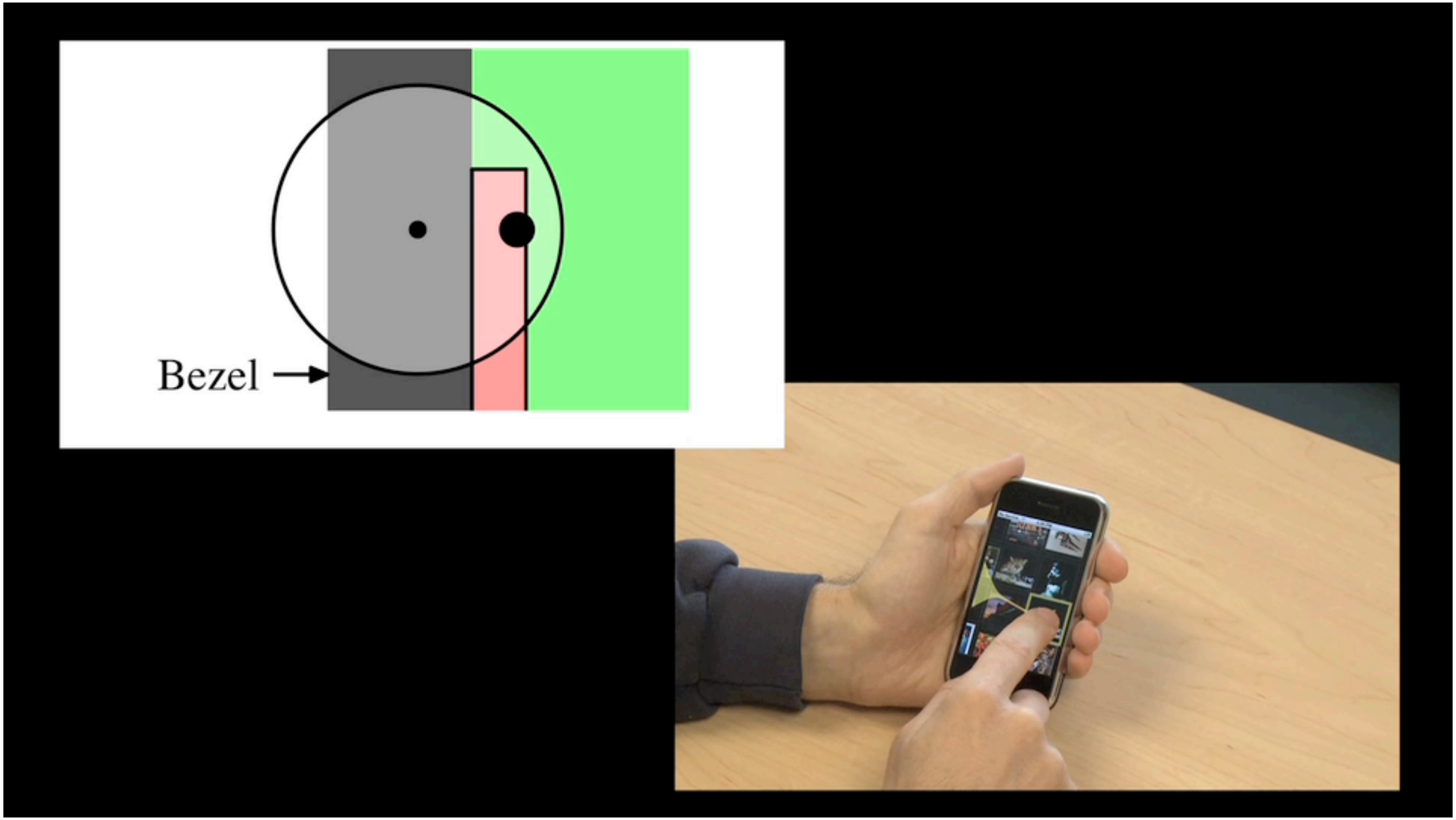
touch on bar: no activation



touch on bezel: activation

Roth, Turner. Bezel Swipe: Conflict-Free Scrolling and Multiple Selection on Mobile Touch Screen Devices. CHI 2009.

Bezel Swipe: Conflict-Free Scrolling and Selection on Mobile Touch Screen Devices



Roth, Turner. Bezel Swipe: Conflict-Free Scrolling and Multiple Selection on Mobile Touch Screen Devices. CHI 2009.

Rubbing and Tapping: Multiple Fingers on Single-Touch Screens

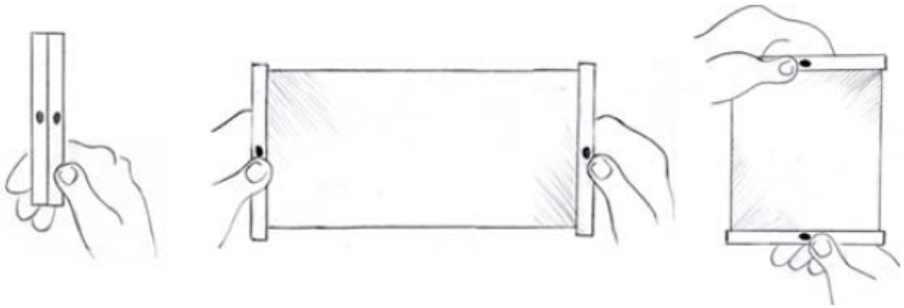
- Zooming on single-touch displays
  - Cursor “jumps” when second finger touches screen
  - Hardware averages touch point in center
- Proposed interaction techniques
  - Rub-Pointing: diagonal rubbing gesture for pointing and zooming in a single-handed technique
  - Zoom-Tapping: dominant hand points, non-dominant hand taps

Olwal, Feiner, Heyman. Rubbing and Tapping for Precise and Rapid Selection on Touch-Screen Displays. CHI 2008.

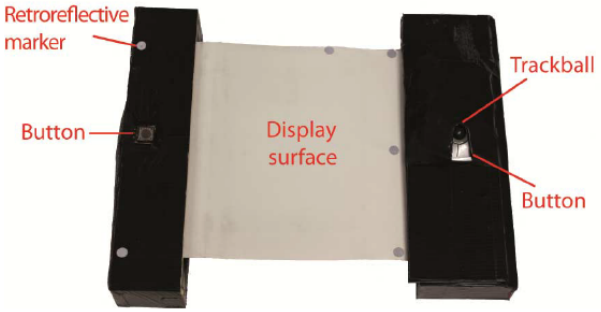
Rubbing and Tapping: Multiple Fingers on Single-Touch Screens

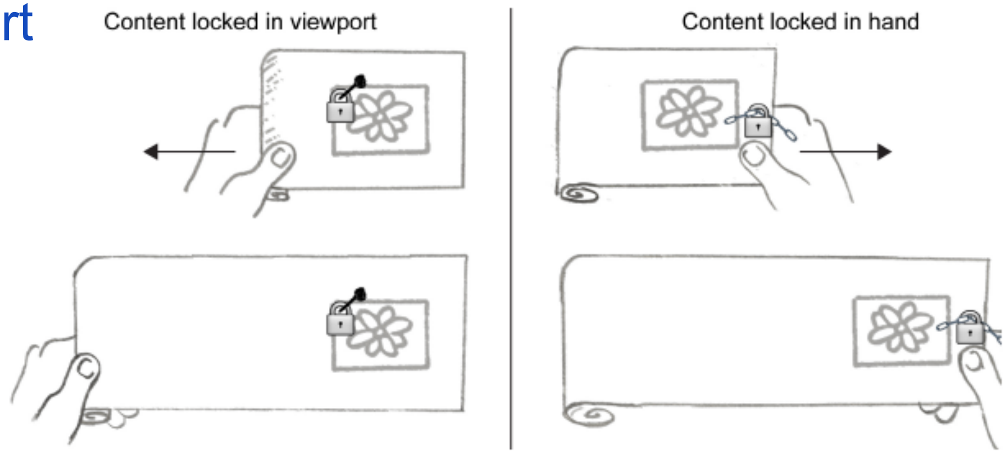
Olwal, Feiner, Heyman. Rubbing and Tapping for Precise and Rapid Selection on Touch-Screen Displays. CHI 2008.

Xpaaand: Interaction Techniques for Rollable Displays



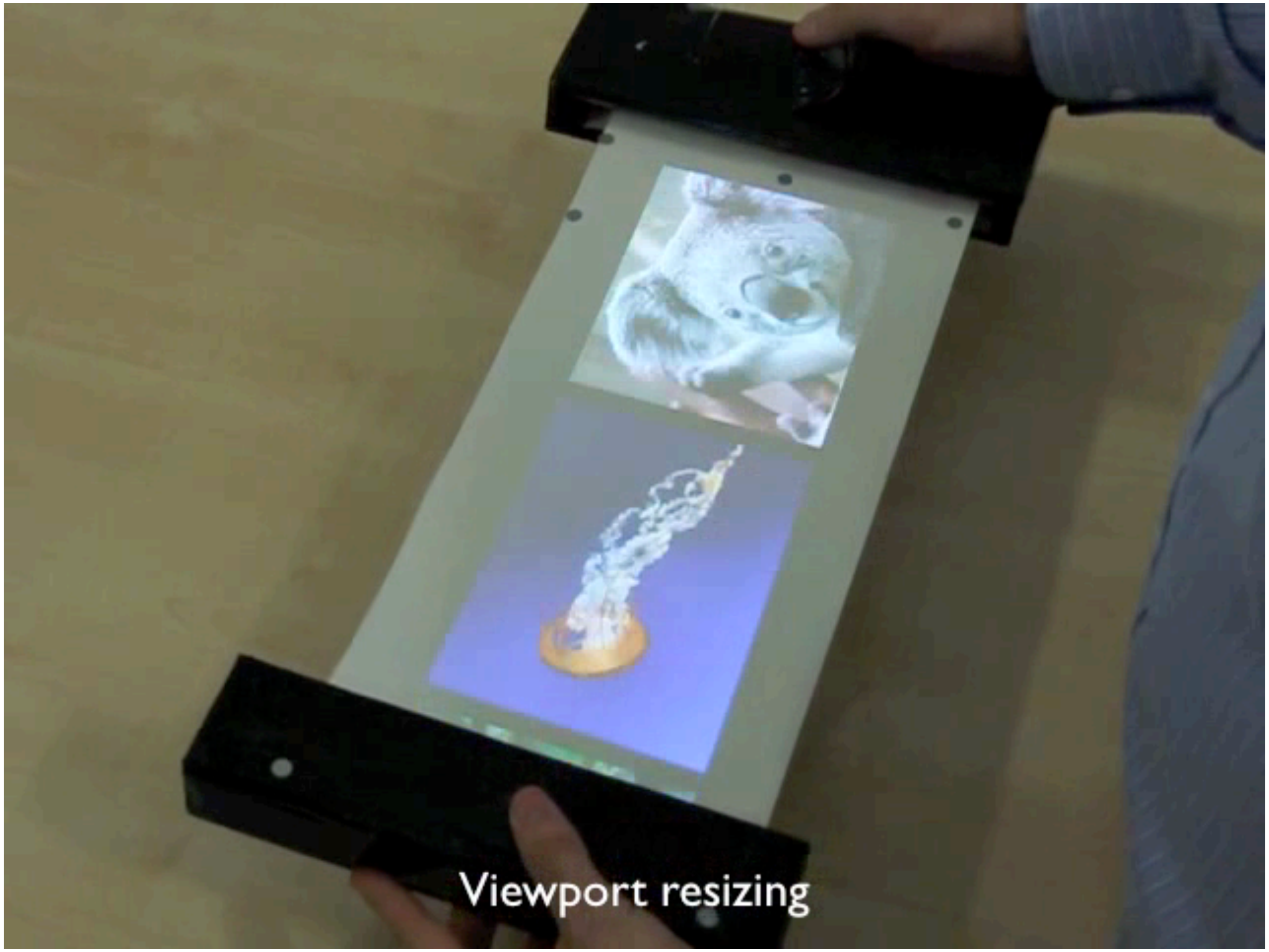
- Concept of a future rollable display
  - Physical resizing of the display as an interaction technique
  - Semantic zooming
- Metaphors
  - Content locked in viewport
  - Content locked in hand





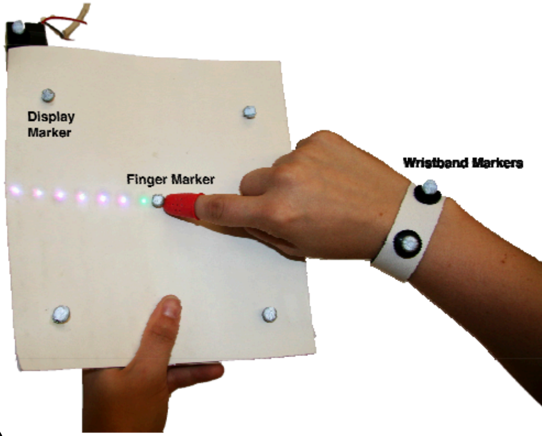
Khalilbeigi, Lissermann, Mühlhäuser, Steimle. Xpaaand: Interaction Techniques for Rollable Displays. CHI 2011.

Xpaaand: Interaction Techniques for Rollable Displays

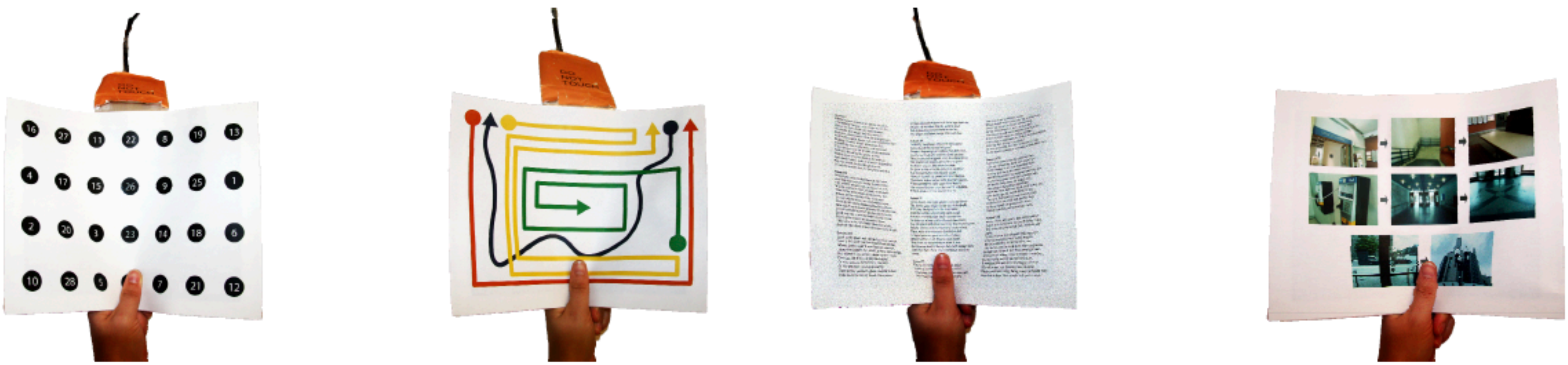


Khalilbeigi, Lissermann, Mühlhäuser, Steimle. Xpaaand: Interaction Techniques for Rollable Displays. CHI 2011.

Effects of Structural Holds on Pointing and Dragging with Flexible Displays

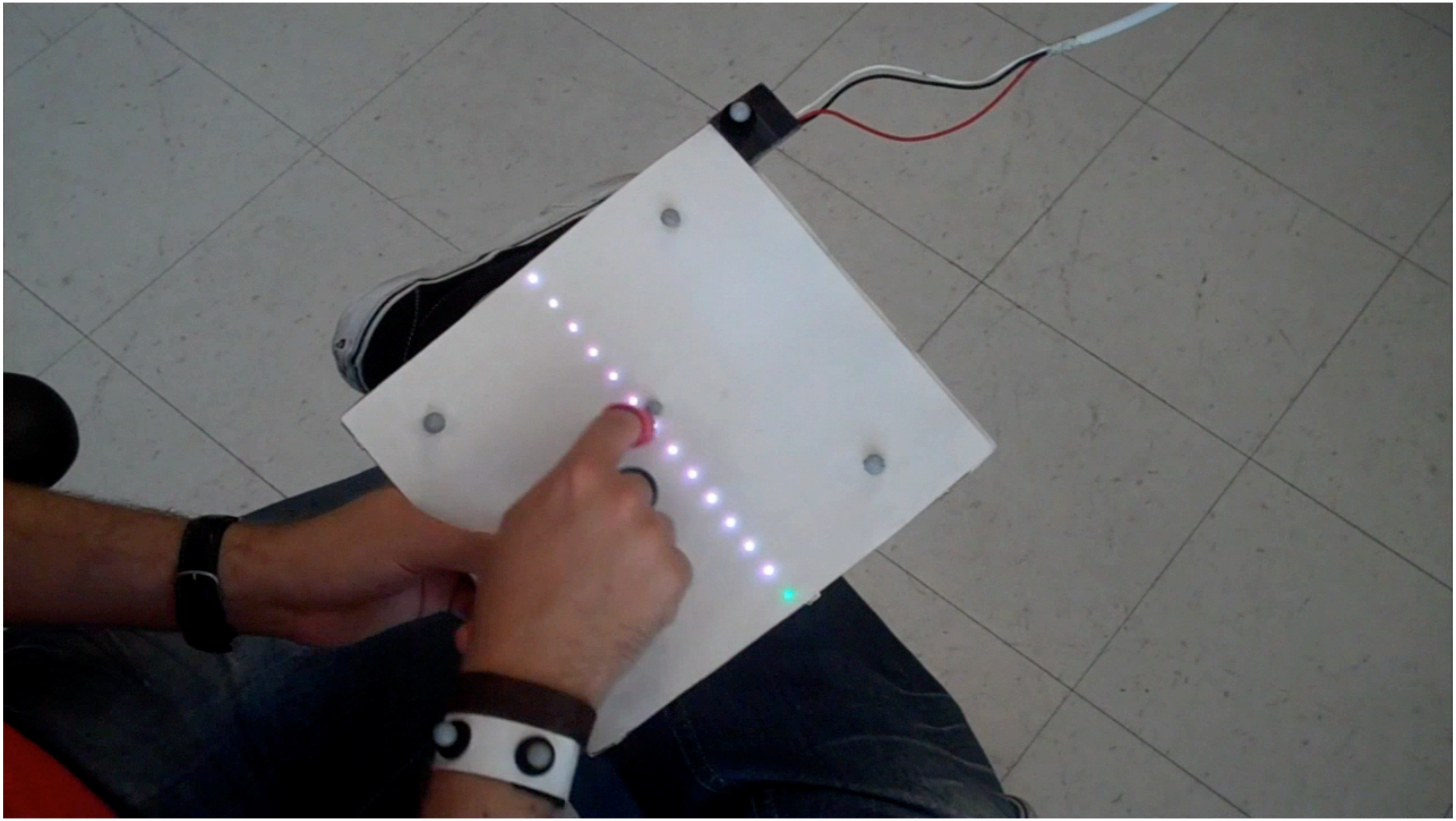


- How do users point and drag with a paper-like display?
  - Study: common holds and force patterns
  - Observed holds: grip zone, rigid / flexible zone
- Efficiency: Rigid areas (produced by holds) had 12% higher pointing and dragging performance



Dijkstra, Perez, Vertegaal. Evaluating Effects of Structural Holds on Pointing and Dragging Performance with Flexible Displays. CHI 2011.

Effects of Structural Holds on Pointing and Dragging with Flexible Displays



Dijkstra, Perez, Vertegaal. Evaluating Effects of Structural Holds on Pointing and Dragging Performance with Flexible Displays. CHI 2011.

PaperPhone: Bend Gestures in Mobile Devices with Flexible E-Paper Display

Use device as watch…

…detach, use as PDA

Lahey, Girouard, Burleson, Vertegaal. PaperPhone: Understanding the Use of Bend Gestures in Mobile Devices with Flexible Electronic Paper Display. CHI 2011.

PaperPhone: Bend Gestures in Mobile Devices with Flexible E-Paper Display

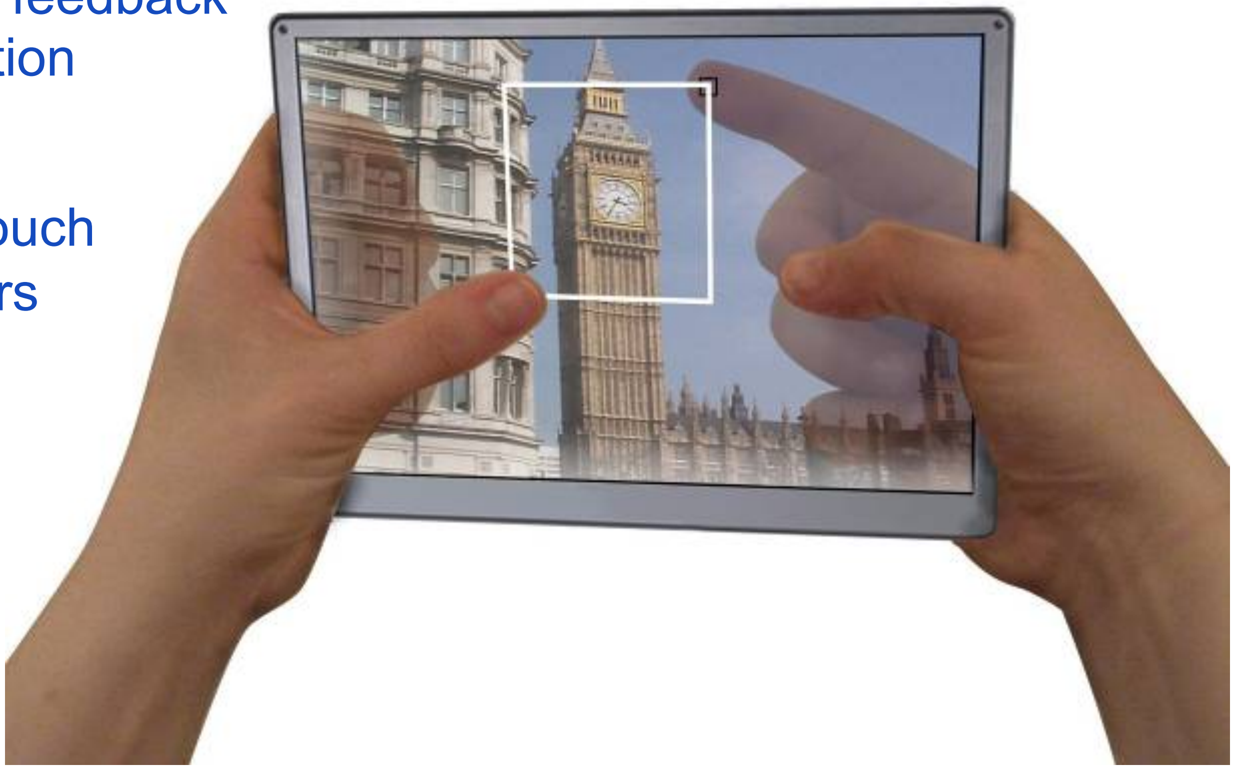
Lahey, Girouard, Burleson, Vertegaal. PaperPhone: Understanding the Use of Bend Gestures in Mobile Devices with Flexible Electronic Paper Display. CHI 2011.

BEHIND-THE-DEVICE INTERACTION

LucidTouch

Wigdor, Forlines, Baudisch, Barnwell, Shen: LucidTouch: A See-Through Mobile Device. UIST'07.

- Behind-the-device multitouch input
- Pseudo transparency
  - Enabling back of the device pointing
  - 3 states + visual feedback
    = land-on selection
- Form-factor
  - Enabling multi-touch
    with all ten fingers



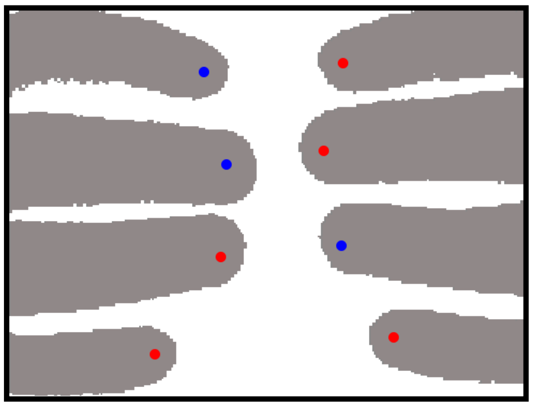
Why Behind-the-Device Interaction?

- Avoid occlusion
- “Fat finger” problem

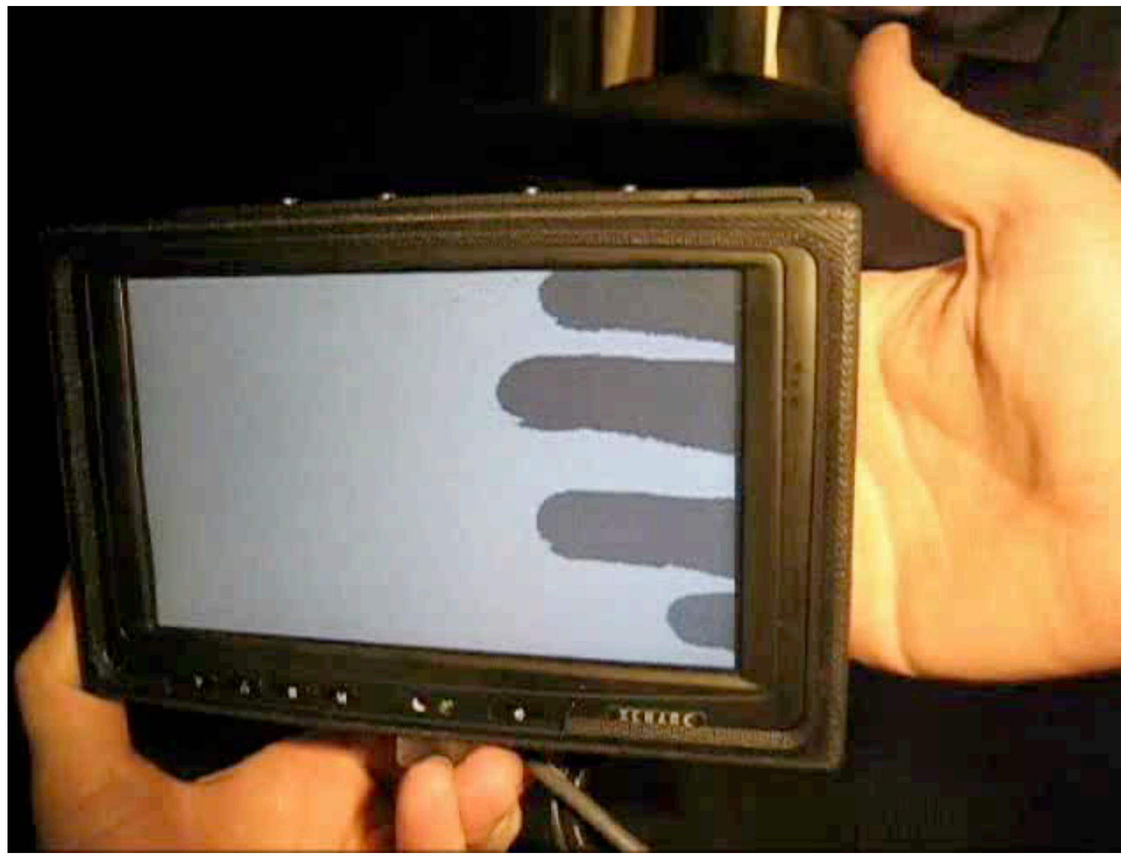
Wigdor, Forlines, Baudisch, Barnwell, Shen: LucidTouch: A See-Through Mobile Device. UIST'07.

Pseudo Transparency

Show finger “shadows” as cues



gray: “shadow”
red: touch
blue: hovering



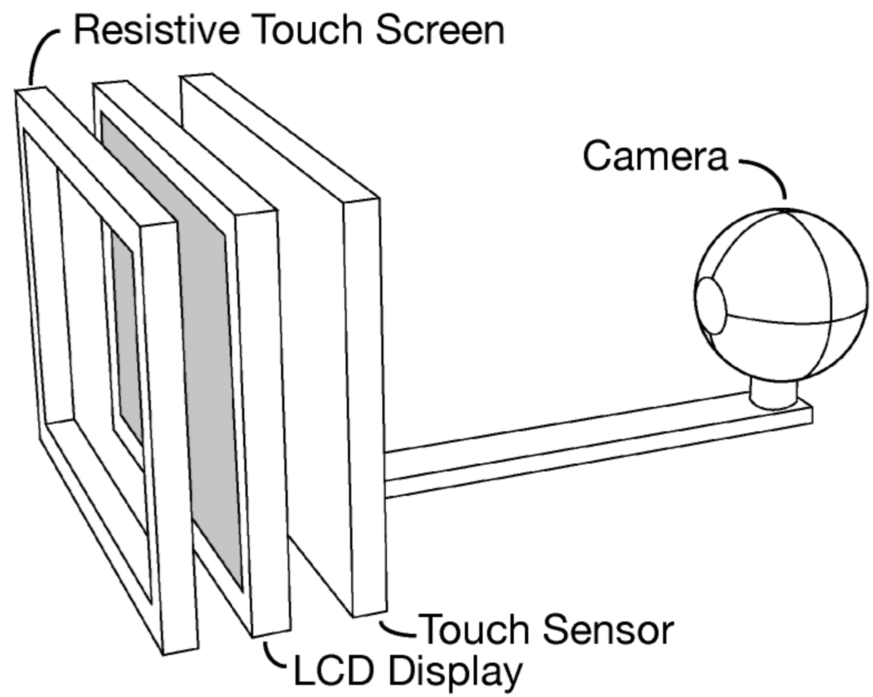
Wigdor, Forlines, Baudisch, Barnwell, Shen: LucidTouch: A See-Through Mobile Device. UIST'07.

LucidTouch Camera See-Through

- Finger shapes and positions tracked by camera
  - Hovering / tracking state
- (Multi-)touch detected by pad
  - Dragging state

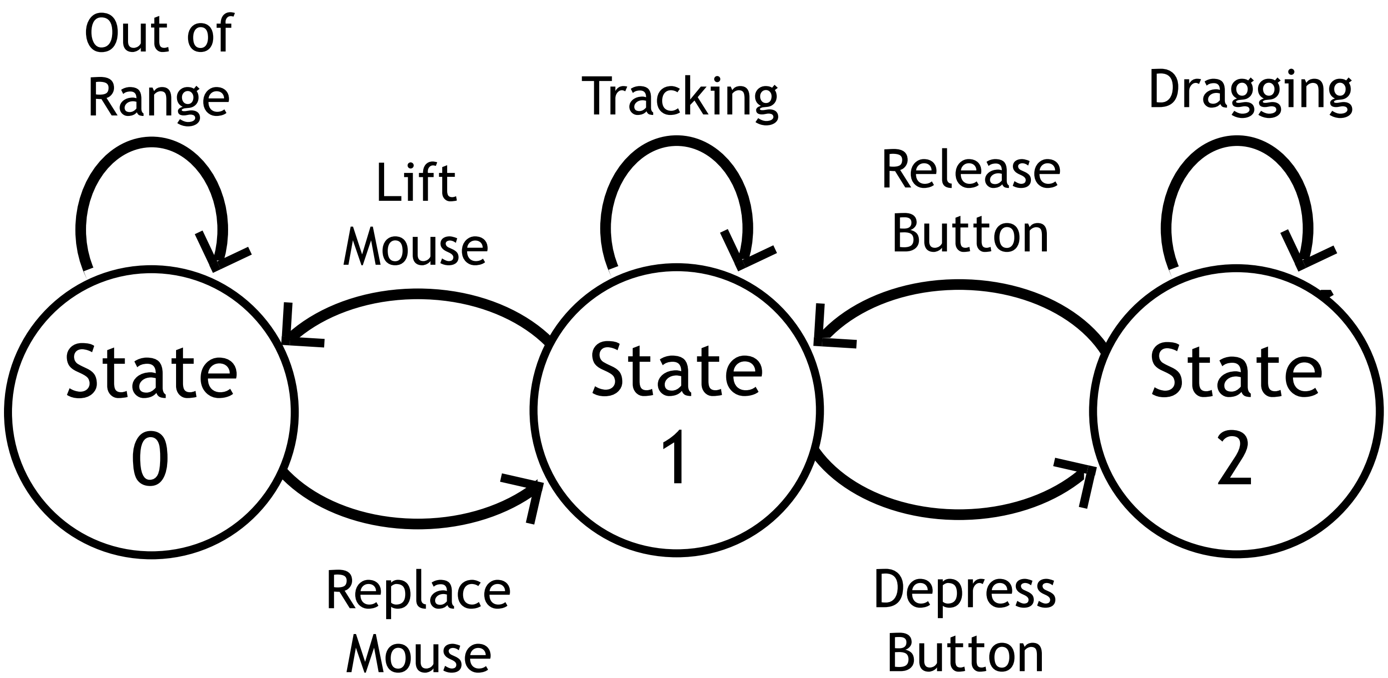
physical
see-through

camera
see-through



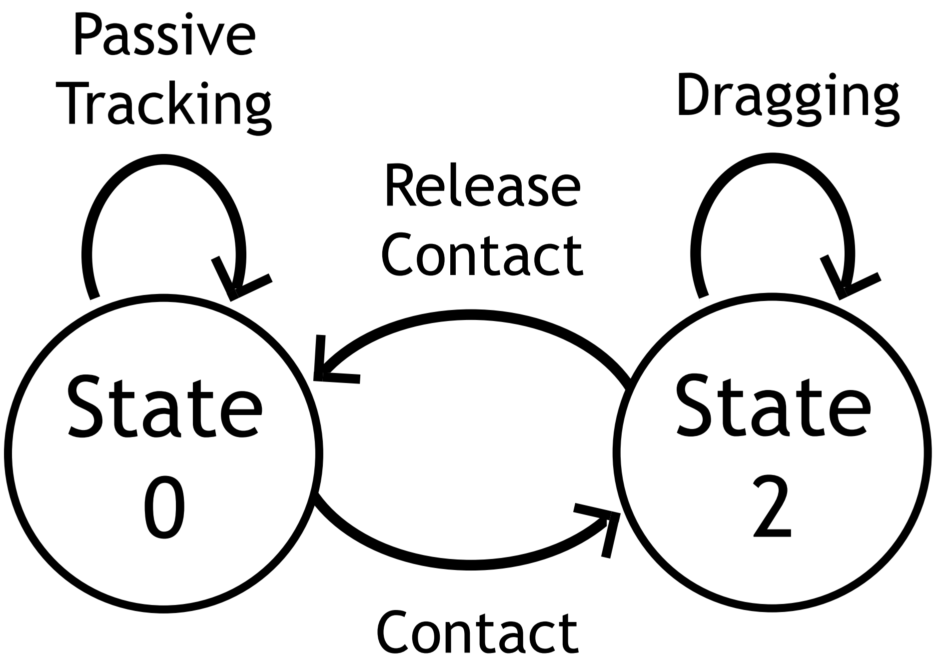
Wigdor, Forlines, Baudisch, Barnwell, Shen: LucidTouch: A See-Through Mobile Device. UIST'07.

Buxton's Three-State Model of Input



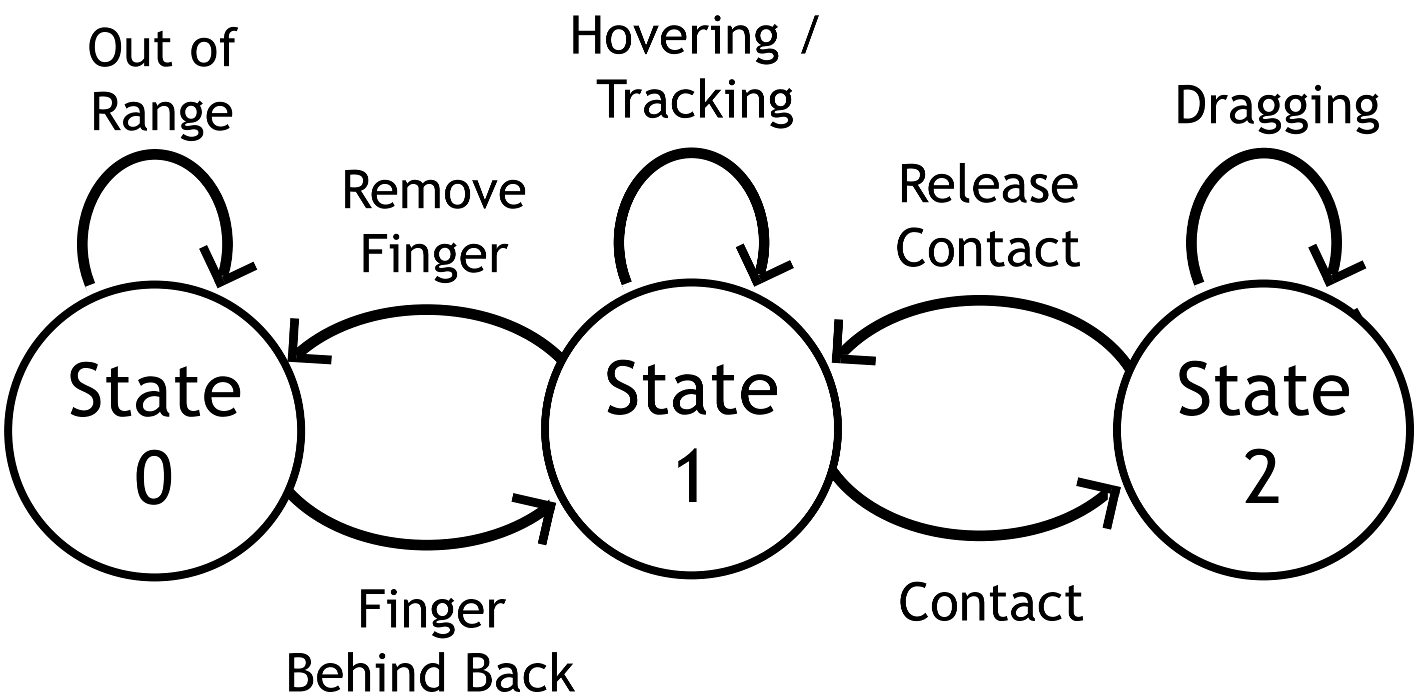
Buxton: A Three-State Model of Graphical Input. In Proc. of INTERACT '90.

Two-State Model for Touch Input



Buxton: A Three-State Model of Graphical Input. In Proc. of INTERACT ’90.

LucidTouch: Three Input States

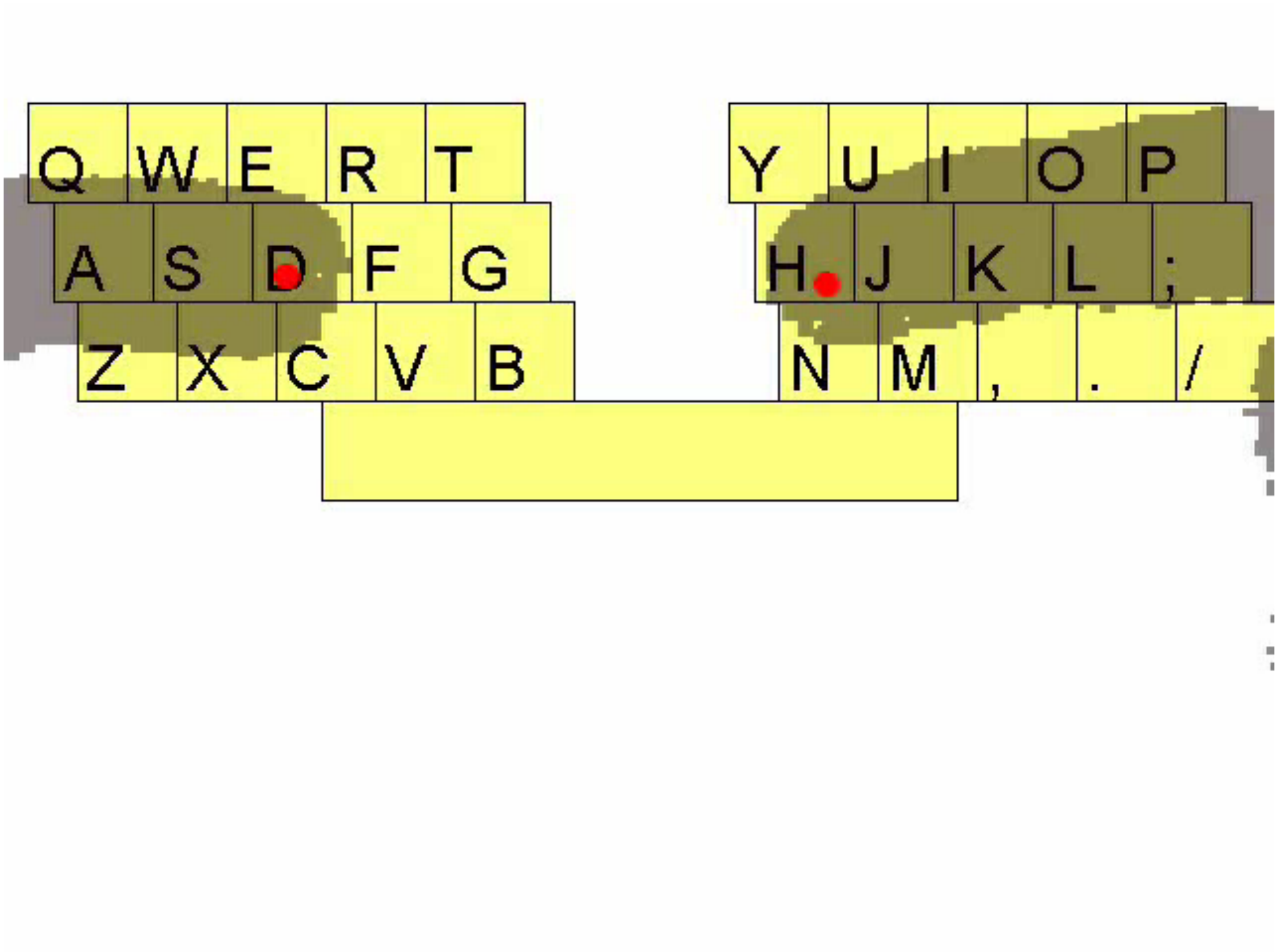


Buxton: A Three-State Model of Graphical Input. In Proc. of INTERACT '90.

LucidTouch Applications: Map

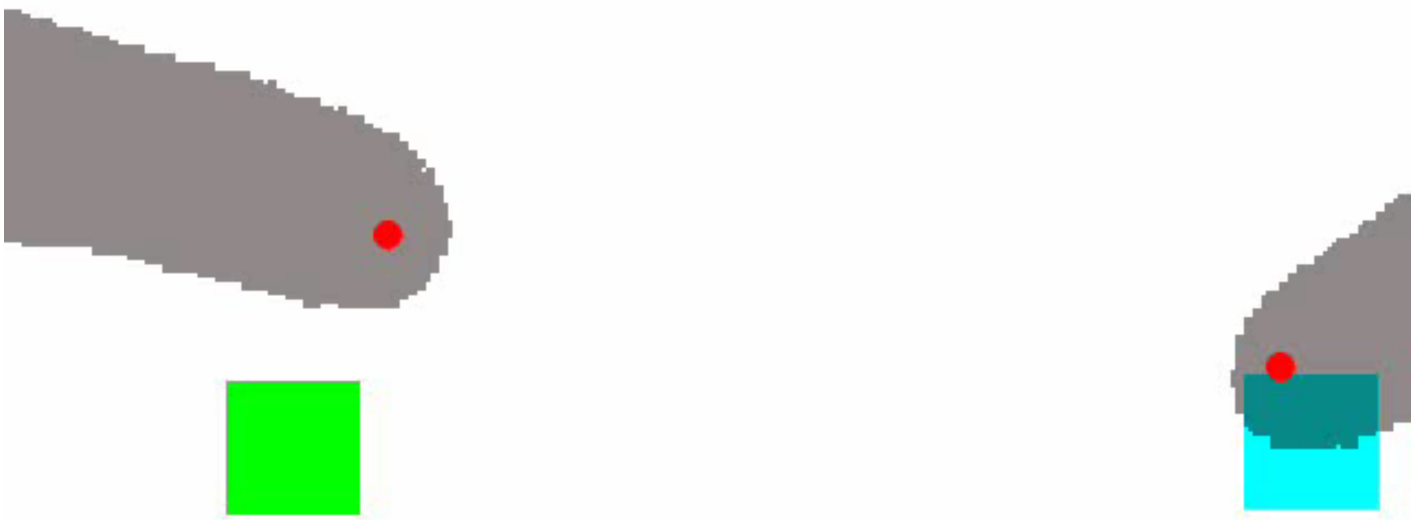
Wigdor, Forlines, Baudisch, Barnwell, Shen: LucidTouch: A See-Through Mobile Device. UIST'07.

LucidTouch Applications: Text Input



Wigdor, Forlines, Baudisch, Barnwell, Shen: LucidTouch: A See-Through Mobile Device. UIST'07.

LucidTouch Issue: Finger Reachability

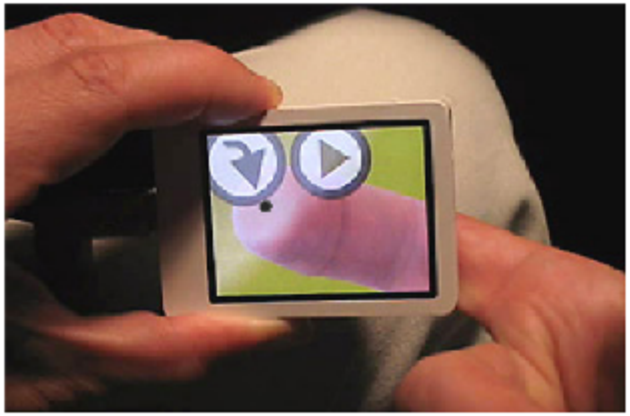


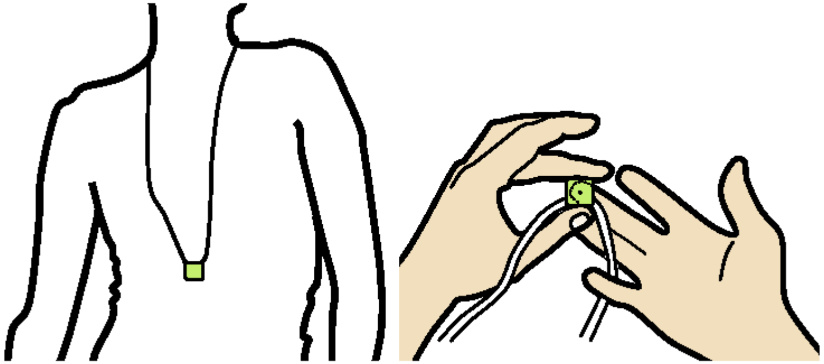
Wigdor, Forlines, Baudisch, Barnwell, Shen: LucidTouch: A See-Through Mobile Device. UIST'07.

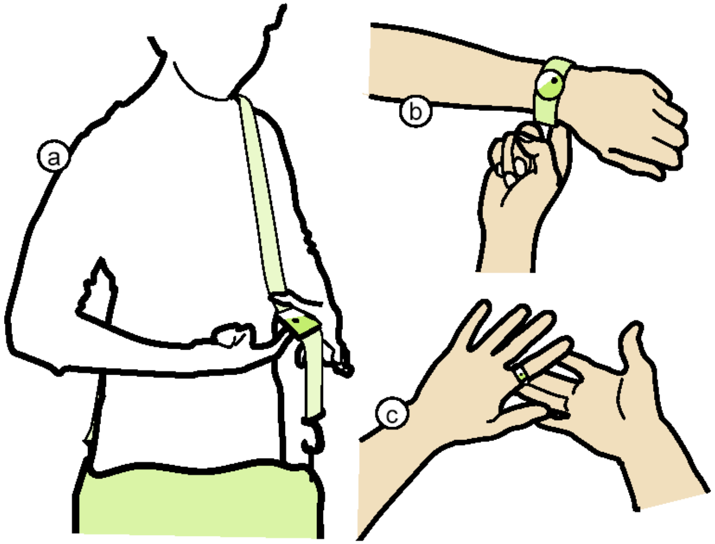
Back-of-Device Interaction Works for Very Small Screens

- Jewelry, watches, etc.

- Pseudo transparency
  - Capacitive touch pad
  - Clickable touch pad







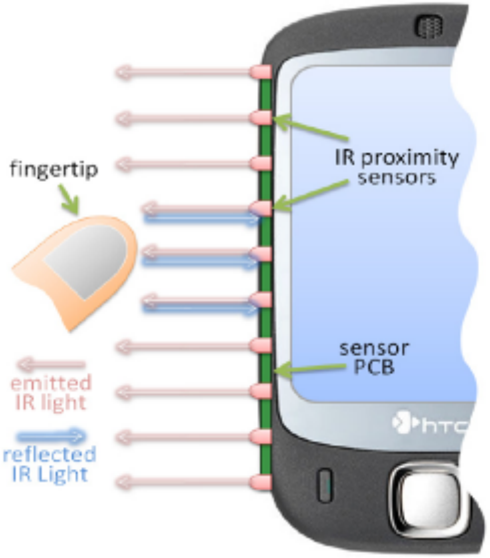
Baudisch, Chi. Back-of-Device Interaction Allows Creating Very Small Touch Devices. CHI 2009.

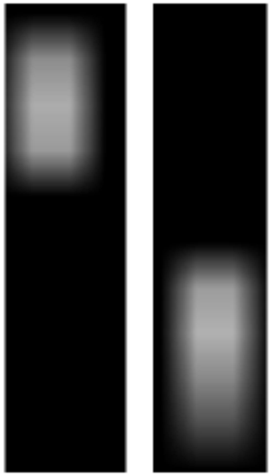
Back-of-Device Interaction Works for Very Small Screens

Baudisch, Chi. Back-of-Device Interaction Allows Creating Very Small Touch Devices. CHI 2009.

Side-of-Device Interaction: SideSight

- Useful if device is placed on table
- Distance sensors along device edges
  - Multipoint interactions
- IR proximity sensors
  - Edge: 10x1 pixel “depth” image





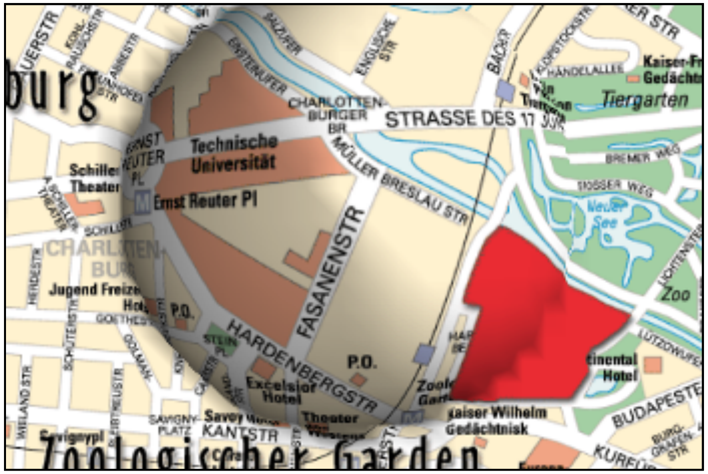
Left and right “depth” images

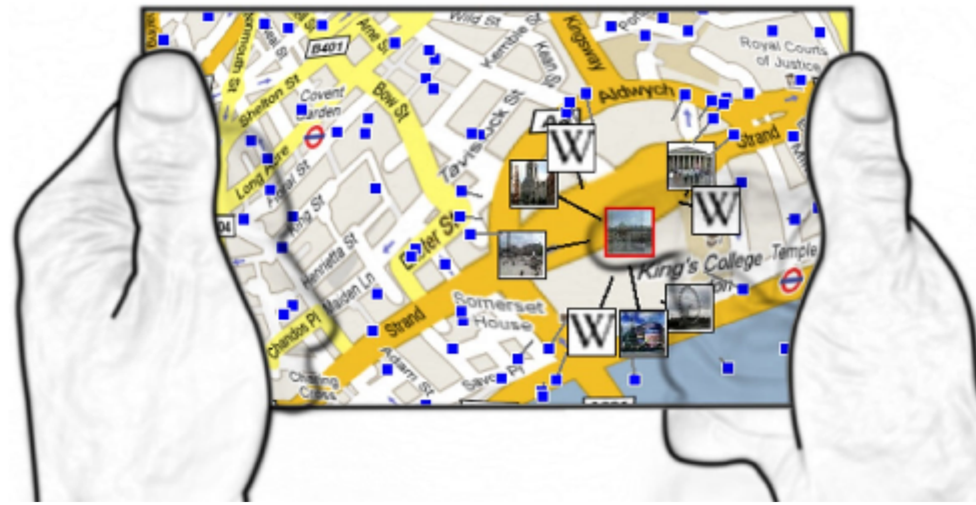
Butler, Izadi, Hodges. SideSight: Multi-“touch” Interaction Around Small Devices. UIST’08.

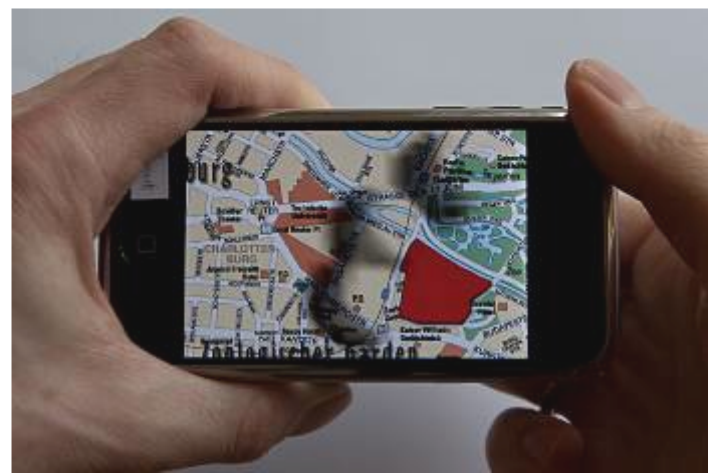
Side-of-Device Interaction: SideSight

Butler, Izadi, Hodges. SideSight: Multi-“touch” Interaction Around Small Devices. UIST’08.

Pressure-Sensitive Map Zooming

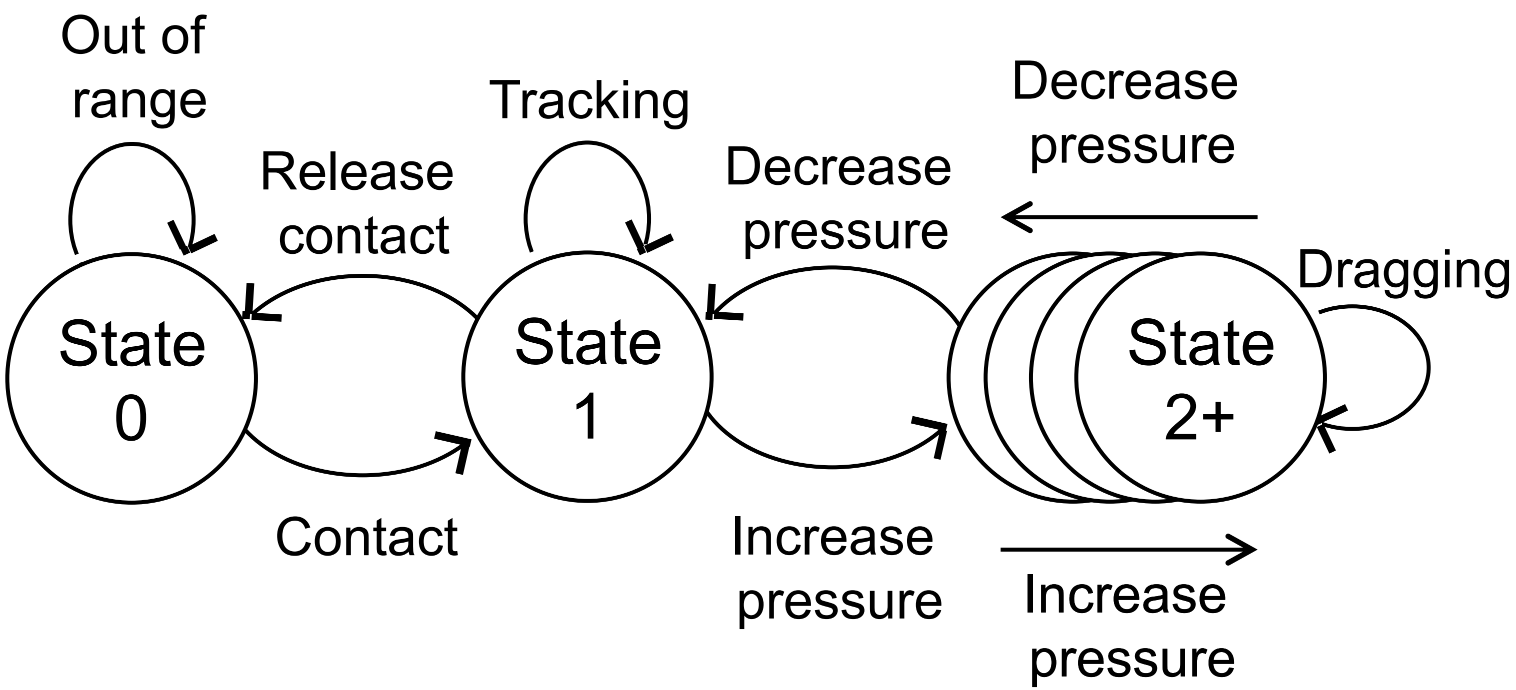






Essl, Rohs, Kratz: Squeezing the Sandwich: A Mobile Pressure-Sensitive Two-Sided Multi-Touch Prototype. Demo at UIST'09.

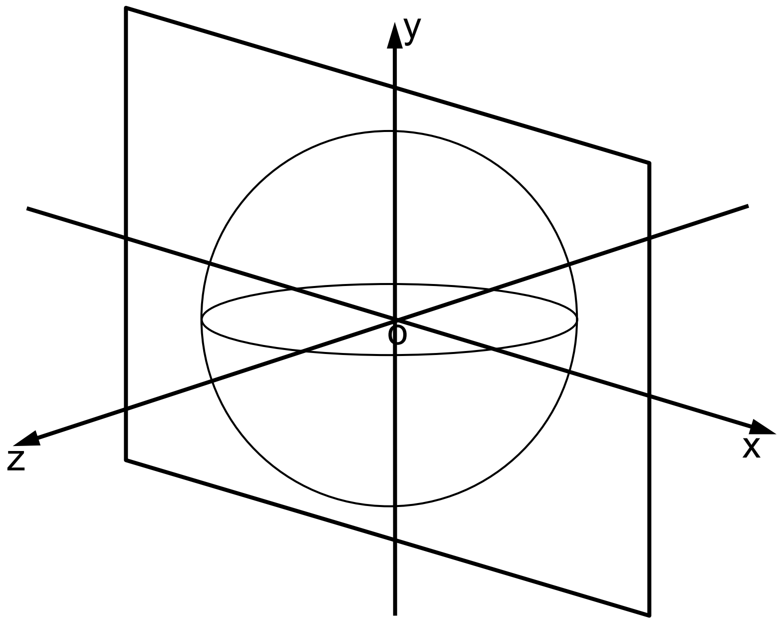
Pressure Sensitive Input: Multiple States



Buxton: A Three-State Model of Graphical Input. In Proc. of INTERACT ’90.

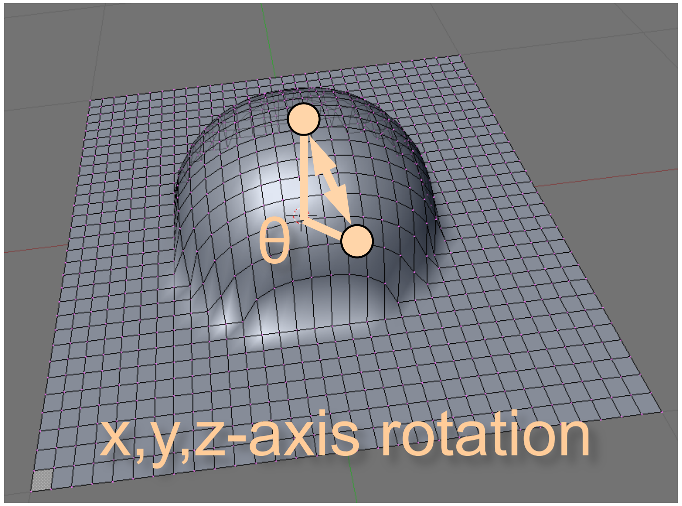
Extension of Virtual Trackball to Back of Device

Full sphere operated from both sides
instead of hemisphere operated from front

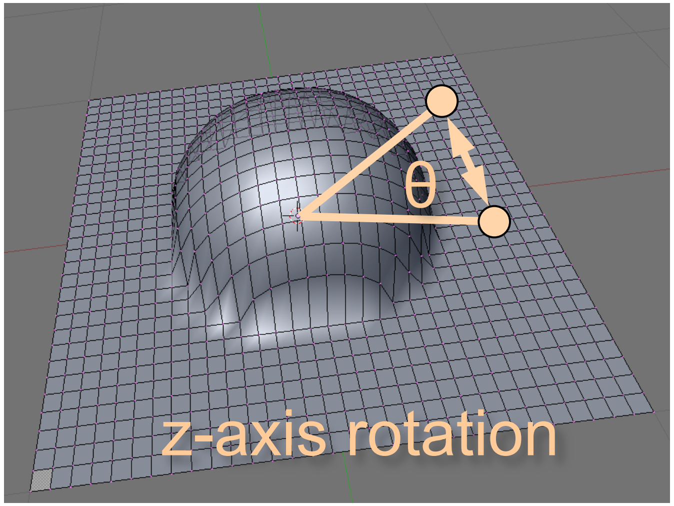


Virtual Trackballs for 3D Object Rotation

x,y,z-axis rotation



z-axis rotation




front

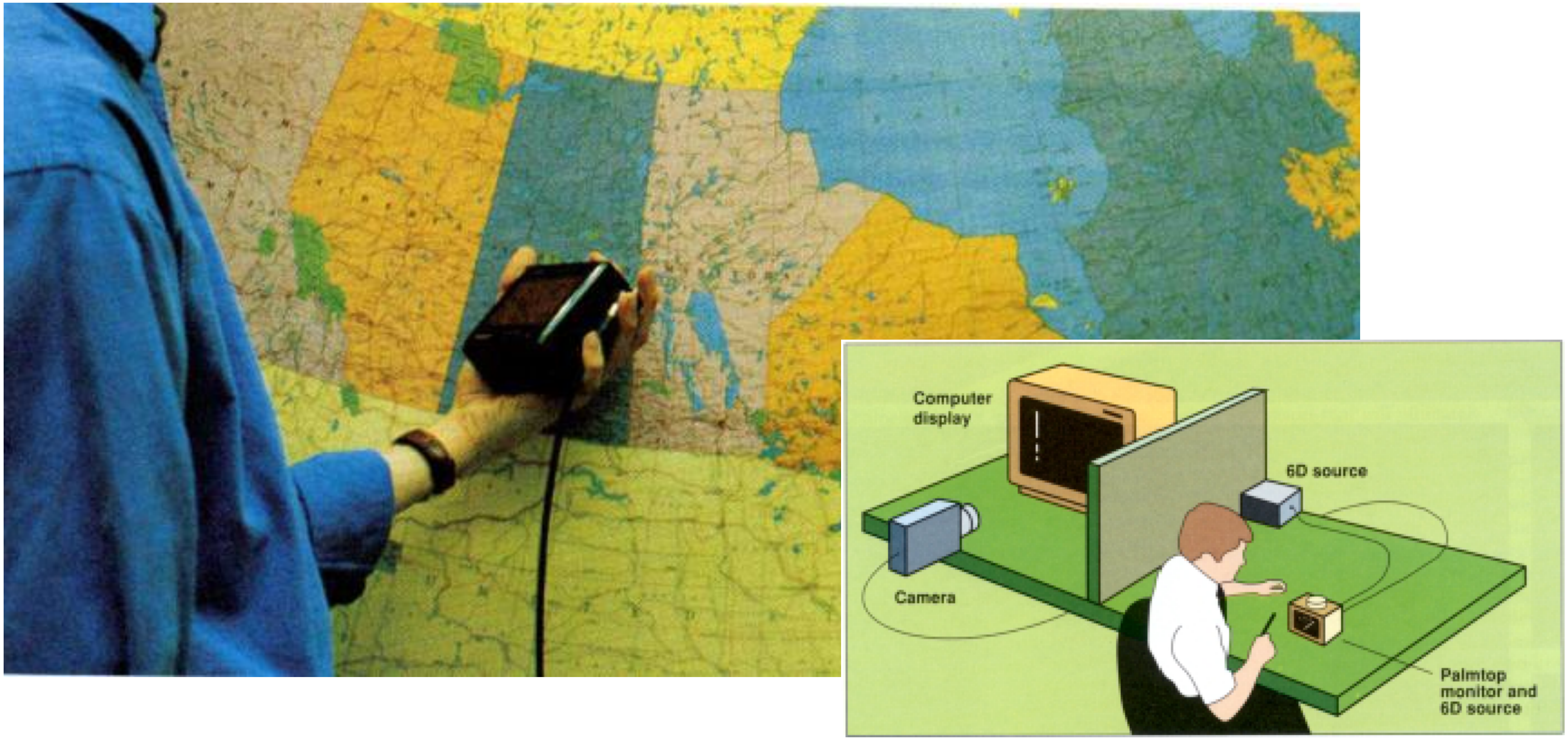
MOBILE DEVICES AND INTERACTIVE SURFACES

Motivation for Combining Mobile and Large Displays

- Support kinesthetic and spatial memory of users
  - Locate information in space
  - Assign application semantics to spatial arrangements
- Focus & context displays
- Private & public displays
- Drag’n’drop in the physical world
  - Movement of data between devices
  - Carry out one task across multiple devices
- Collaboration
- Capturing information on public space

Fitzmaurice 1993: Spatially Aware Palmtop Computers

- Fitzmaurice, G. W.: Situated information spaces and spatially aware palmtop computers. Commun. ACM 36, 7 (Jul. 1993), pp. 39-49.



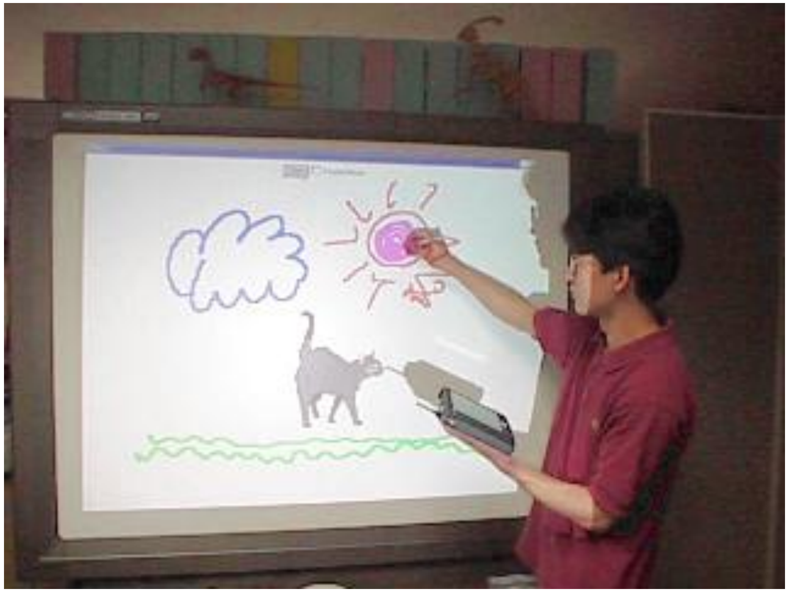
“Ubiquitous Graphics”

- Focus & context displays
  - Wall display for low resolution overview
  - Handheld display for high resolution details
- Ultrasonic tracking
  - Mimio XI ultrasonic pens attached to display
  - Pen emits ultrasonic signal when touching wall
- Users can add annotations and objects

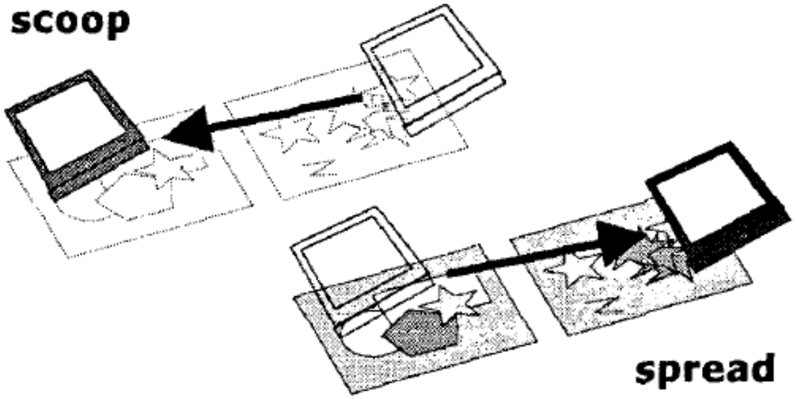
Sanneblad, Holmquist. Ubiquitous graphics: Combining hand-held and wall-size displays to interact with large images. AVI '06.

http://www.youtube.com/watch?v=uw0a7Zd1JVM

“Pick-and-Drop” and “Hyper Palette”



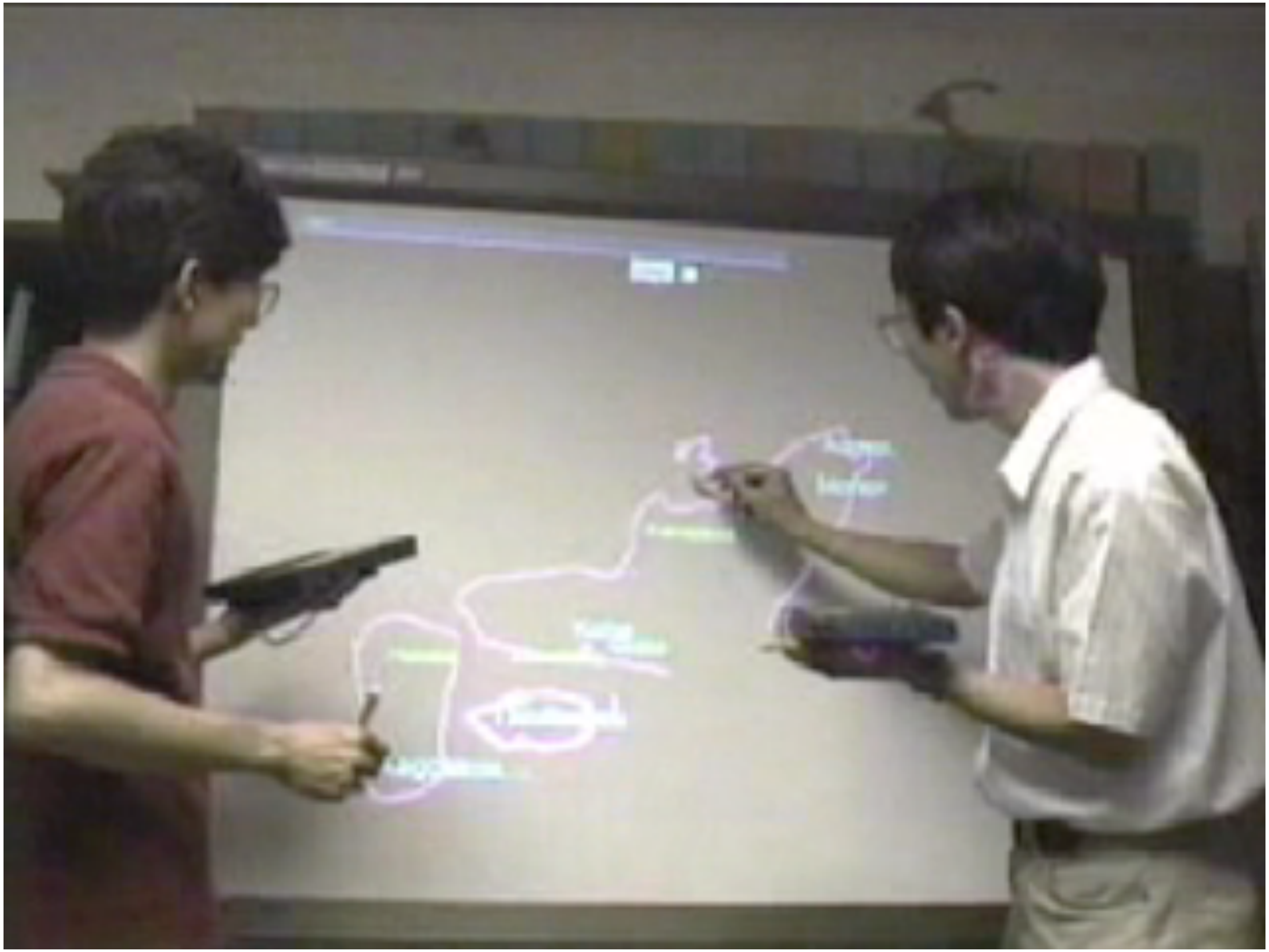
- Pick-and-Drop
  - Direct manipulation for smart environments
  - Extended “drag-and-drop” concept
  - Create text on PDA, pick-and-drop to whiteboard
- Hyper Palette
  - PDA as interaction device for table
  - Electromagnetic 6D trackers
  - Scoop-and-spread: tilting plus movement



Rekimoto. Pick-and-drop: a direct manipulation technique for multiple computer environments. UIST '97.

Ayatsuka, Matsushita, Rekimoto. HyperPalette: A hybrid computing environment for small computing devices. CHI '00.

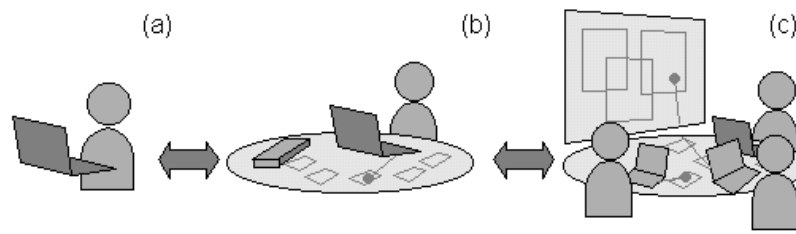
"Pick-and-Drop"

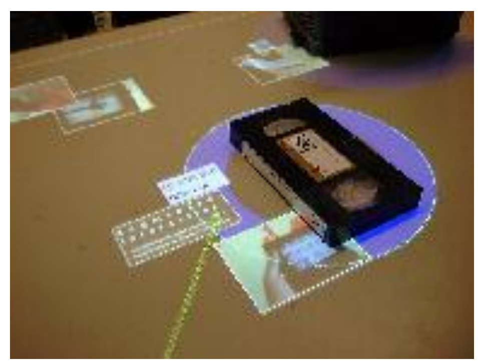


Rekimoto. Pick-and-drop: a direct manipulation technique for multiple computer environments. UIST '97.

Augmented Surfaces

- Interchanging information between mobile devices, interactive surfaces, and physical objects
  - Camera-based object recognition
  - Projected displays as extensions of device screens
- Hyperdragging
  - Move information across boundary of devices and surfaces





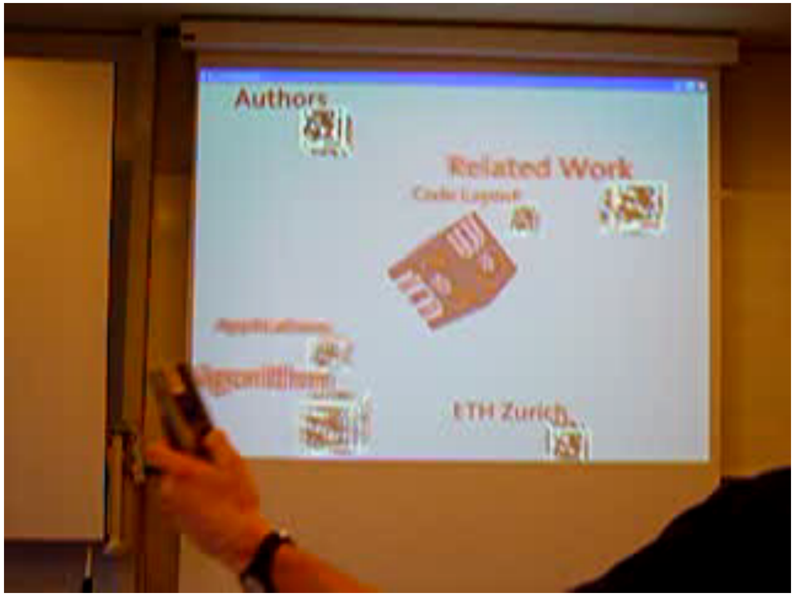
Rekimoto, Saitoh: Augmented surfaces: A spatially continuous work space for hybrid computing environments. CHI '99.

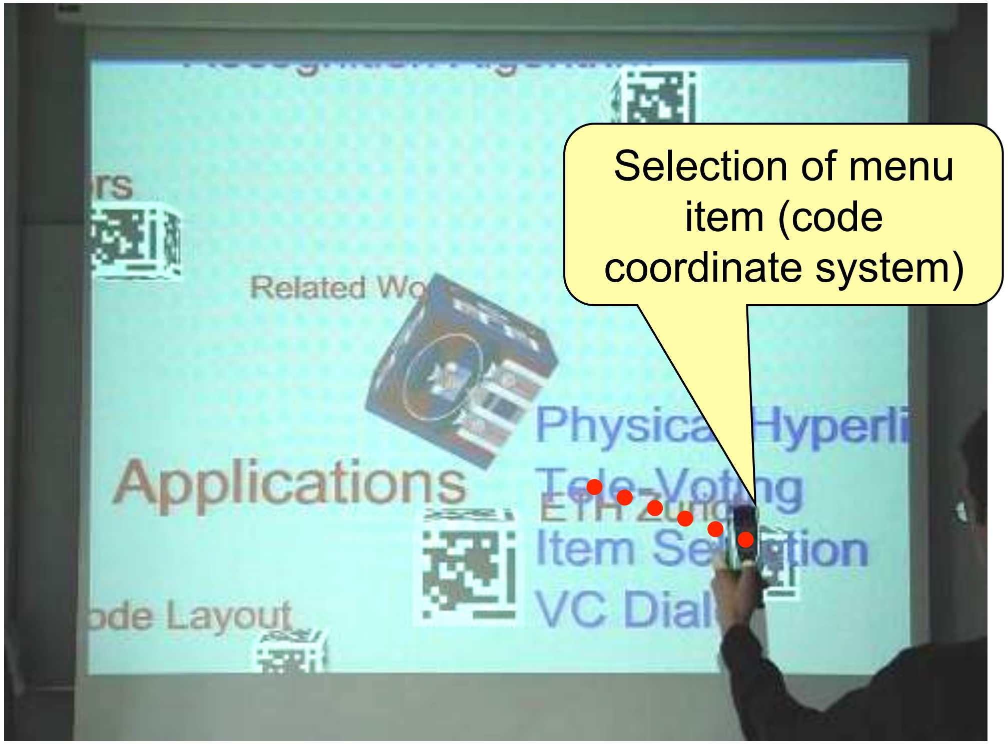
Augmented Surfaces

Rekimoto, Saitoh: Augmented surfaces: A spatially continuous work space for hybrid computing environments. CHI '99.

Interaction with Large Public Displays

- Train stations, air ports, museums, shopping malls



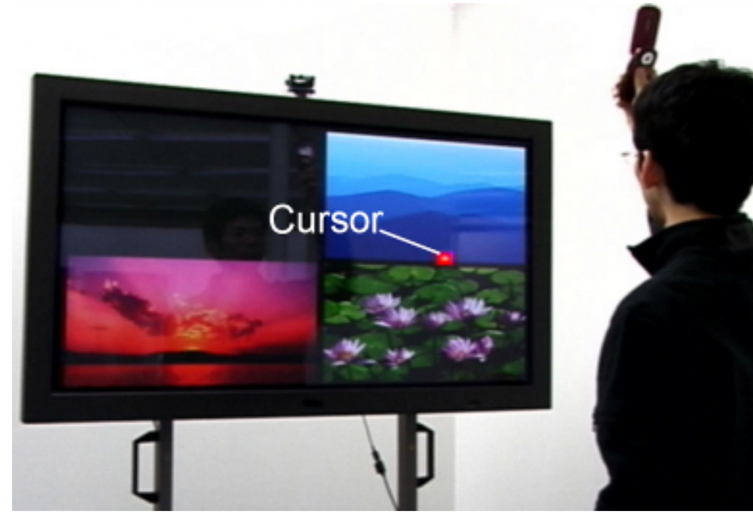


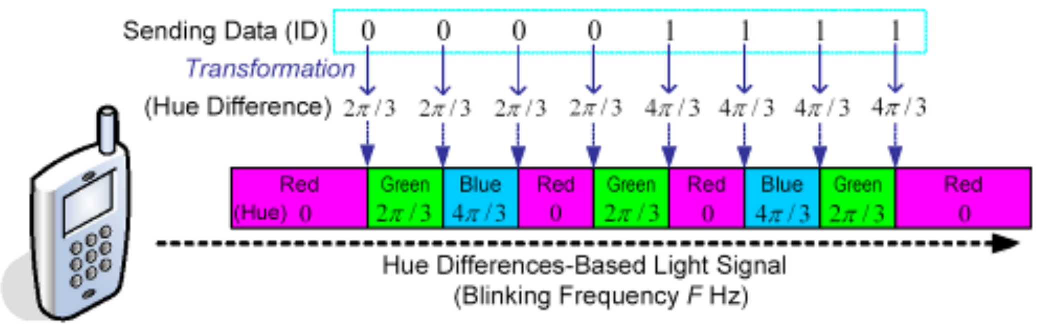
Selection of menu item (code coordinate system)

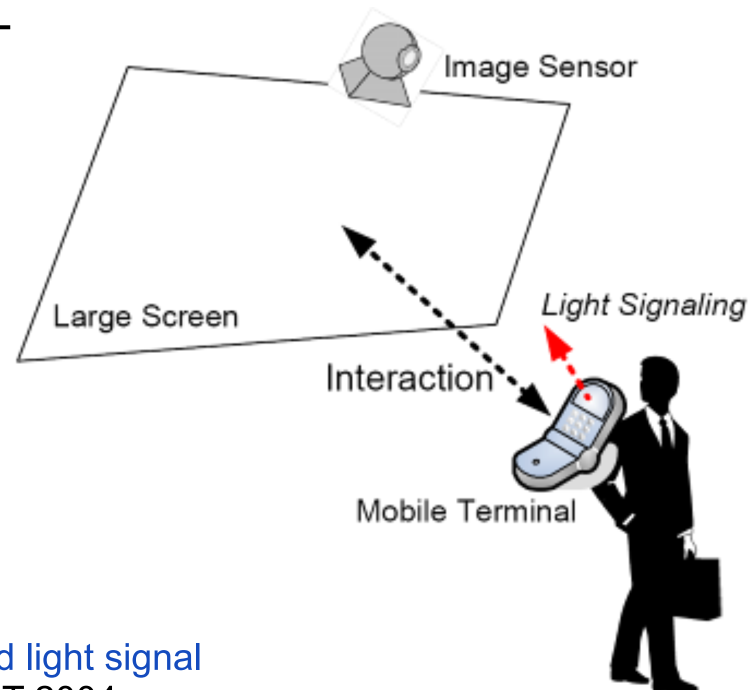
Content associated with menu item is transferred to the mobile phone

C-Blink: Visual Communication

- Camera on top of display
- Cell phone screen blinks in different colors
- Hue-difference signal
  - Hue in HSV color space







Miyaoku, Higashino, Tonomura: C-Blink: A hue-difference-based light signal marker for large screen interaction via any mobile terminal. UIST 2004.

Touch Projector: Mobile Interaction-Through-Video

- Touch Projector: Interact with remote screens through a live video image on the mobile device
  - Position tracking w.r.t. surrounding displays
  - Project image onto target display
- Select targets, drag targets between displays

http://www.youtube.com/watch?v=ITMAKHzbI1E

Boring, Baur, Butz, Gustafson, Baudisch: Touch Projector: Mobile Interaction-Through-Video. Proc. CHI 2010.

Touch Projector

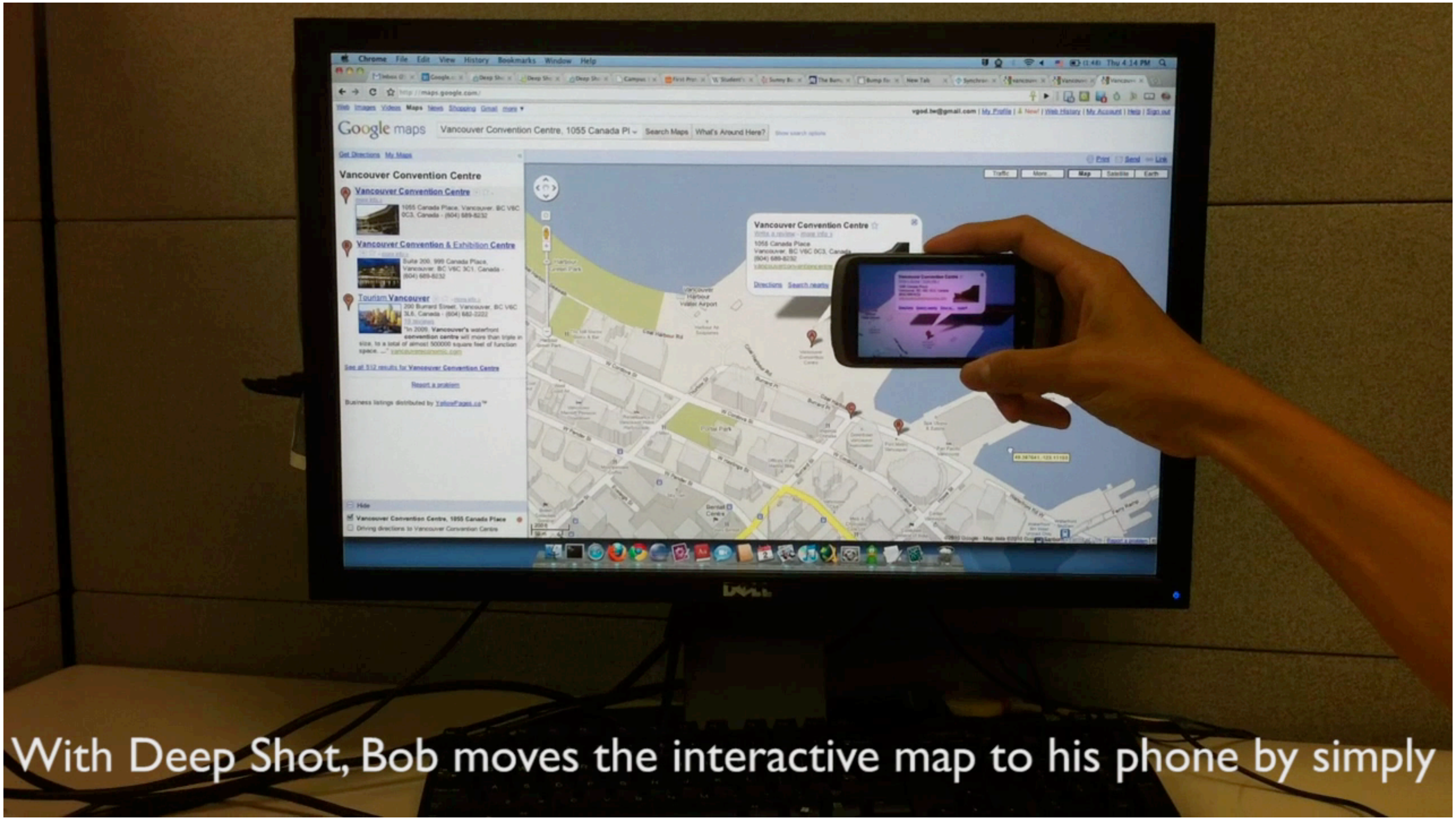
Boring, Baur, Butz, Gustafson, Baudisch: Touch Projector: Mobile Interaction-Through-Video. Proc. CHI 2010.

Deep Shot: Migrating Tasks Across Devices Using Mobile Phone Cameras

- User tasks often span multiple devices
- Deep Shot supports migrating tasks across devices
  - Take a picture
  - Recognize content
  - Recreate content on mobile

Chang, Li. Deep Shot: A Framework for Migrating Tasks Across Devices Using Mobile Phone Cameras. CHI 2011.

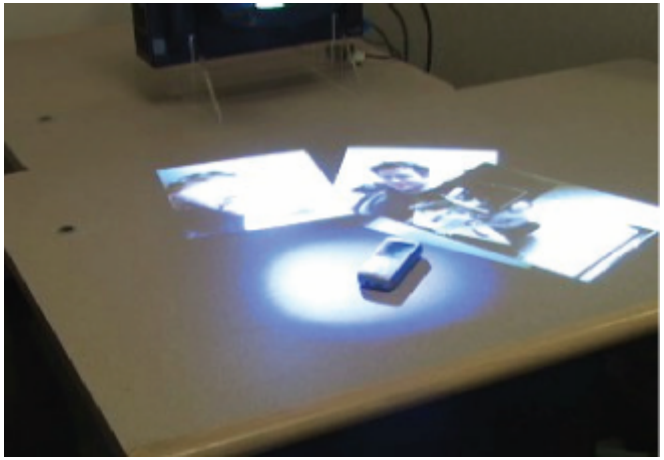
Deep Shot: Migrating Tasks Across Devices Using Mobile Phone Cameras



Chang, Li. Deep Shot: A Framework for Migrating Tasks Across Devices Using Mobile Phone Cameras. CHI 2011.

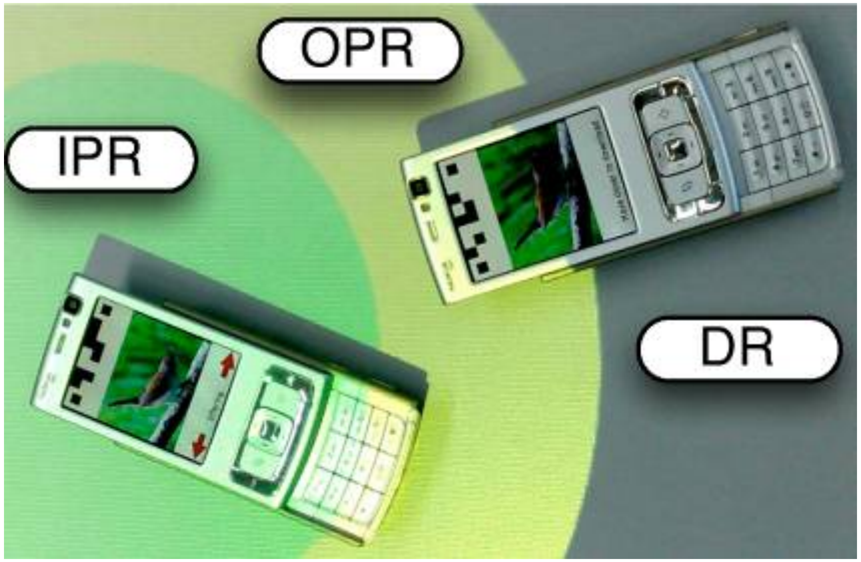
BlueTable: Connecting Wireless Mobile Devices on Interactive Surfaces

- Association of a mobile device with an interactive surface
- Camera detects objects as connected components (blobs) of a certain size and shape
- BlueTable checks whether detected blob is a mobile device
  - Sends Bluetooth request to blink IRDA port to each device in turn
  - Downside: slow

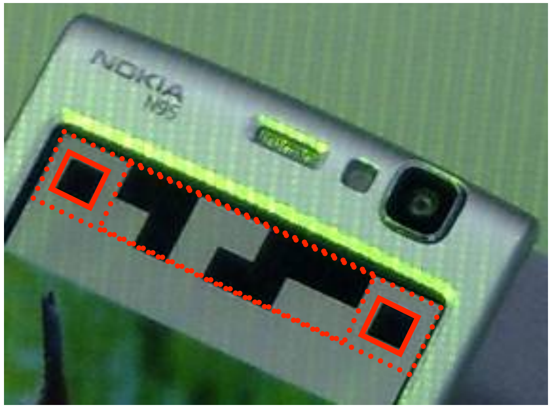


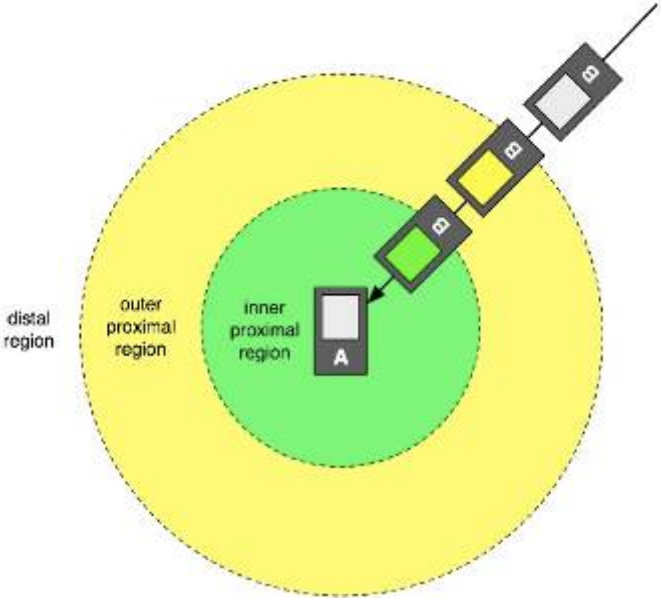
Wilson and Sarin: BlueTable: Connecting Wireless Mobile Devices on Interactive Surfaces Using Vision-Based Handshaking. Graphics Interface 2007. http://research.microsoft.com/~awilson

Mobile Devices and Interactive Tabletops



- Camera-projector system
  - Works with regular tables
  - Pubs, cafés, meeting rooms
- Map spatial configurations to application-specific semantics
  - Proximity regions around devices
- Dynamic marker





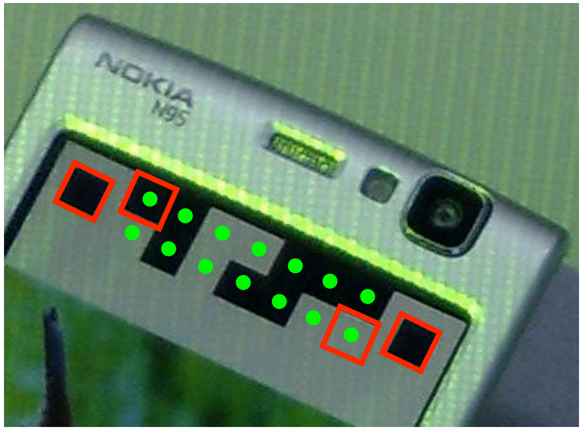
Kray, Rohs, Hook, Kratz: Bridging the Gap between the Kodak and the Flickr Generations: A Novel Interaction Technique for Collocated Photo Sharing. IJHCS 2009.

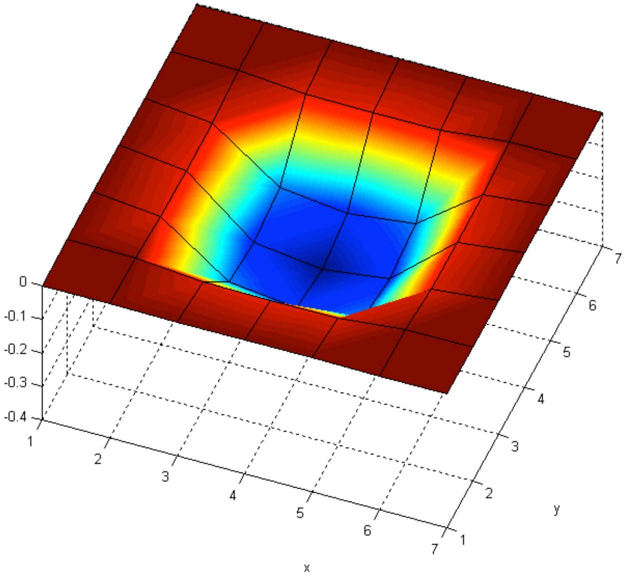
Marker Recognition Algorithm

- Find corner stone candidates
  - Convolve image with 7x7 “Gaussian” kernel

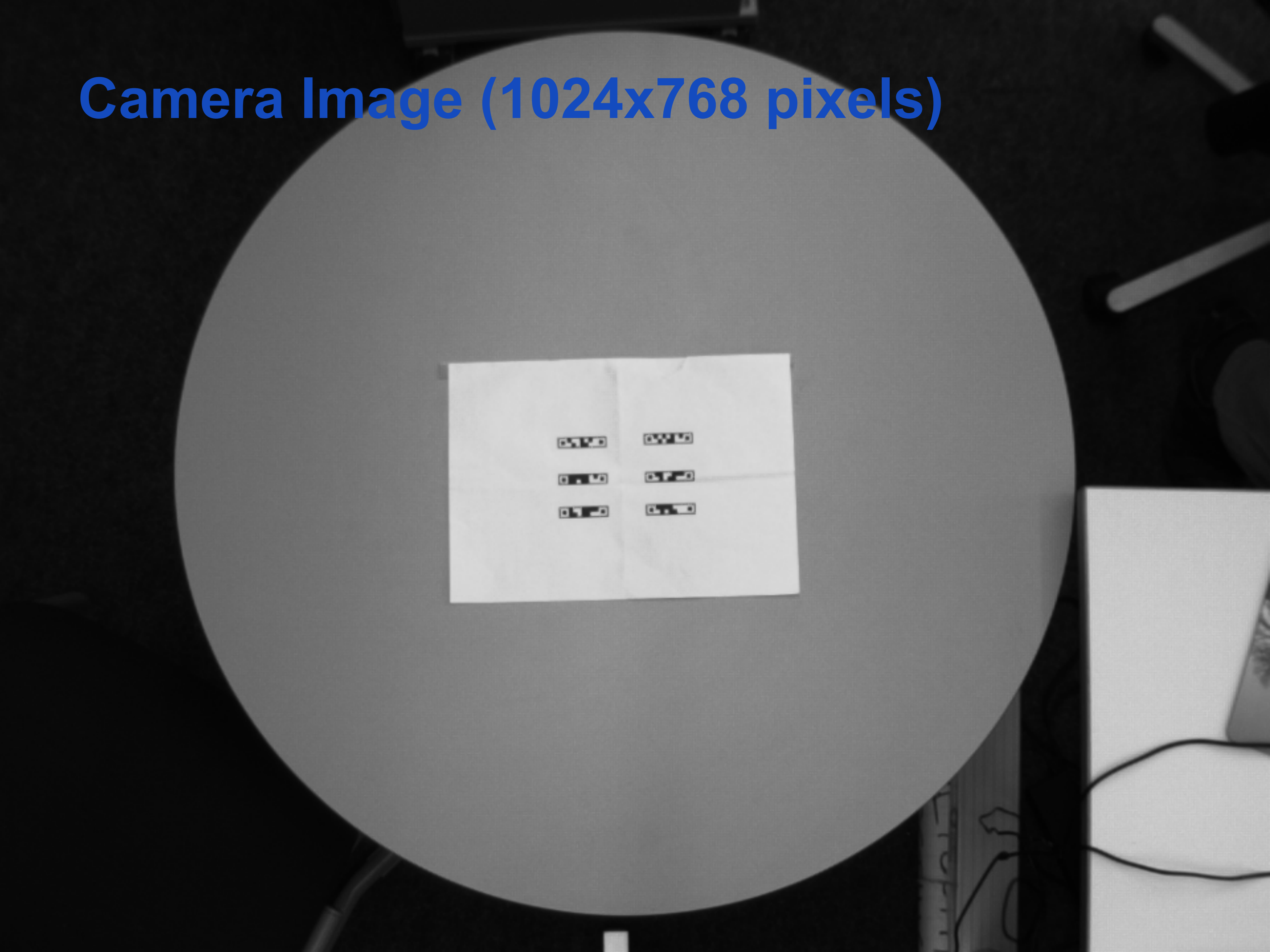
$$k(x,y) = b\,exp(a(x^4 + y^4)), \quad x,y = -3..3$$
$$a = -(2\,s^2)^{-1}, b = -(s\,\sqrt{2\pi})^{-1}, s = 1.9$$

  - Separable in two 1D kernels
- Thresholding (cross-correlation ≥0.72)
- Non-maximum suppression
- Find pairs of corner stone candidates
- Compute homography and sample data area
- Determine orientation
- Decode value, compute position, rotation, size

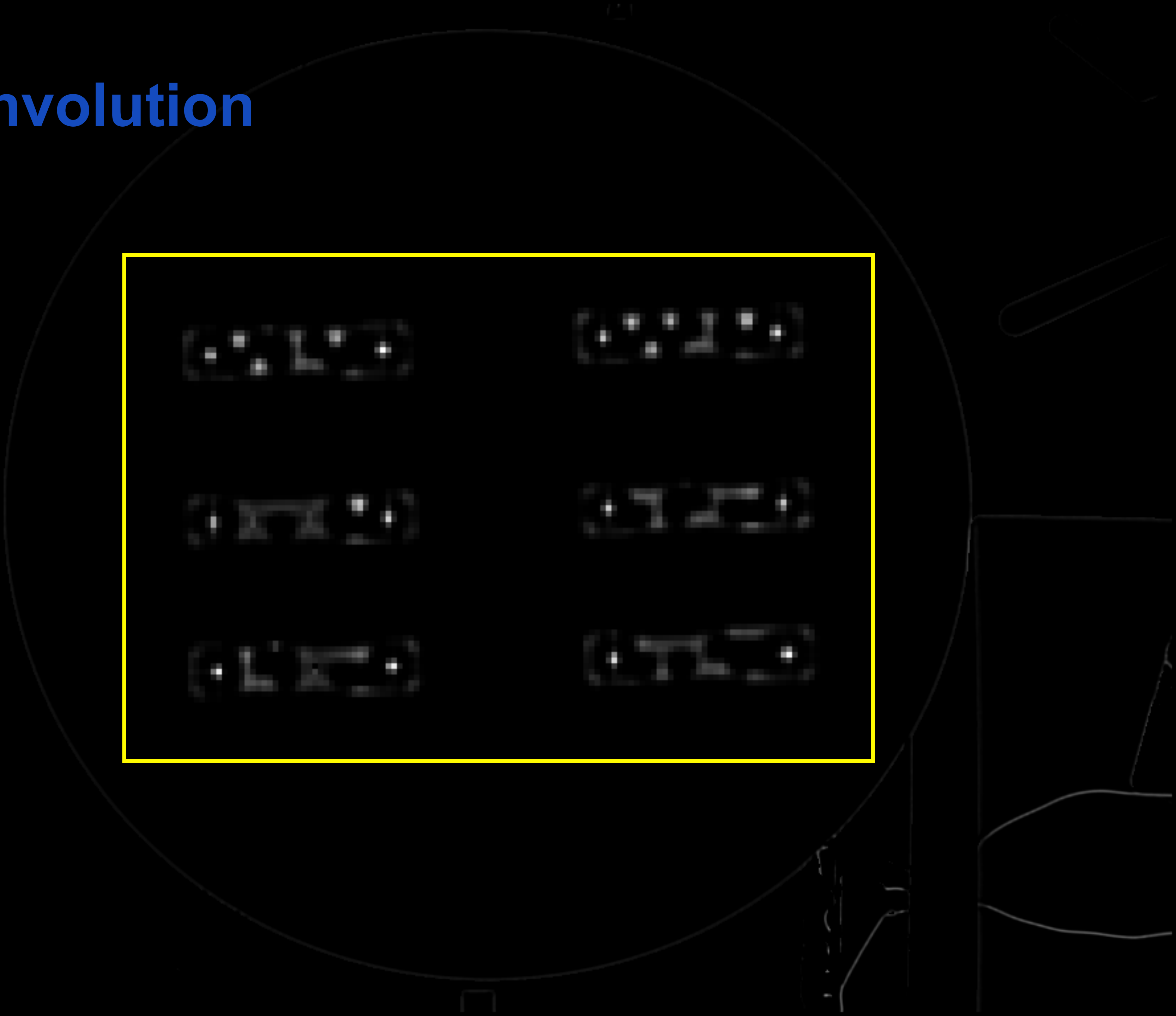




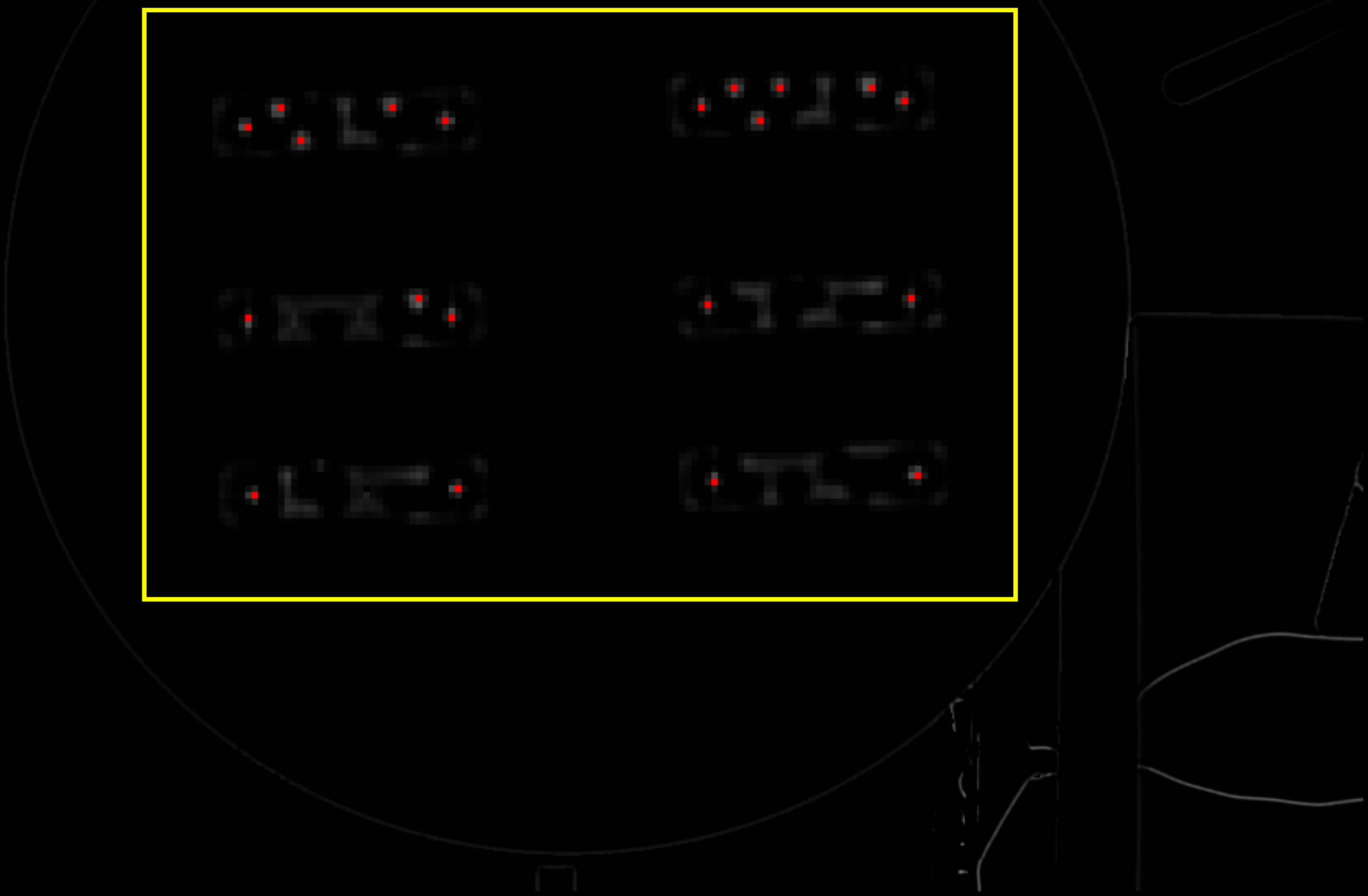
Camera Image (1024x768 pixels)



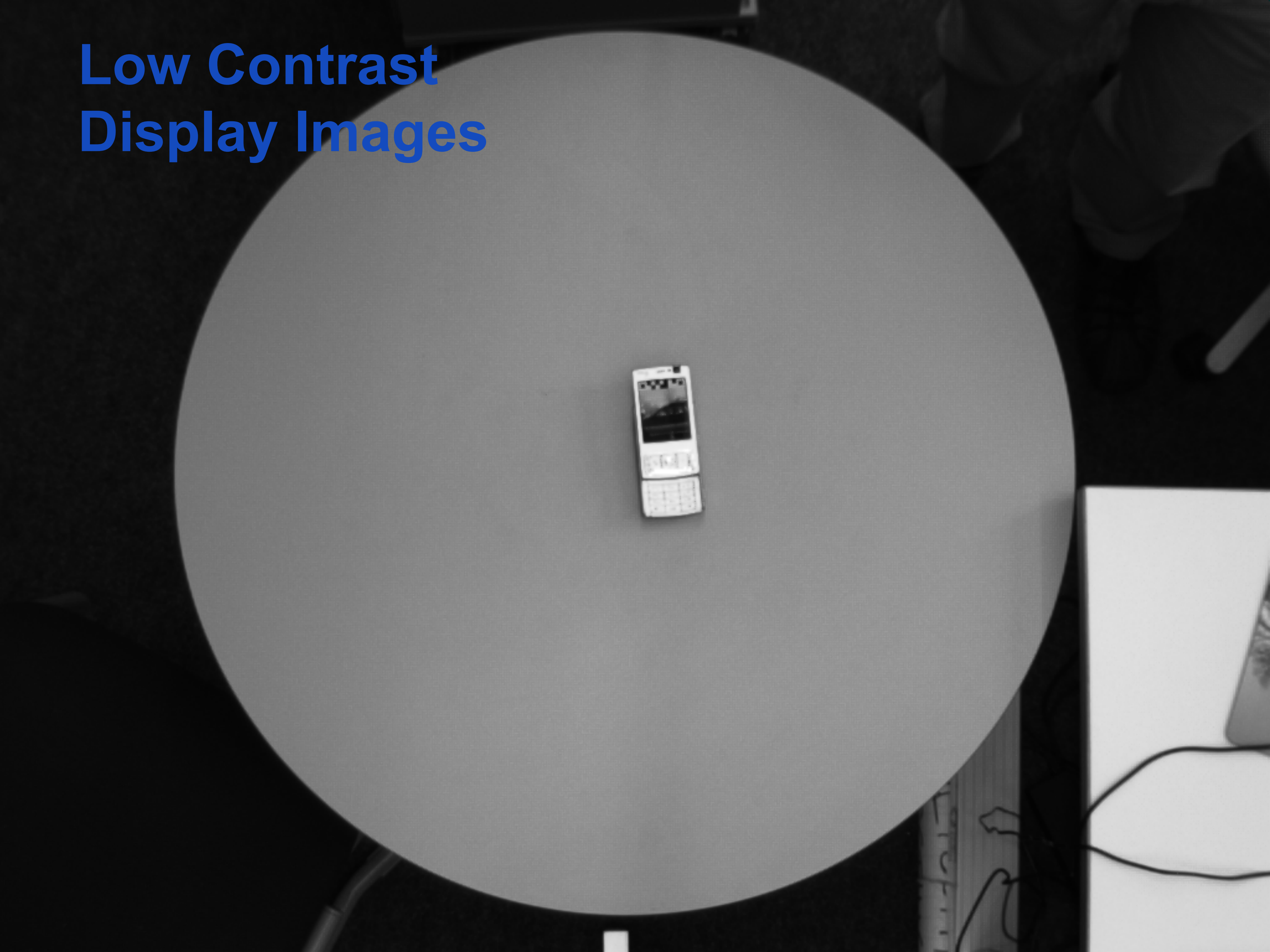
Convolution



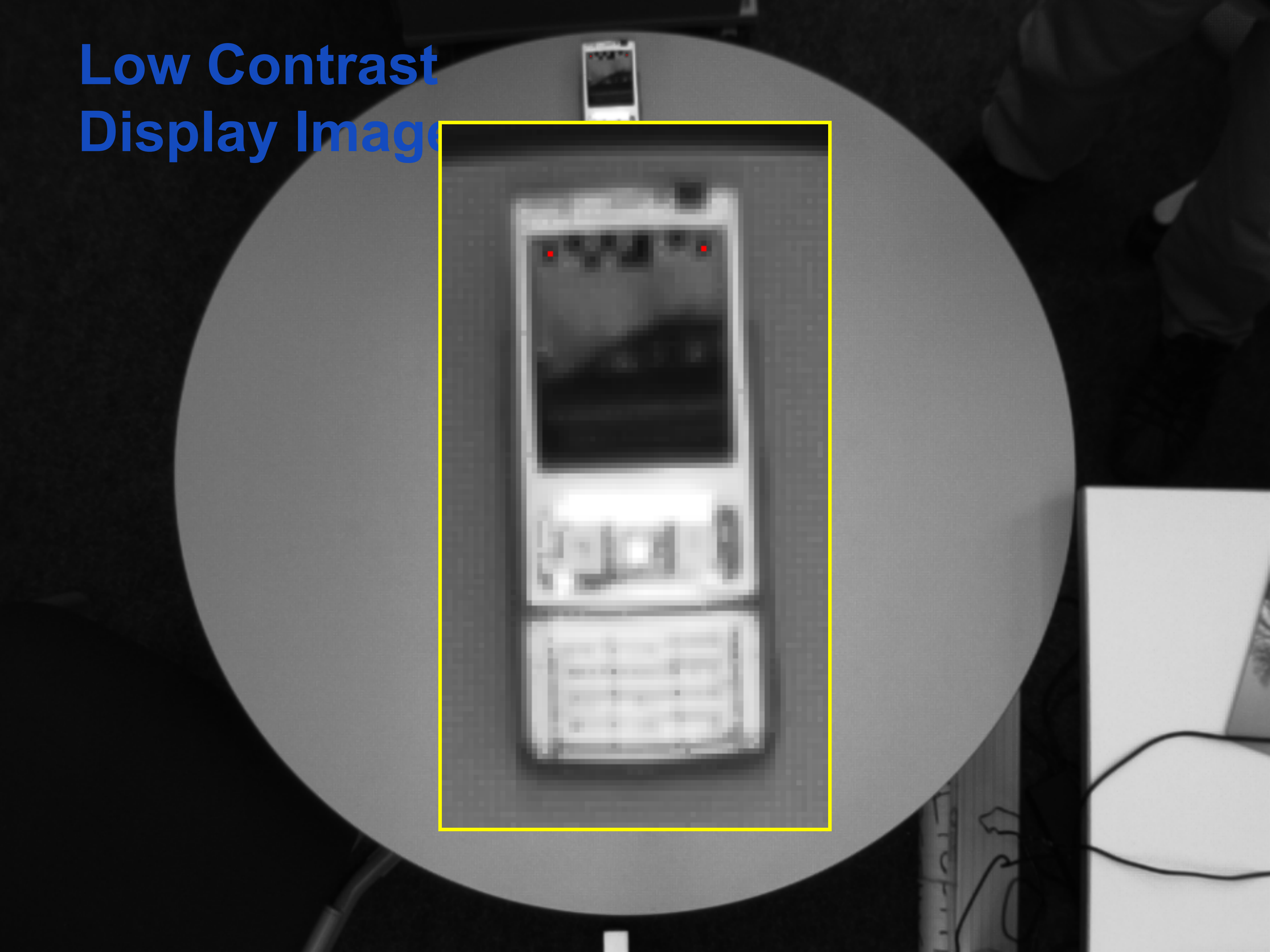
Thresholding and Non-Maxima Suppression



Low Contrast Display Images



Low Contrast Display Image



The End