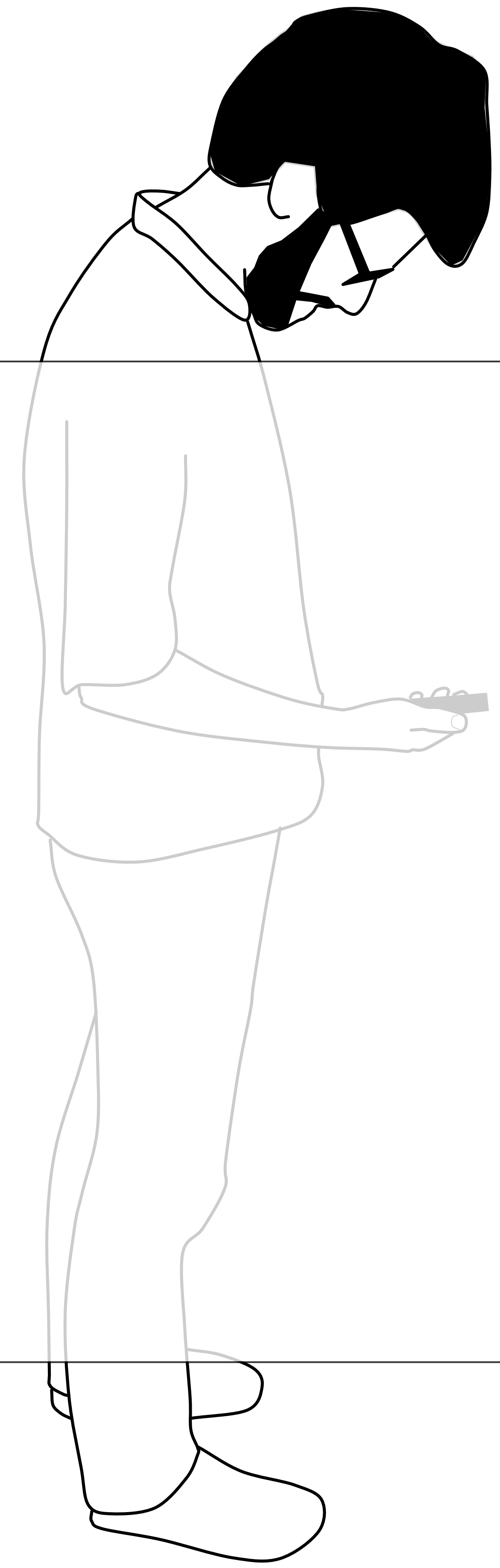
Mobile Technologies



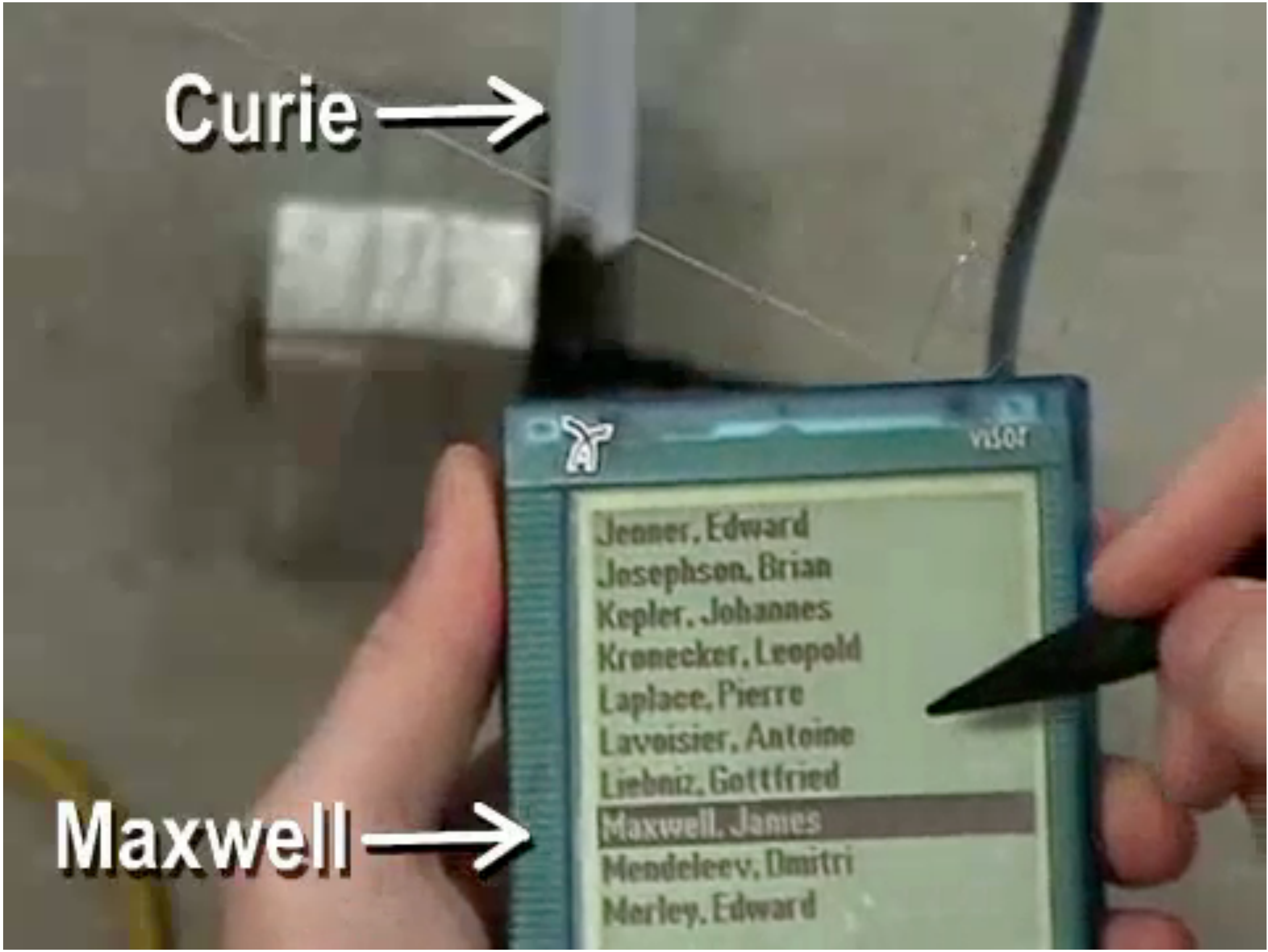
- context and task
- challenges
- input technologies
- **challenges in interaction design**
- output technologies

Dealing with small screens

- Imagine a bigger space around the screen
  - peephole displays
  - Halo & Wedge
- Use appropriate visualization techniques
  - fisheye techniques
  - Focus & context
  - zoom & pan
- Expaaand the screen
- Get rid of the entire screen
  - Imaginary interfaces

http://www.youtube.com/watch?v=b3tIlGwgTzU
http://staff.www.ltu.se/~qwazi/reading/papers/yee-peep-chi2003-paper.pdf

Peephole displays (Ka-Ping Yee, CHI 2003)



Halo (Baudisch & Rosenholtz, 2003)

Baudisch, Rosenholtz: Halo: A Technique for Visualizing Off-Screen Locations. CHI 2003.

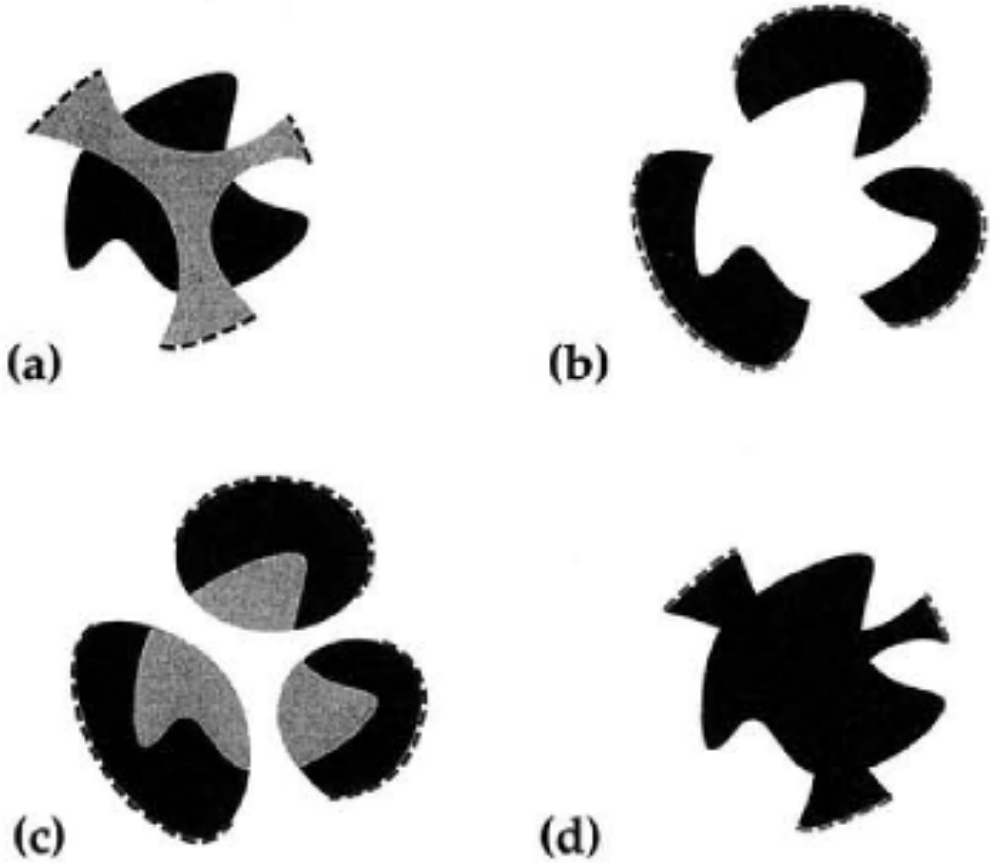
Source: Patrick Baudisch

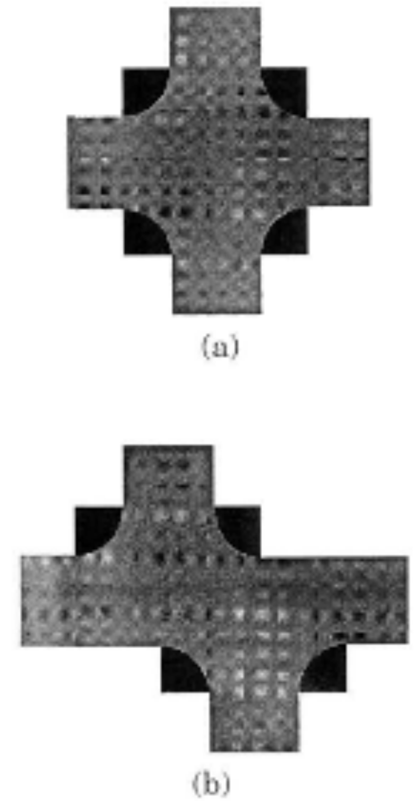
Streetlamp Metaphor

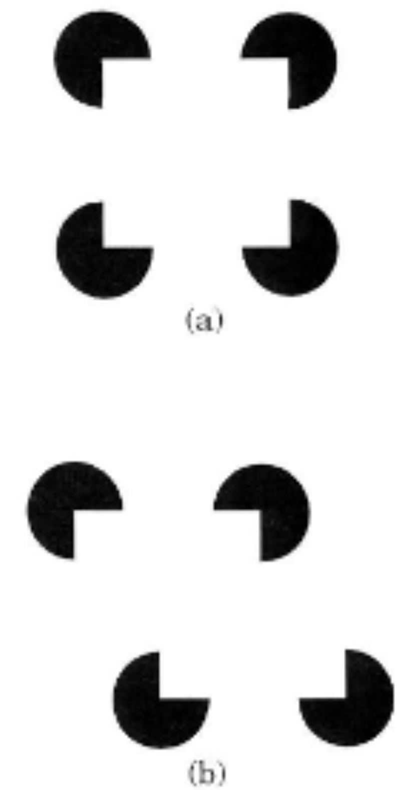
- Aura visible from distance
- Aura is round
- Overlapping auras aggregate
- Fading of aura indicates distance

Source: Patrick Baudisch

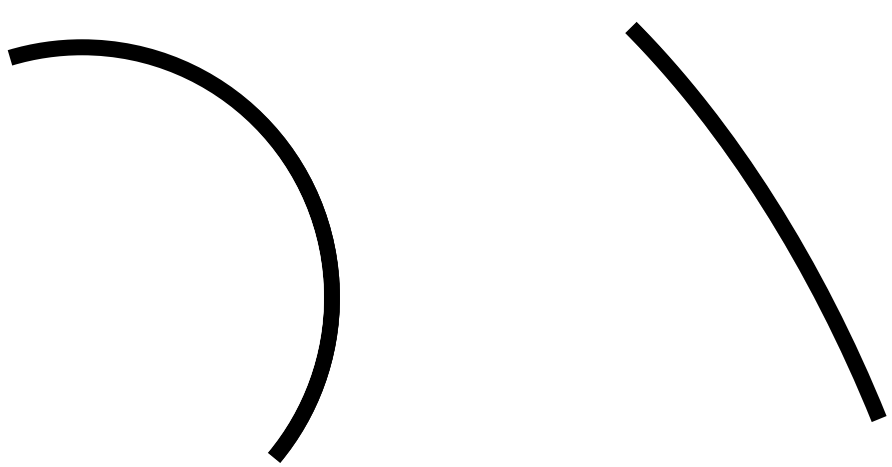
Gestalt Laws: Perceptual Completion







Shipley and Kellman 1992



Source: Patrick Baudisch

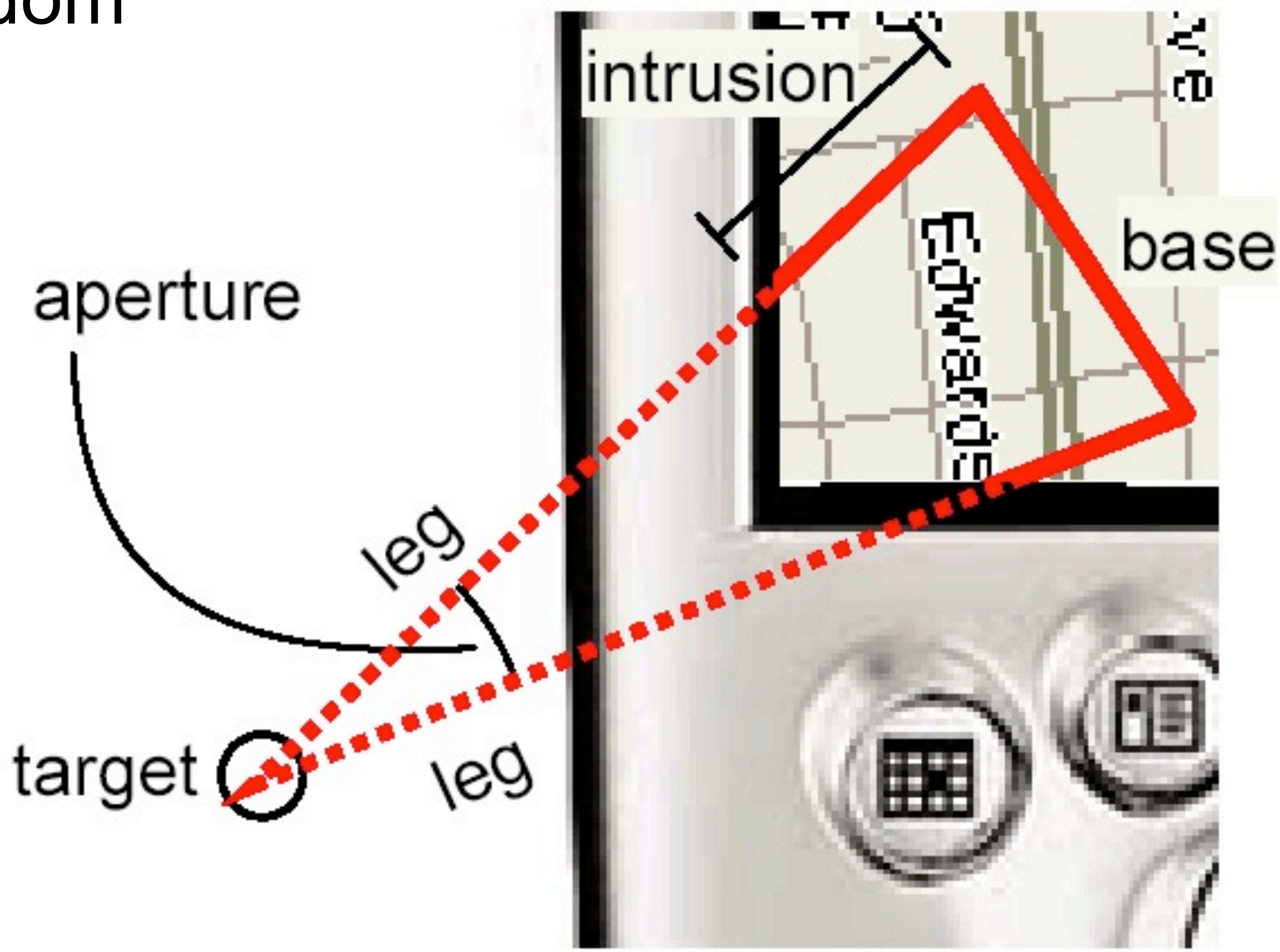
Limitation of Halo: Clutter

- Clutter from overlapping or large number of halos
- Wedge: Isosceles triangles
  - Legs point towards target
  - Rotation, aperture
- No overlap
  - Layout algorithm adapts rotation and aperture

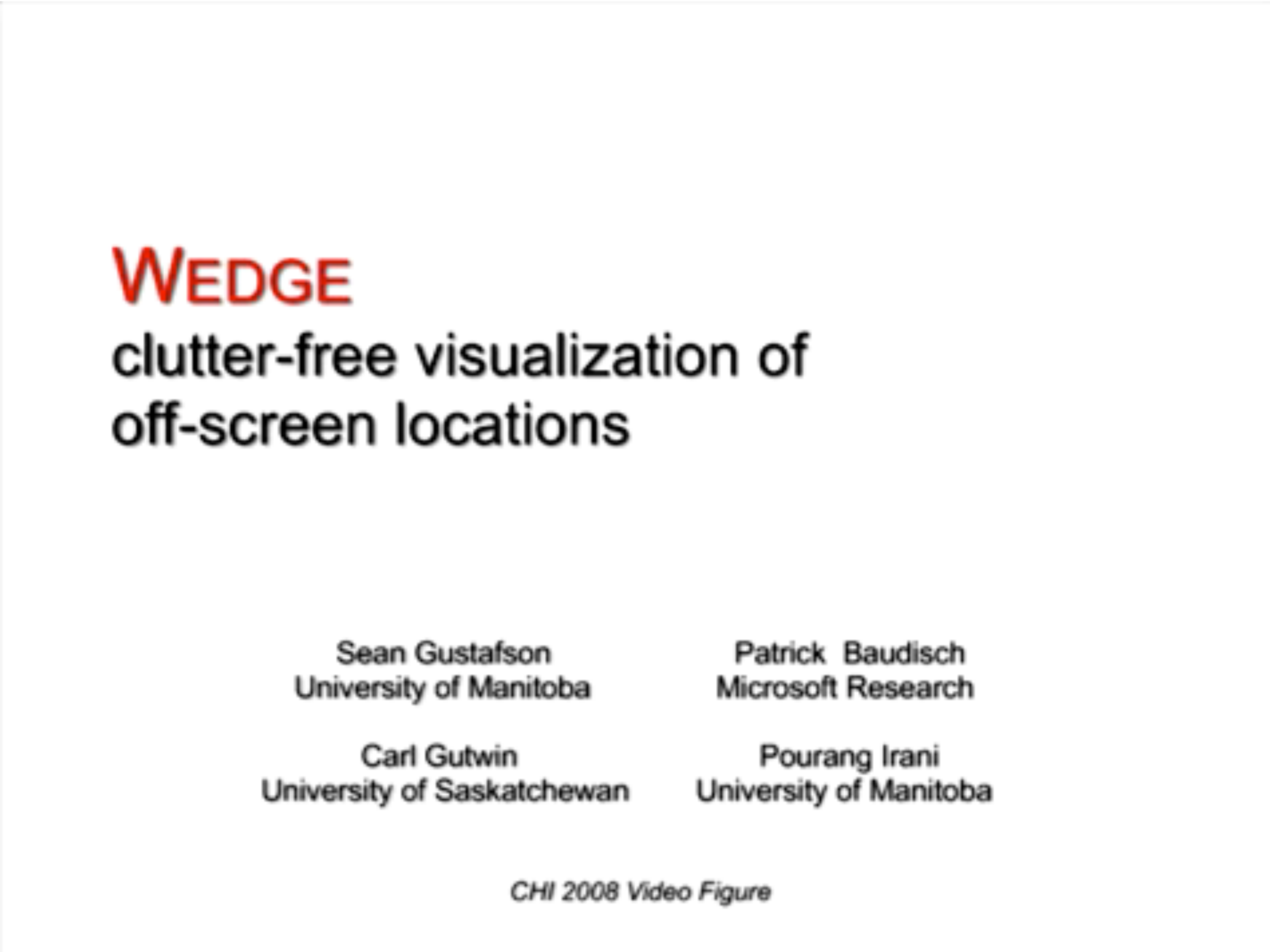
Gustafson, Baudisch, Gutwin, Irani: Wedge: Clutter-Free Visualization of Off-Screen Locations. CHI 2008.

The Wedge

- Degrees of freedom
  - Rotation
  - Intrusion
  - Aperture

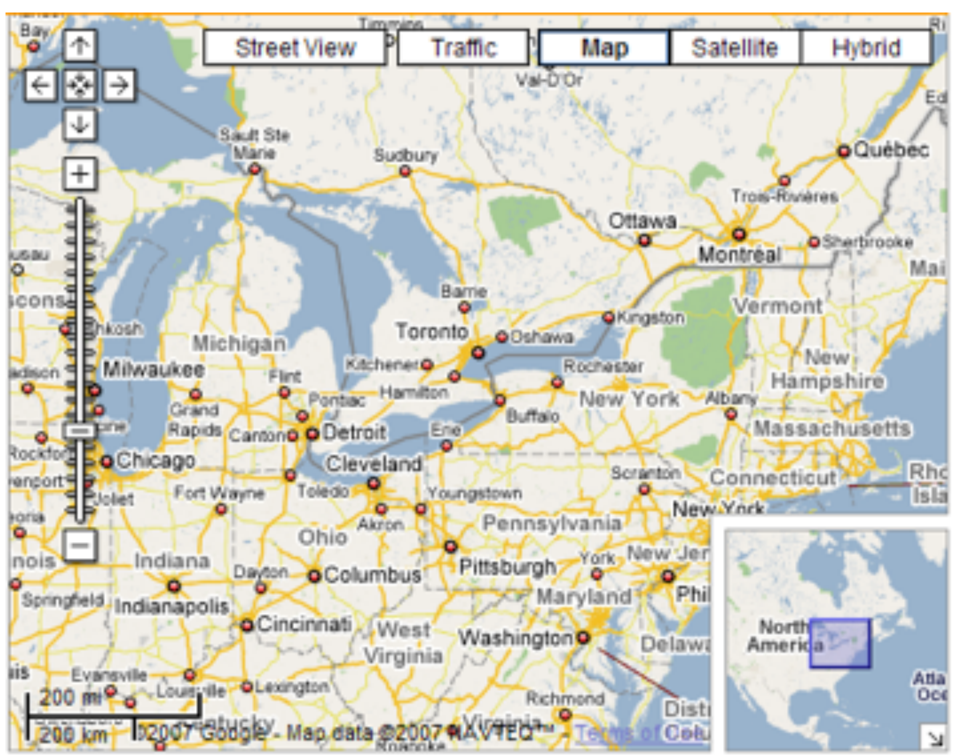


Halo & Wedge: Video



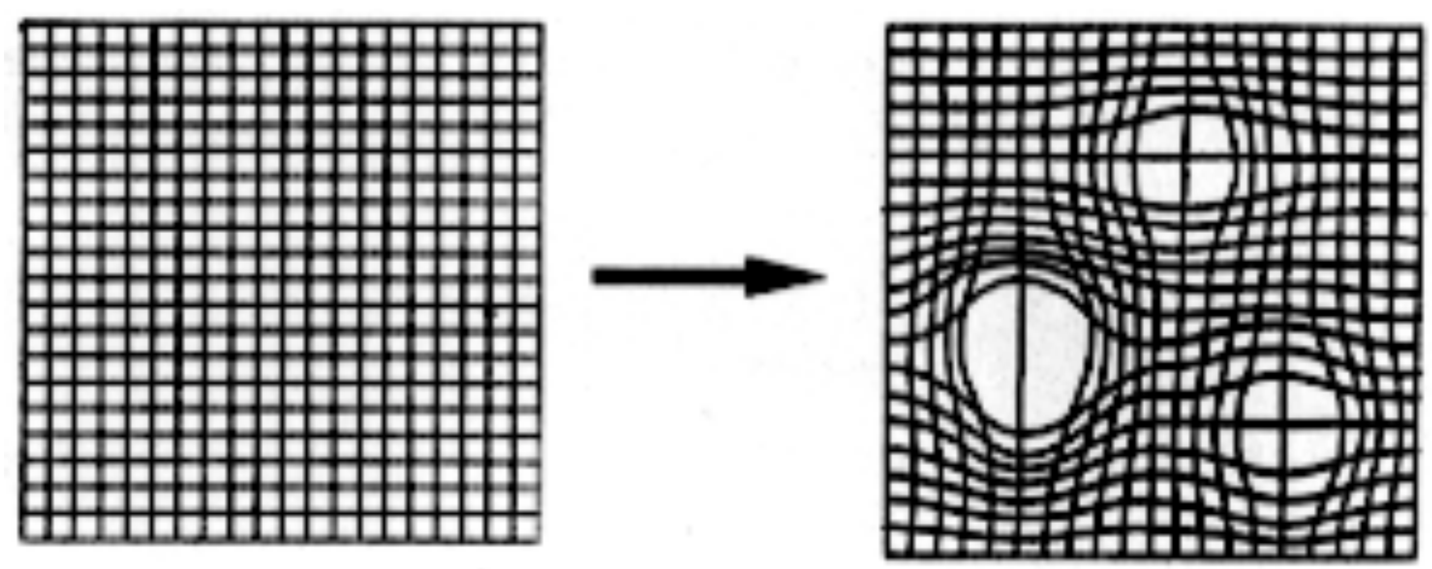
AppLens & LaunchTile

- Using visualization techniques known from InfoViz
  - pan & zoom
  - overview & detail
  - fisheye distortion
- Thereby display more information on a small screen
  - known problem in InfoViz for ages!!



http://quince.infragistics.com/Patterns/857942c9-9397-4007-bae3-5e2364f2489a/rId9.png

http://www.infovis-wiki.net/images/9/96/Fisheye_grid.gif



Focus + Context: DateLens

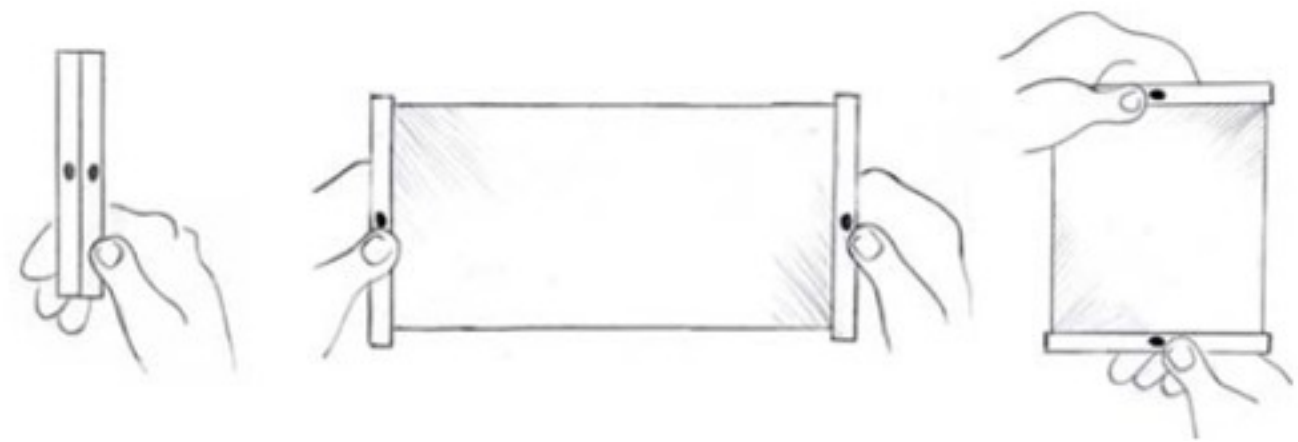
- Calendar with fisheye view and semantic zoom
- Integrate context and detail, distortion

Bederson, Clamage, Czerwinski, Robertson: DateLens: A Fisheye Calendar Interface for PDAs. ACM TOCHI, 2004.

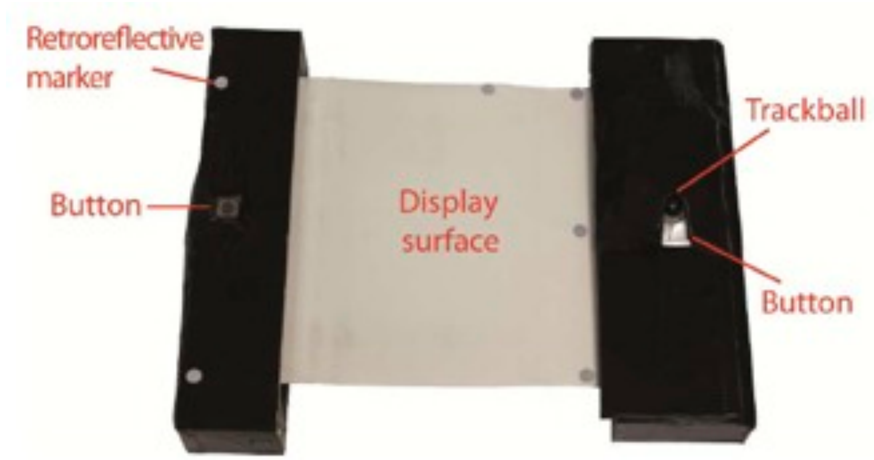
https://www.youtube.com/watch?v=QCaCFCOAb7Q

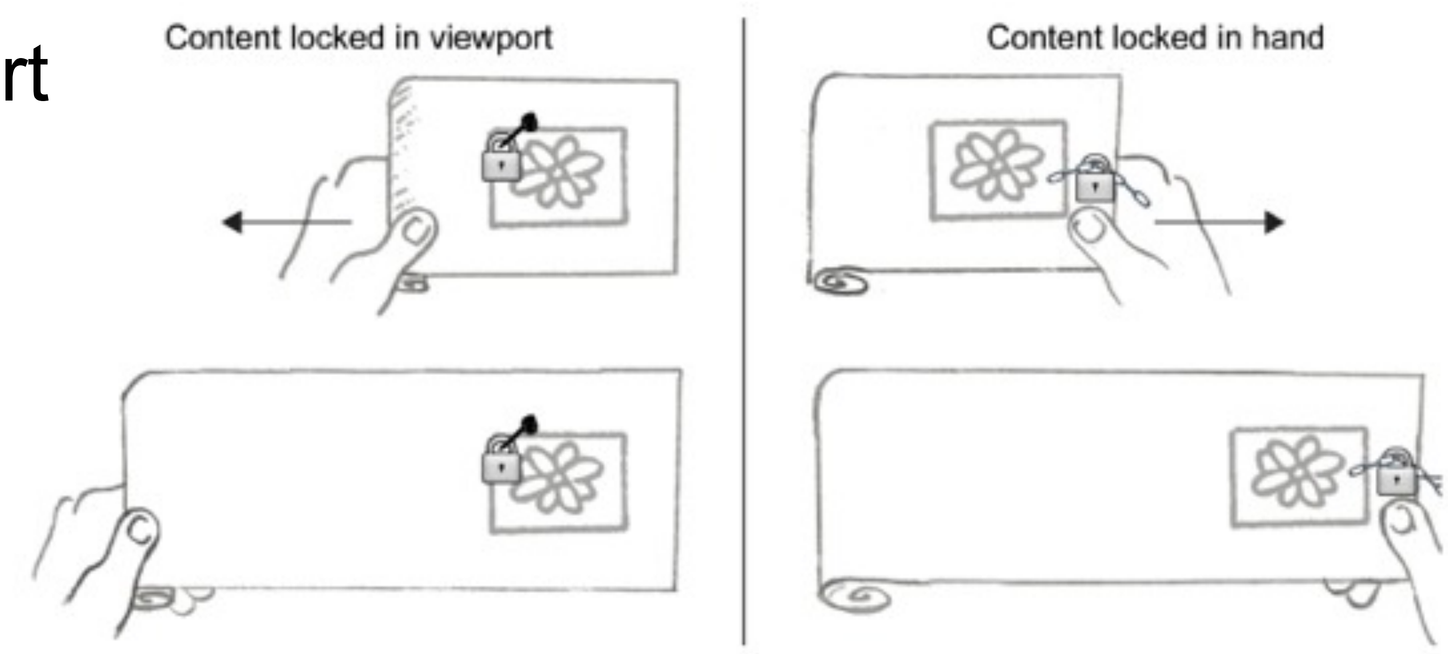
LaunchTile & AppLens (CHI 2005)

Xpaaand: Interaction Techniques for Rollable Displays



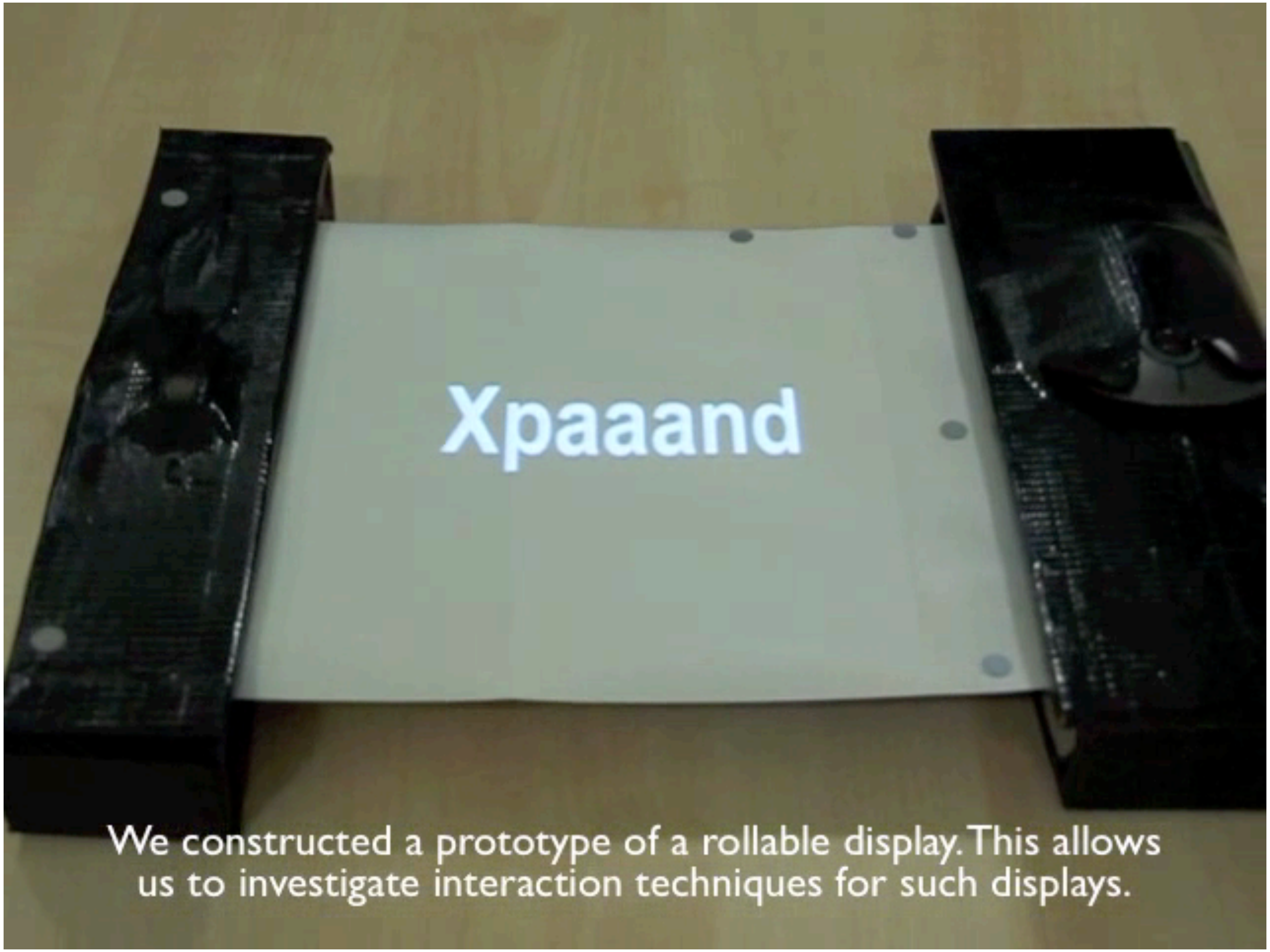
- Concept of a future rollable display
  - Physical resizing of the display as an interaction technique
  - Semantic zooming
- Metaphors
  - Content locked in viewport
  - Content locked in hand





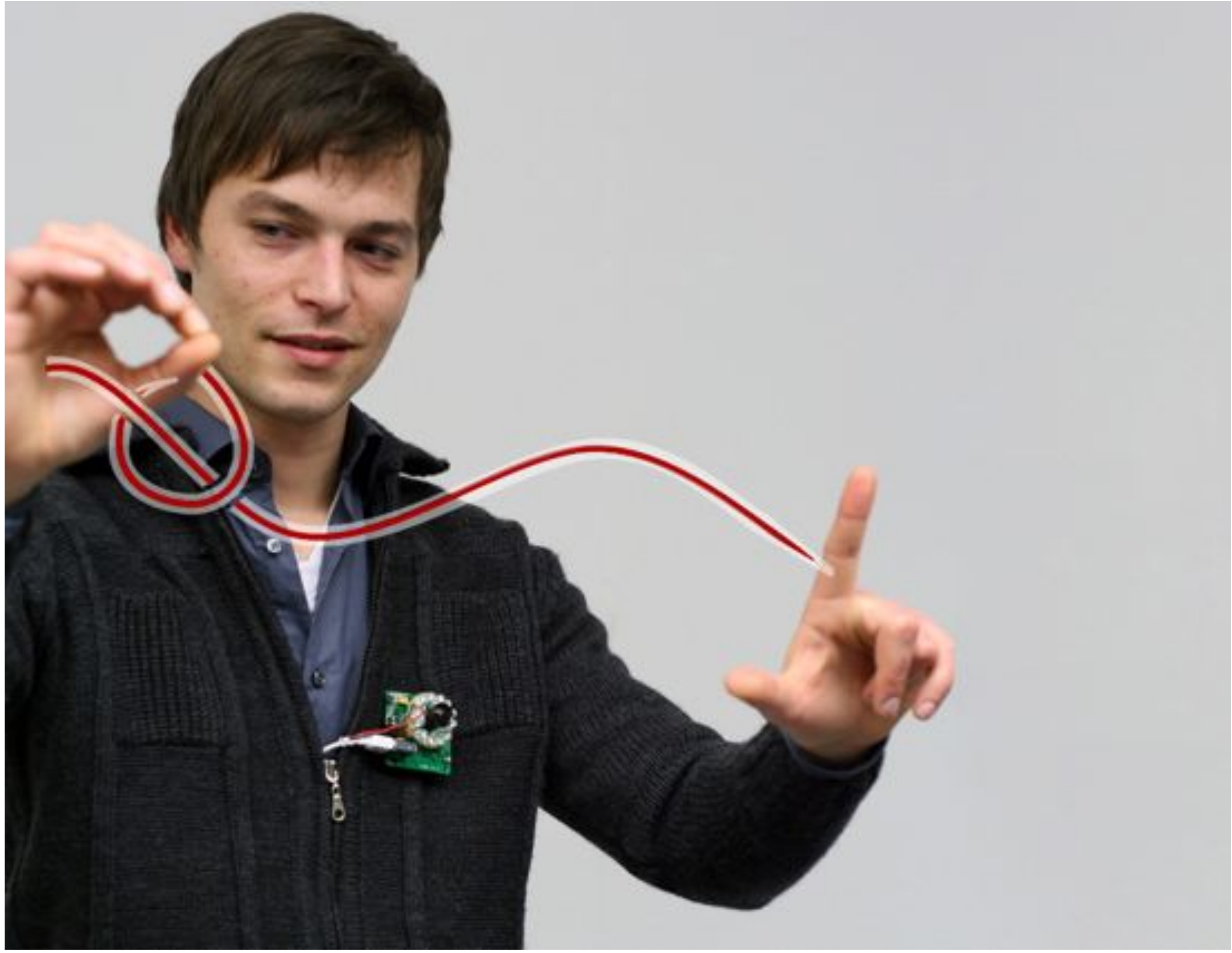
Khalilbeigi, Lissermann, Mühlhäuser, Steimle. Xpaaand: Interaction Techniques for Rollable Displays. CHI 2011.

Xpaaand: Interaction Techniques for Rollable Displays



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

Imaginary interfaces



- Get rid of the screen altogether
- imagine a large area for interaction
- interpret gestures to act on it

- Sean Gustafson, Daniel Bierwirth and Patrick Baudisch. 2010. Imaginary Interfaces: Spatial Interaction with Empty Hands and Without Visual Feedback. In *Proceedings of the Symposium on User Interface Software and Technology (UIST '10)*, 3-12.
- http://www.hpi.uni-potsdam.de/baudisch/projects/imaginary_interfaces.html https://www.youtube.com/watch?v=718RDJeISNA


Imaginary
Interfaces

Dealing with imprecise touch

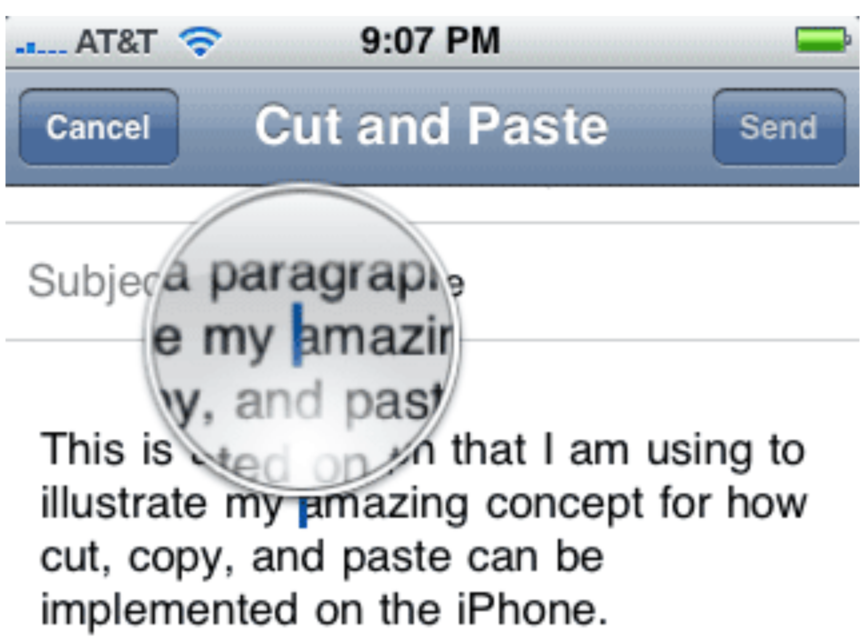
- Precision input techniques
  - Offset Cursor / Shift
  - Tap Tap / MagStick
  - PrecisionRolls
  - BezelSwipe

- Using the back of the device

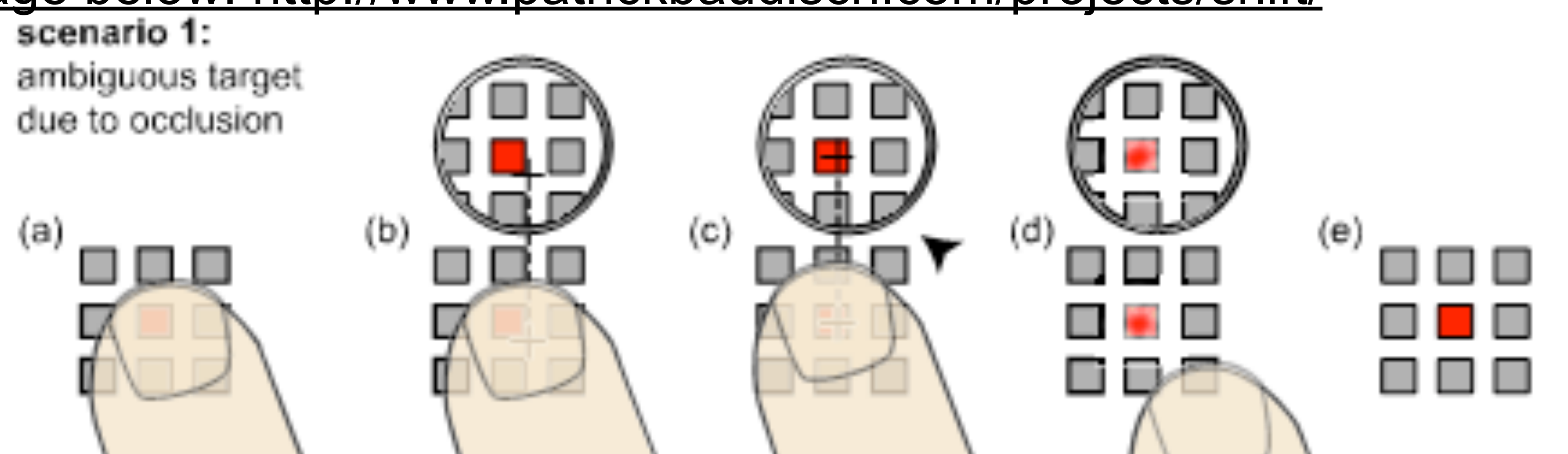
Offset Cursor & Shift

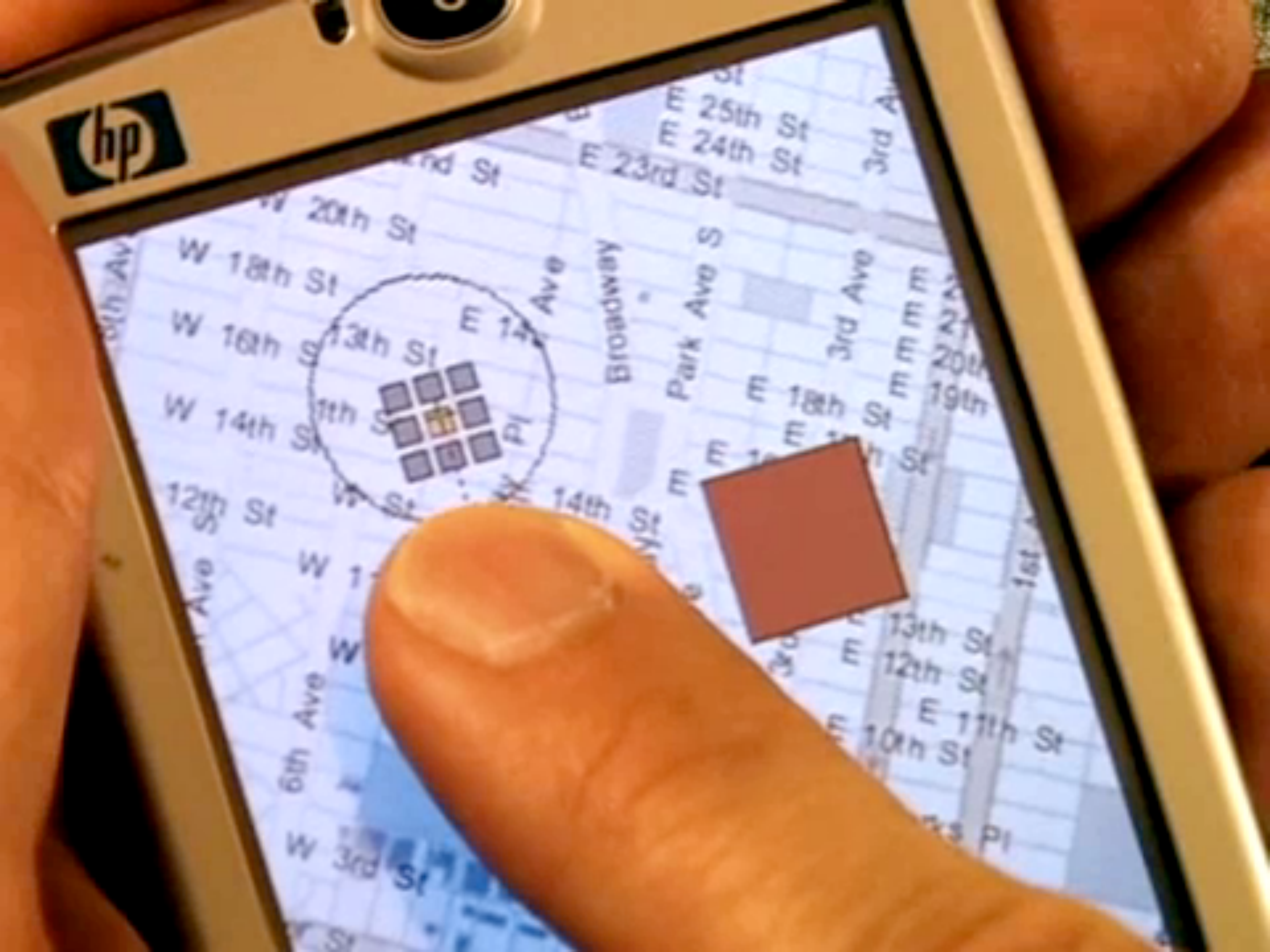
- Problem: fat finger occludes small target
- Idea: enlarge the area under the finger and display it next to the finger
- Currently used e.g. in iOS

- Problems??



next slide: https://www.youtube.com/watch?v=kkoFIDArYks
image left: http://www.ironicsans.com/images/cutpaste02.png
image below: http://www.patrickbaudisch.com/projects/shift/




E 25th St
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W 16th St
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12th St
Broadway
Park Ave S
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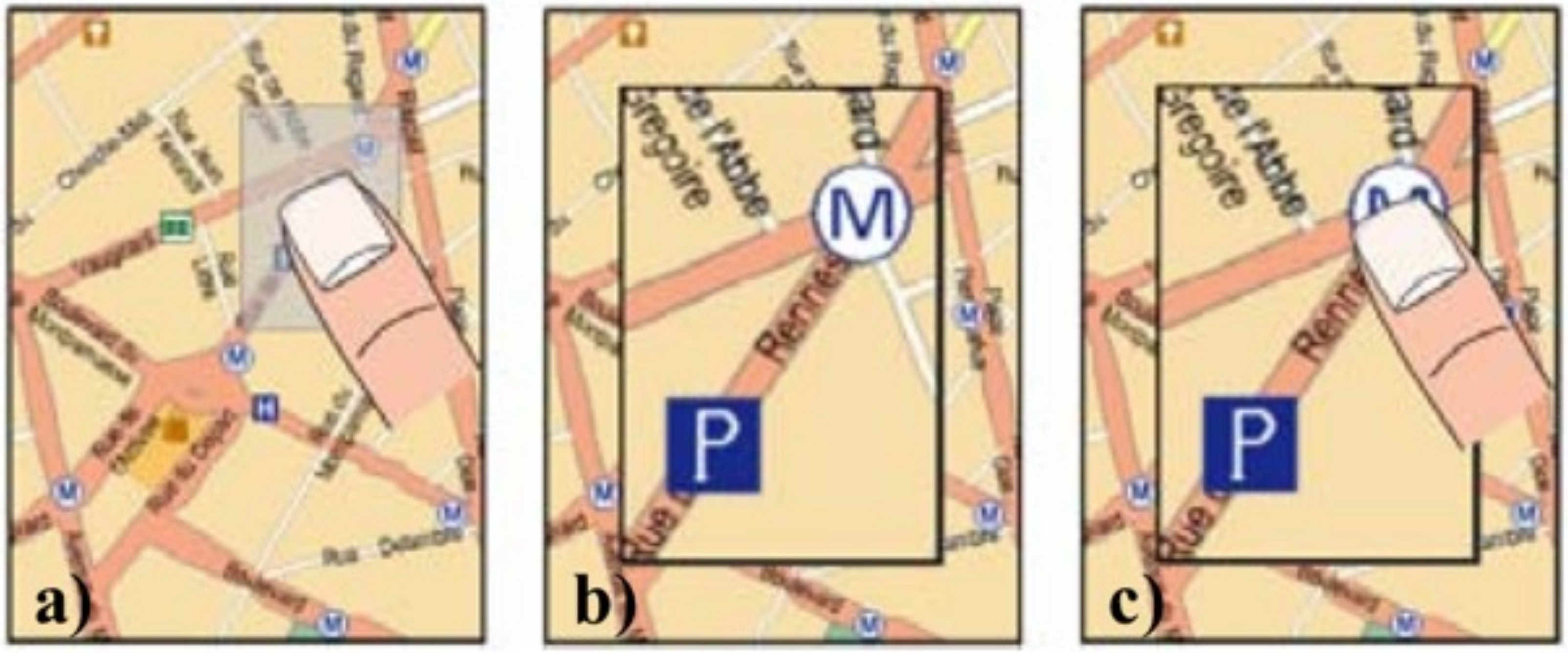
E 18th St
E 19th
13th St
E 12th St
E 11th St
E 10th St
6th Ave
W 3rd St

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)

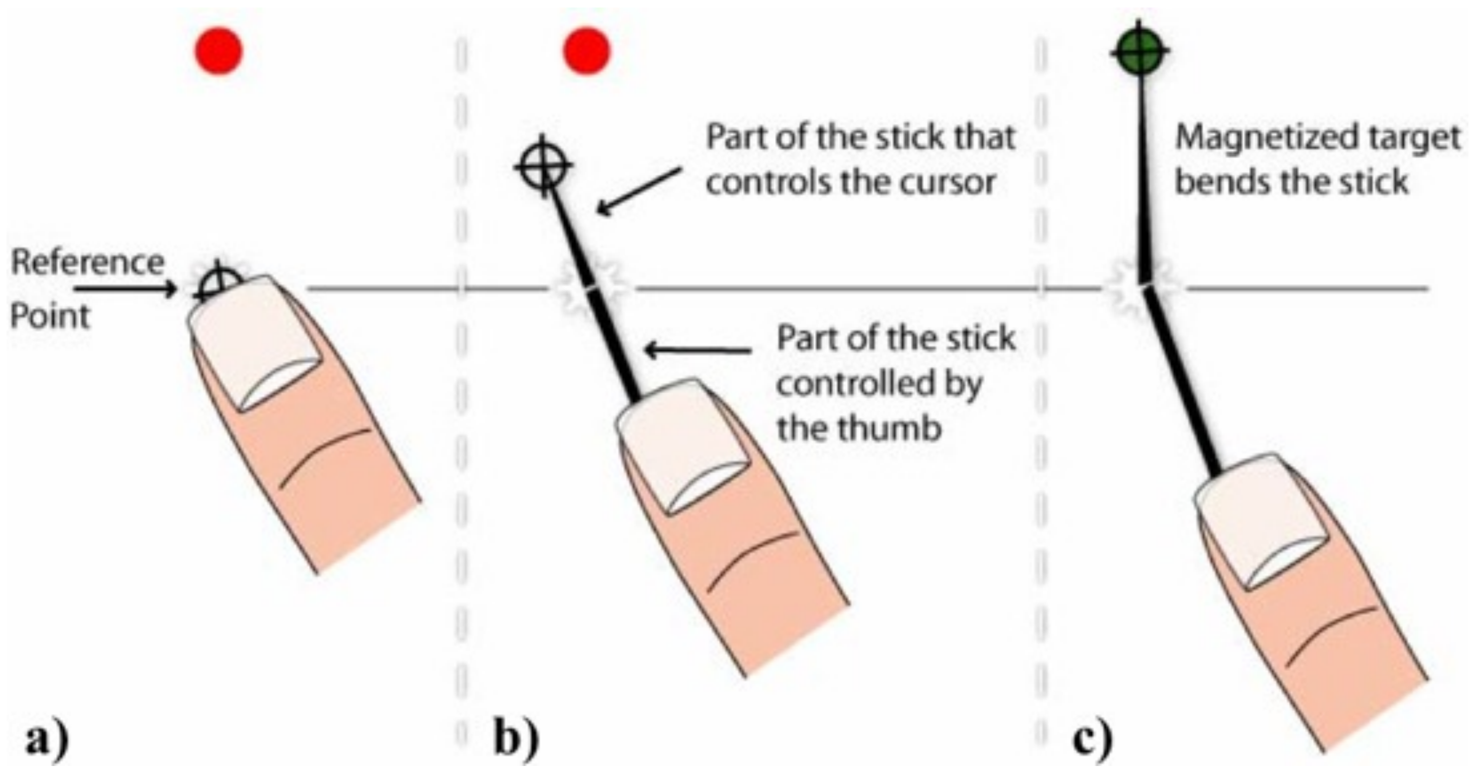


How to distinguish single touch?

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

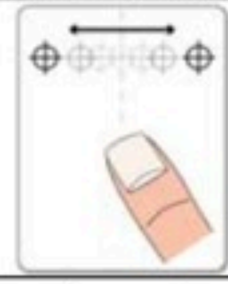
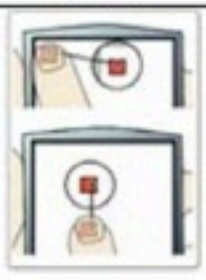
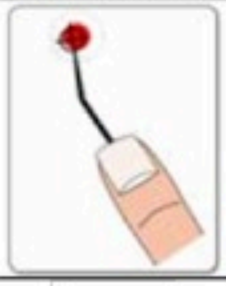
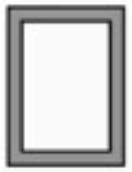
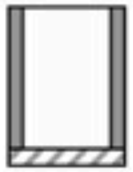
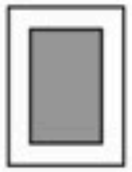
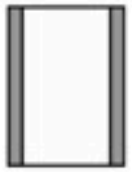


Is moving away from the target intuitive?

Is MagStick better than simple Offset Cursor?

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

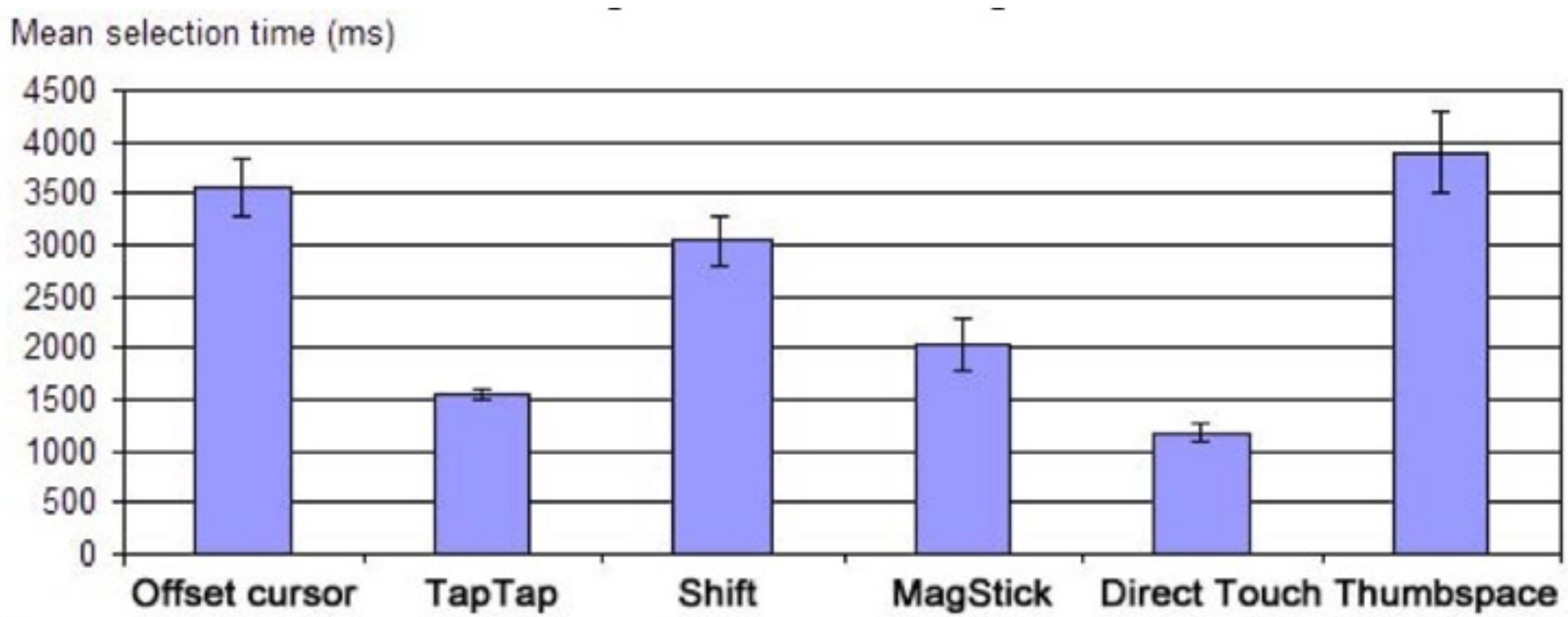
Precision Touch Input: Comparison Experiment

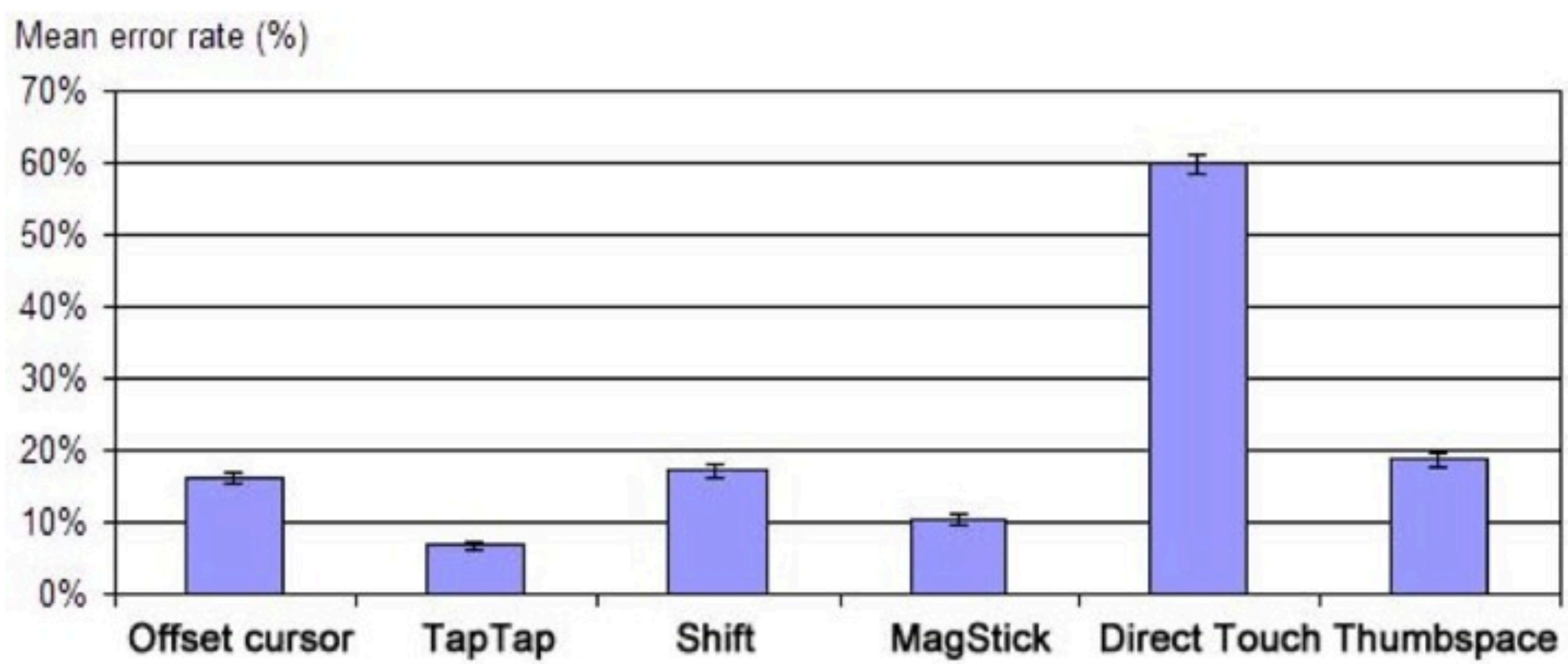
	Direct Touch	Offset Cursor	Adaptive Offset	Thumbspace	Shift	TapTap	MagStick
Overview							
Target Accessibility							
	Grayed areas are difficult to reach – Hatched areas are impossible to reach						
Thumb Occlusion	Everywhere	None	None	Center (if same relative and absolute positions)	On top left	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

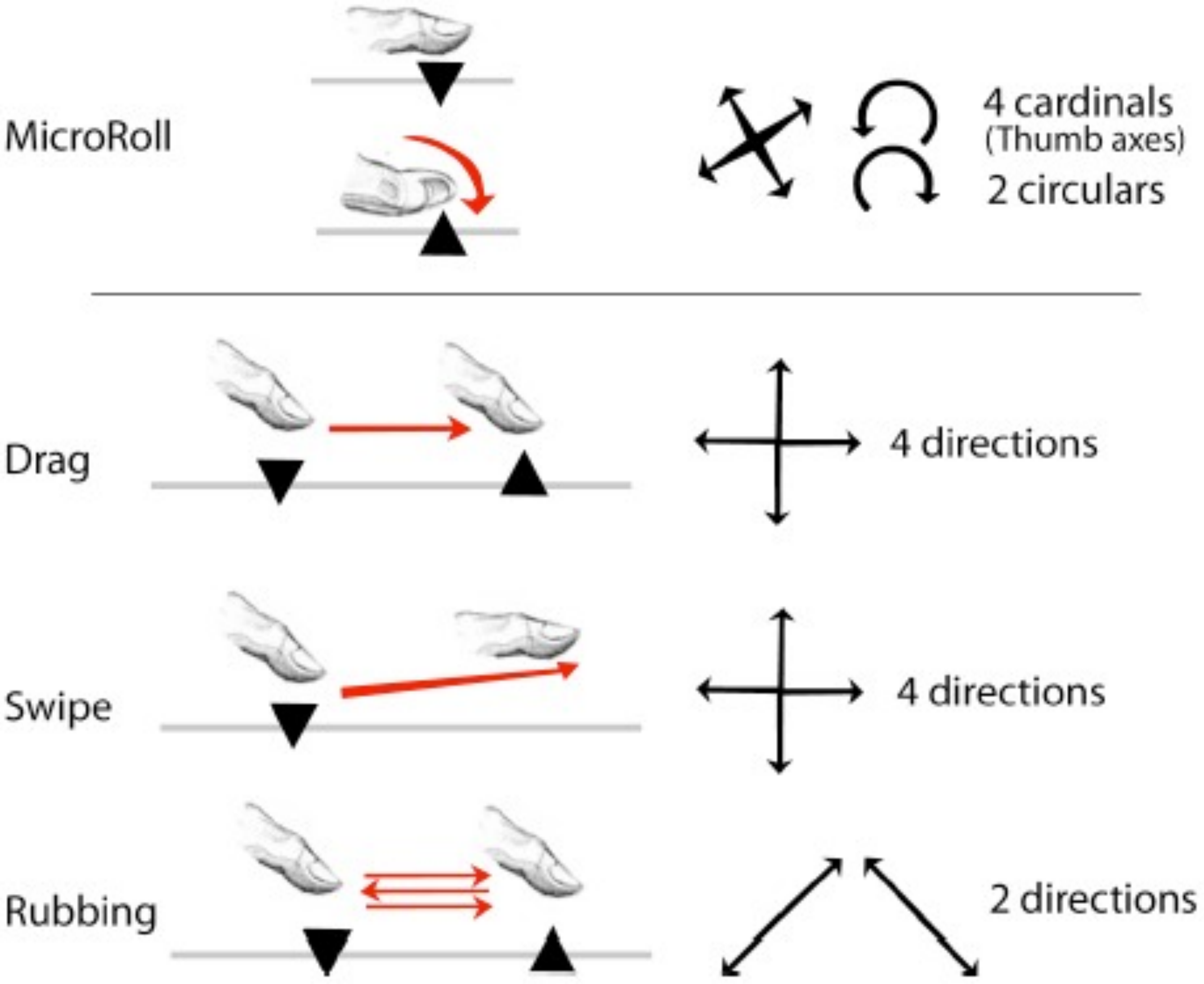




Roudaut, et al. TapTap and MagStick: Improving one-handed target acquisition on small touch-screens. AVI 2008.

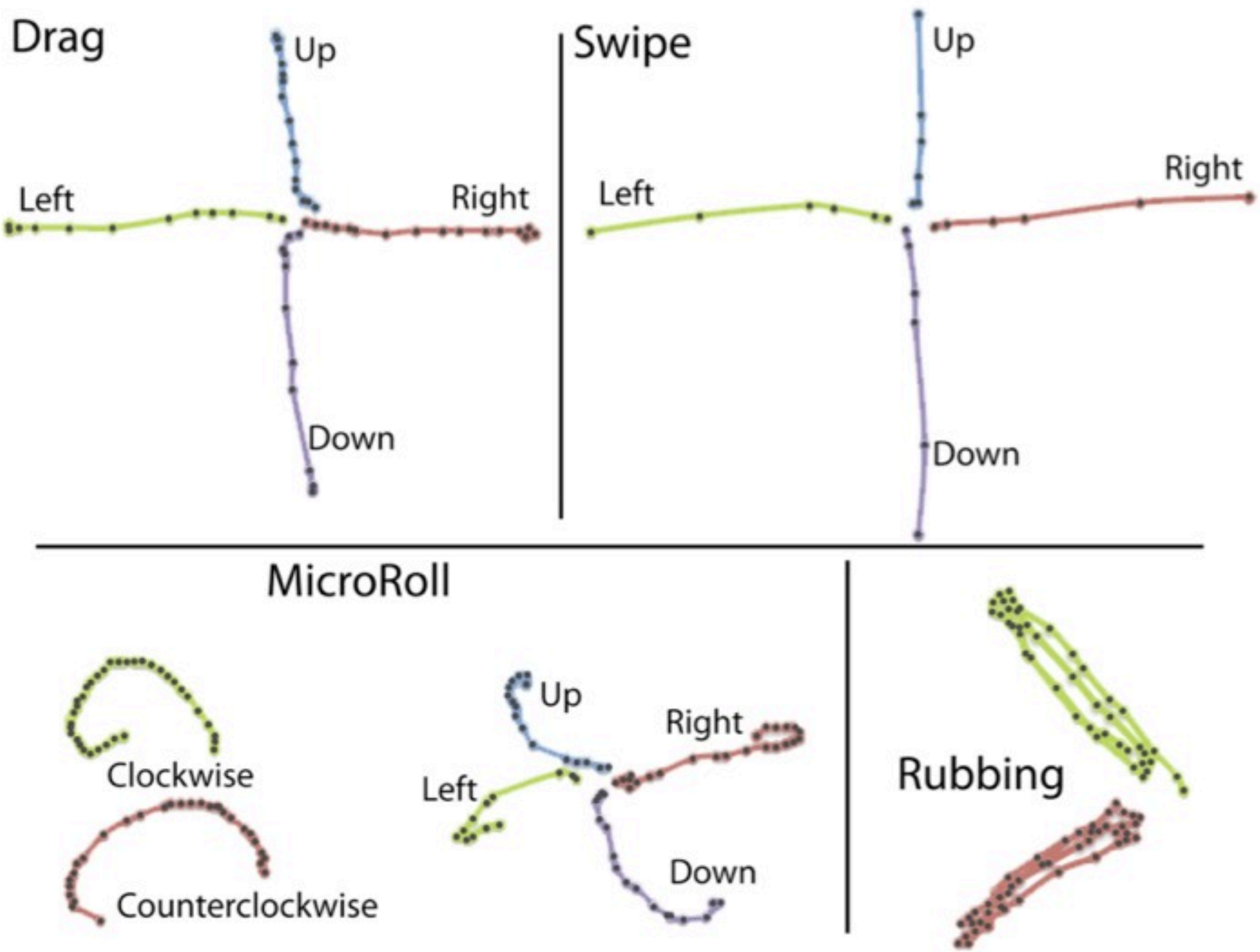
MicroRolls: Expanding Touch-Screen Input by Distinguishing Rolls vs. Slides of the Thumb

- 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



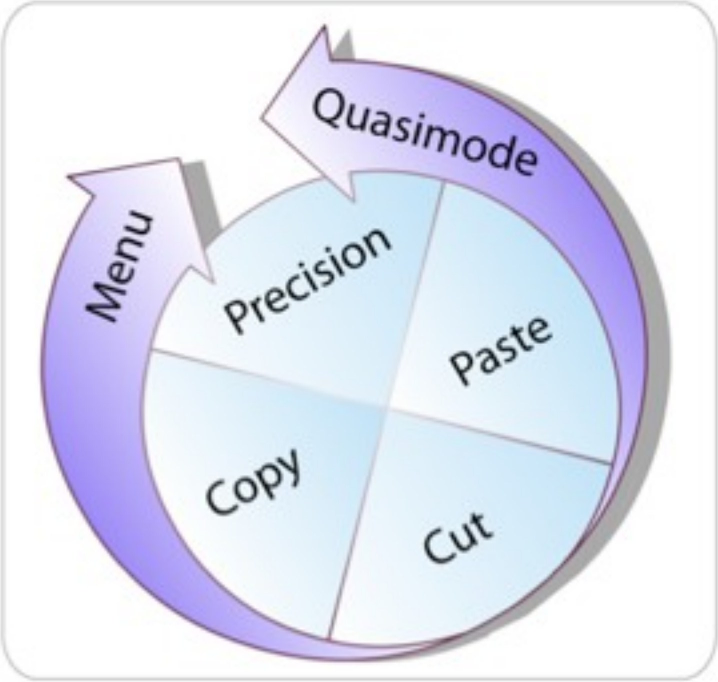
Roudaut, Lecolinet, Guiard. MicroRolls: Expanding Touch-Screen Input Vocabulary by Distinguishing Rolls vs. Slides of the Thumb. CHI 2009.

Kinematic Traces of Different Touch Gestures

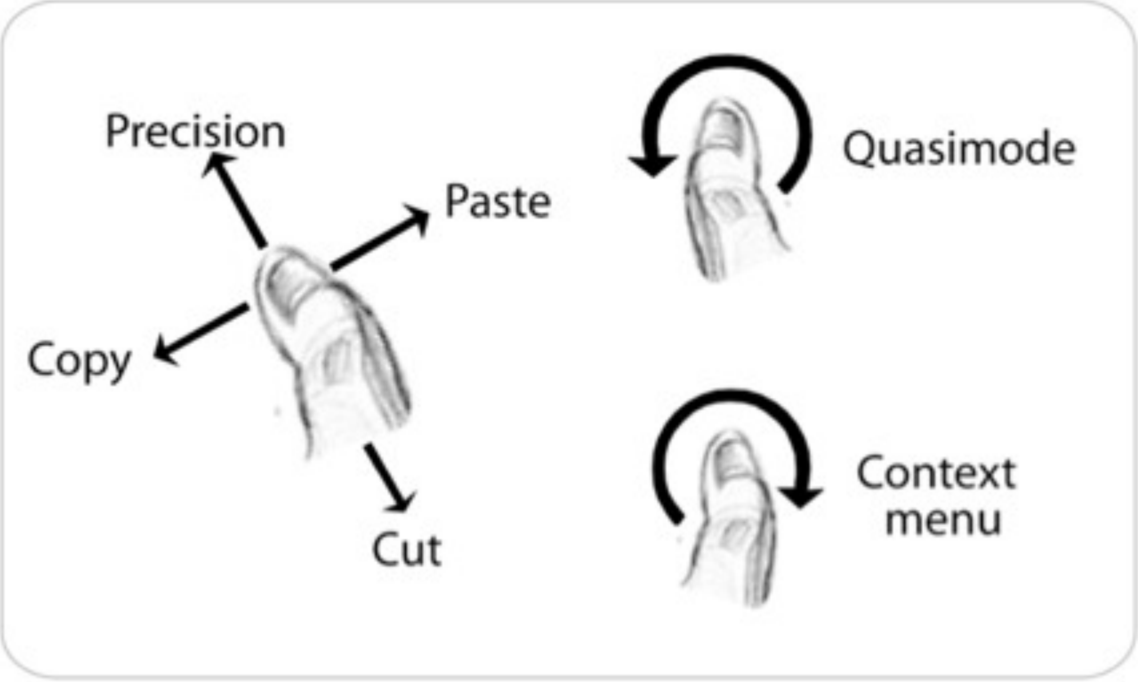


Roudaut, Lecolinet, Guiard. MicroRolls: Expanding Touch-Screen Input Vocabulary by Distinguishing Rolls vs. Slides of the Thumb. CHI 2009.

Mapping MicroRoll Gestures to Actions



Menu (300ms timeout)

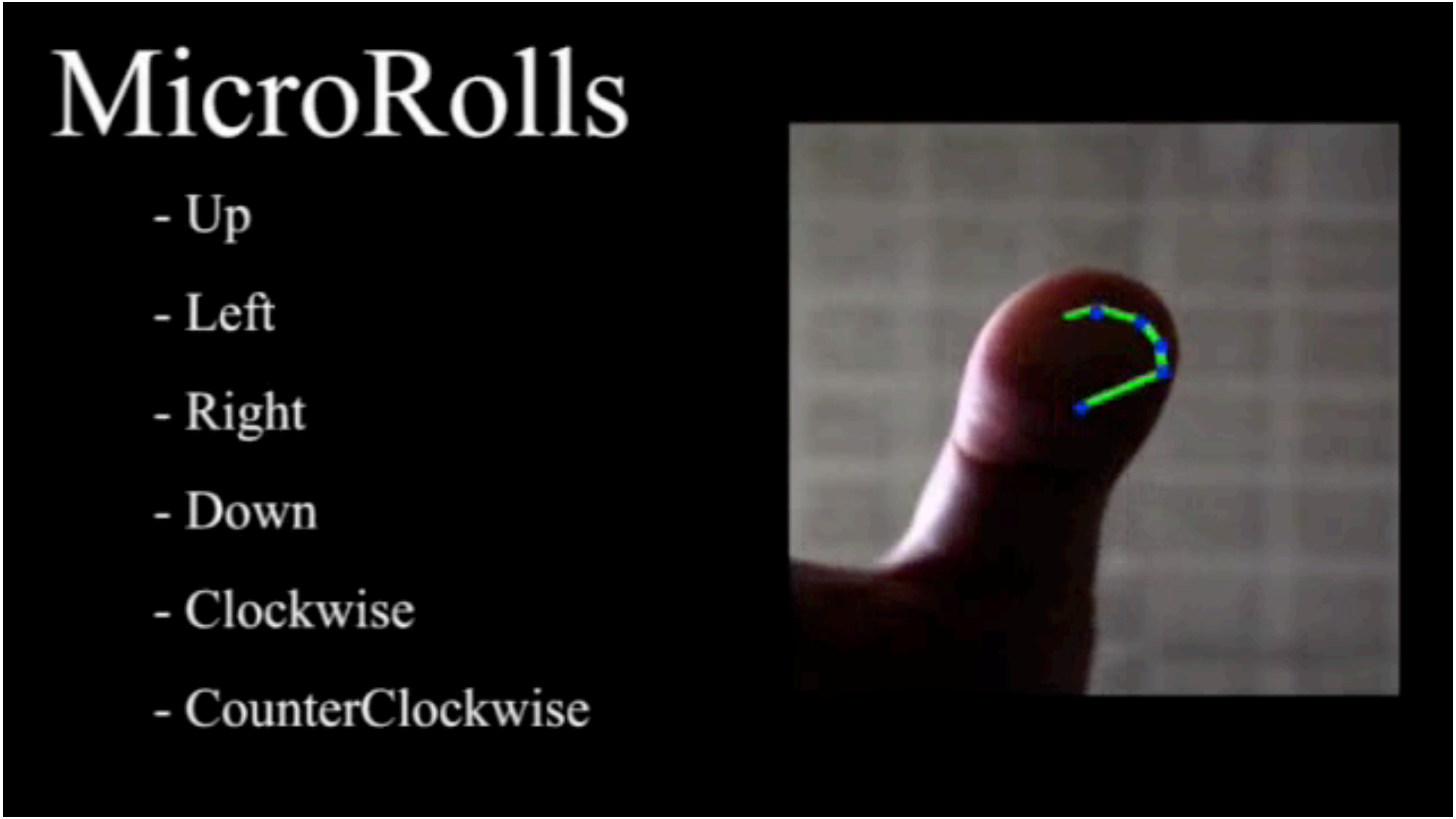


MicroRoll gestures

- 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.

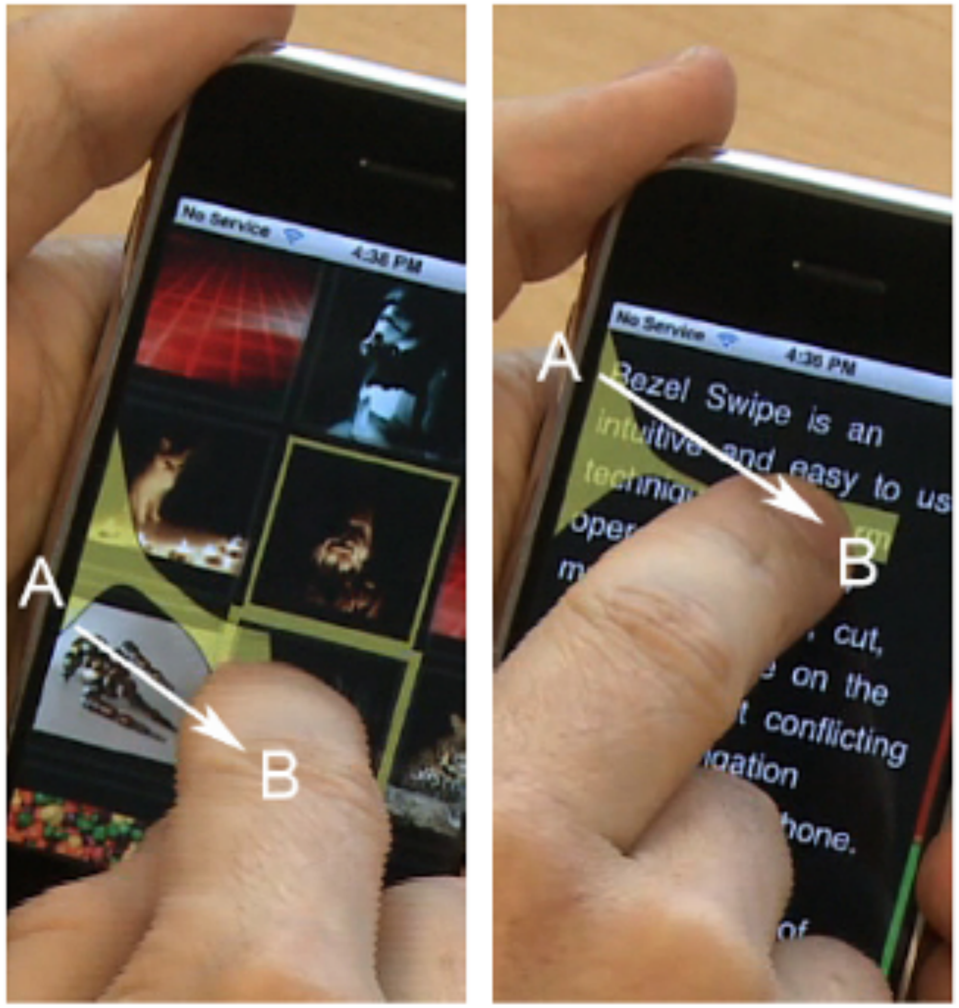
MicroRolls: Expanding Touch-Screen Input by Distinguishing Rolls vs. Slides of the Thumb

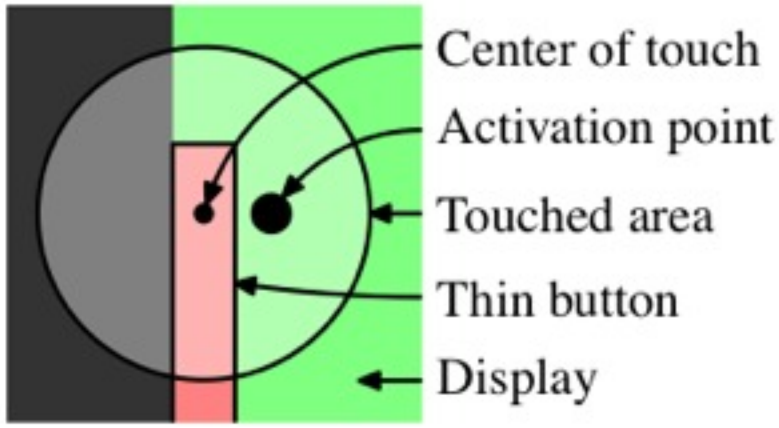


Roudaut, Lecolinet, Guiard. MicroRolls: Expanding Touch-Screen Input Vocabulary by Distinguishing Rolls vs. Slides of the Thumb. CHI 2009.

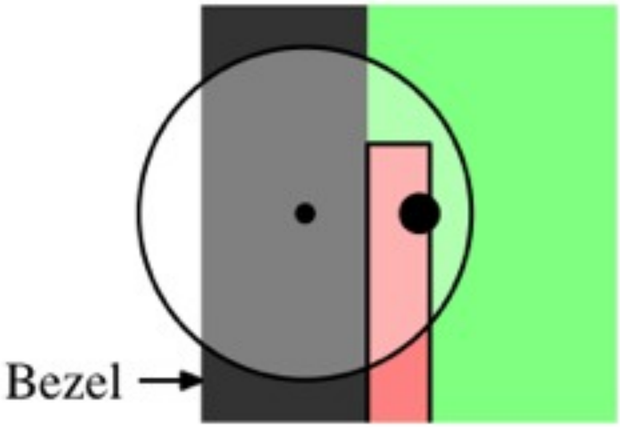
Bezel Swipe: Conflict-Free Scrolling and Selection on Mobile Touch Screen Devices

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





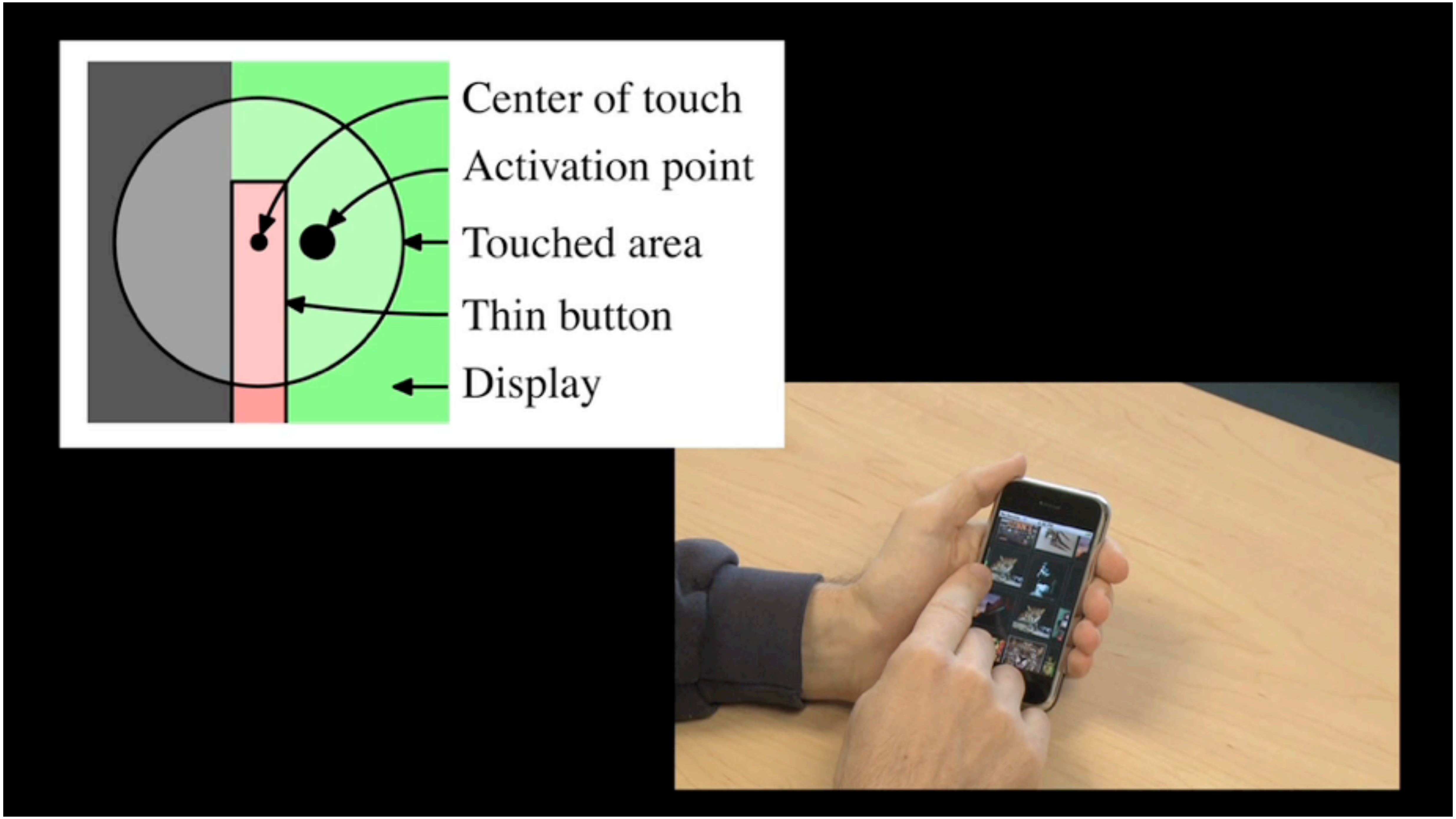
touch on bar:
no activation



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



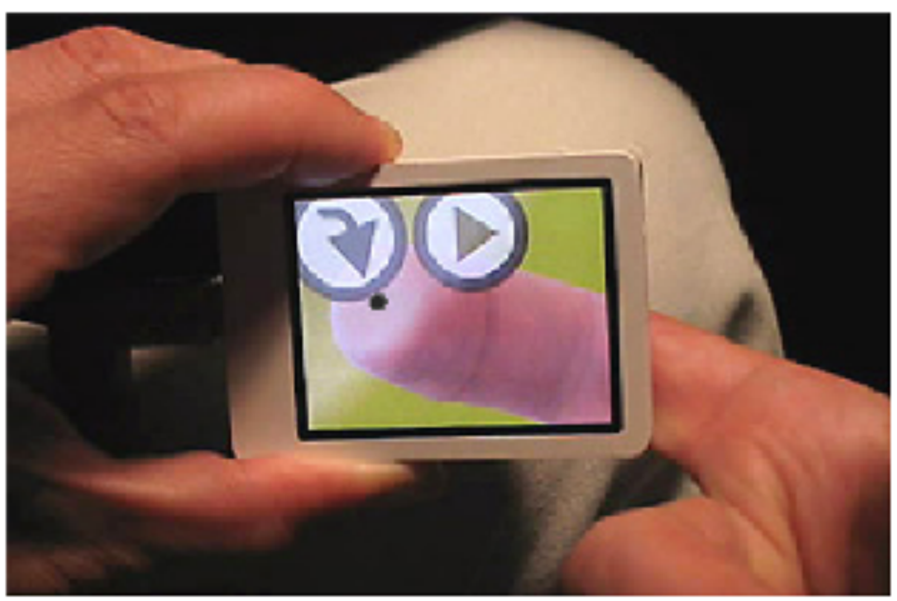
Roth, Turner. Bezel Swipe: Conflict-Free Scrolling and Multiple Selection on Mobile Touch Screen Devices. CHI 2009.

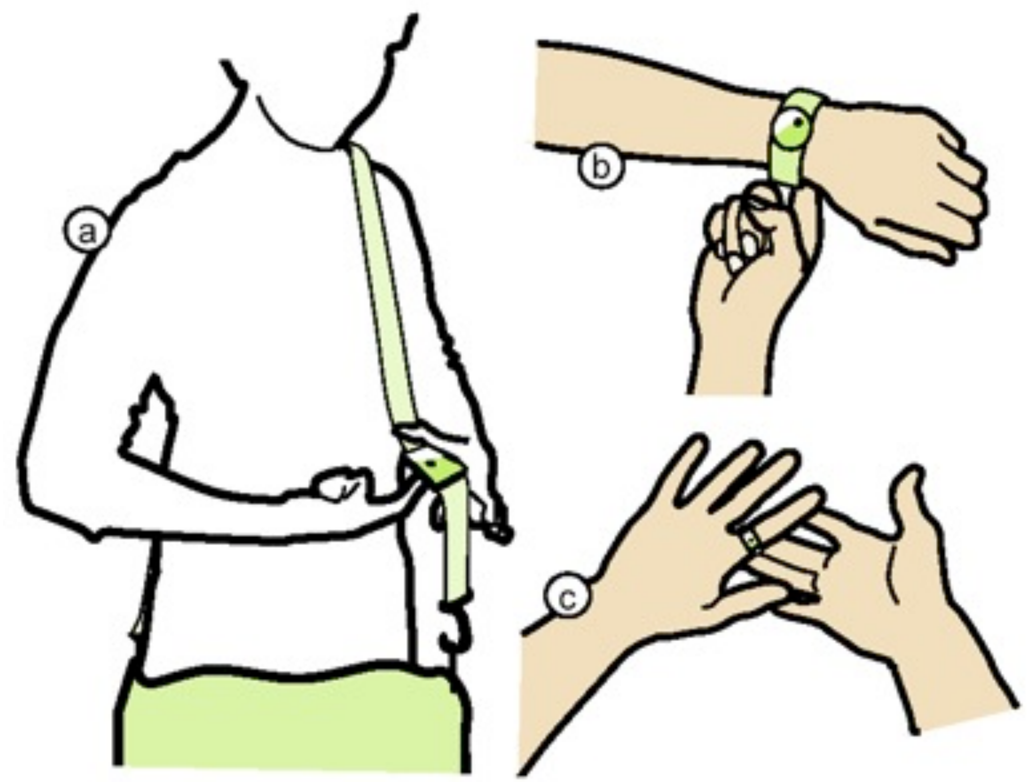
iOS 5 Notification Bar

Image source: http://www.macstories.net/stories/ios-5-notification-center/

Back-of-Device Interaction Works for Very Small Screens

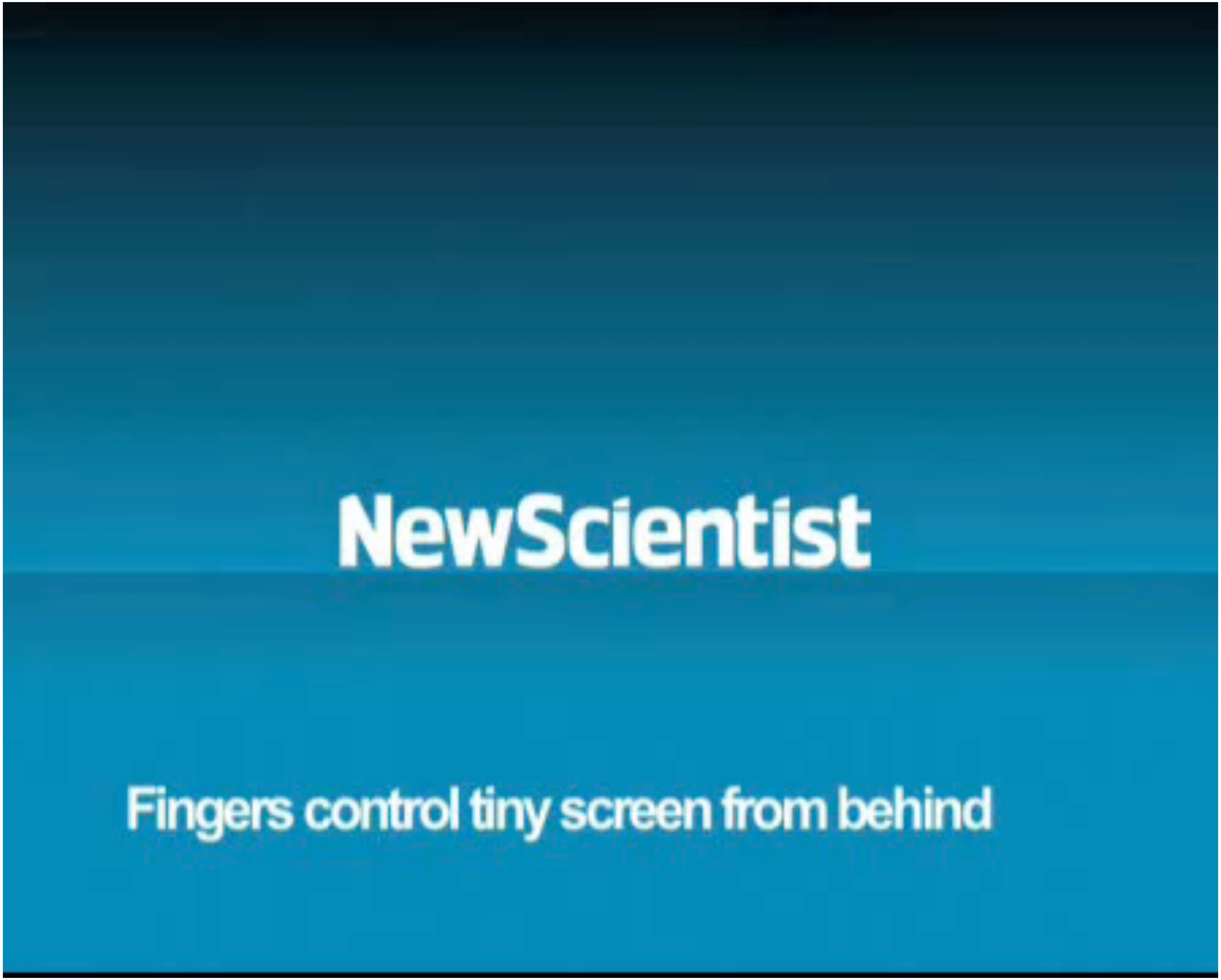
- Jewelry, watches, etc.
- Pseudo transparency
  - Capacitive touch pad
  - Clickable touch pad





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

http://www.youtube.com/watch?v=4xfgZy2B5ro

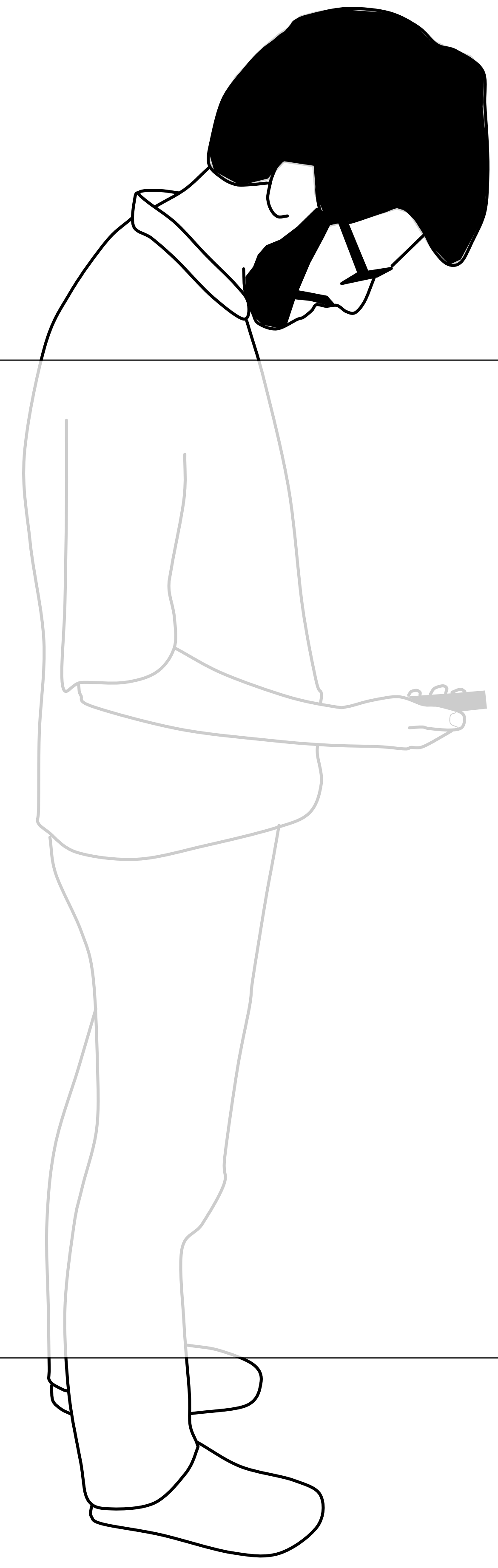


Take-home messages

- Be creative with small screens!
  - use known visualization techniques
    - lack of space is well known in InfoViz!!
  - think of good mental models
    - street lamp metaphor, imaginary interfaces...
  - imagine future form factors to be different
    - Xpaaand, Gummi, ...

- Don‘t get stuck with imprecise input
  - use novel visualization techniques
  - look closer at the sensor output data
  - imagine future sensors to be elsewhere ;-)

Mobile Technologies



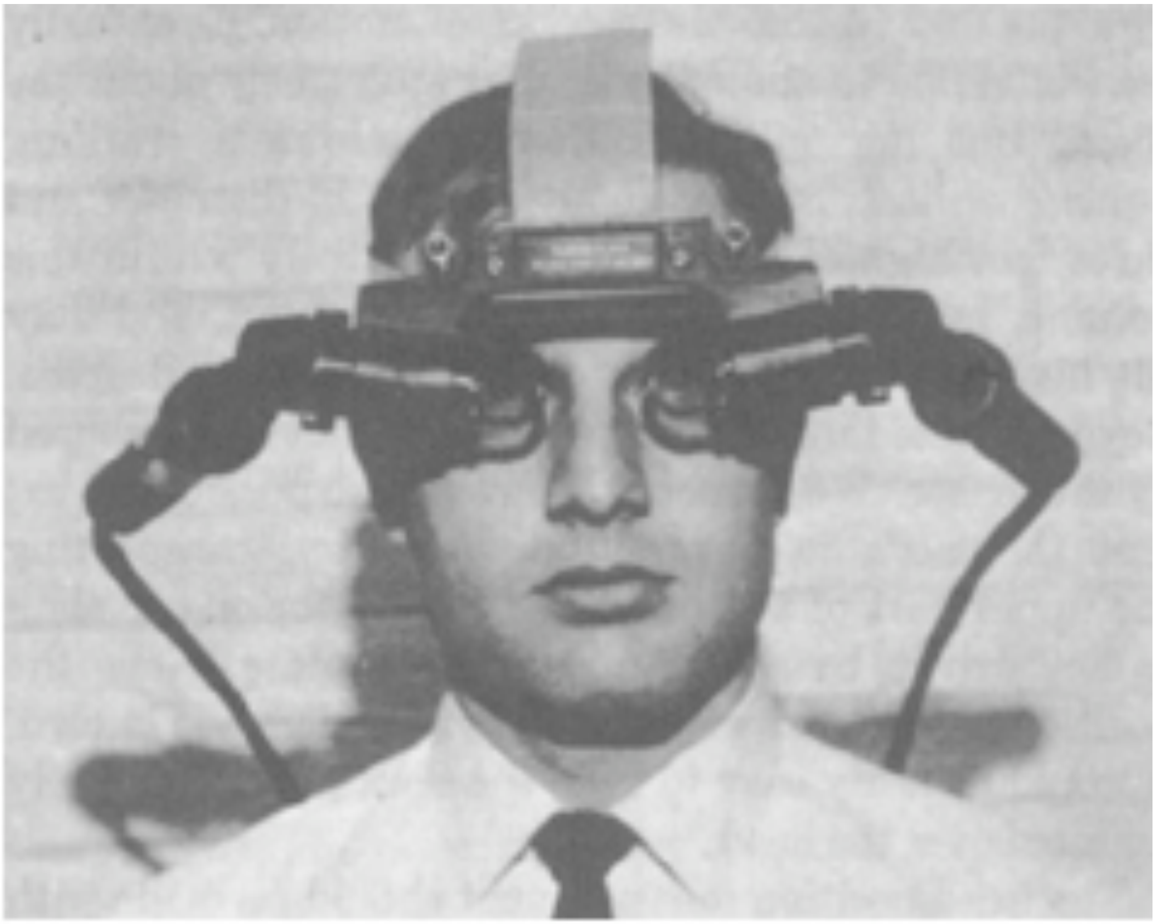
- context and task
- challenges
- input technologies
- challenges in interaction design
- **output technologies**

Visual output

- LCD screens (you know all about that... ;-)

- closed HMDs
- video see-through HMDs
- optical see-through HMDs
  - example:google glass
- HUDs

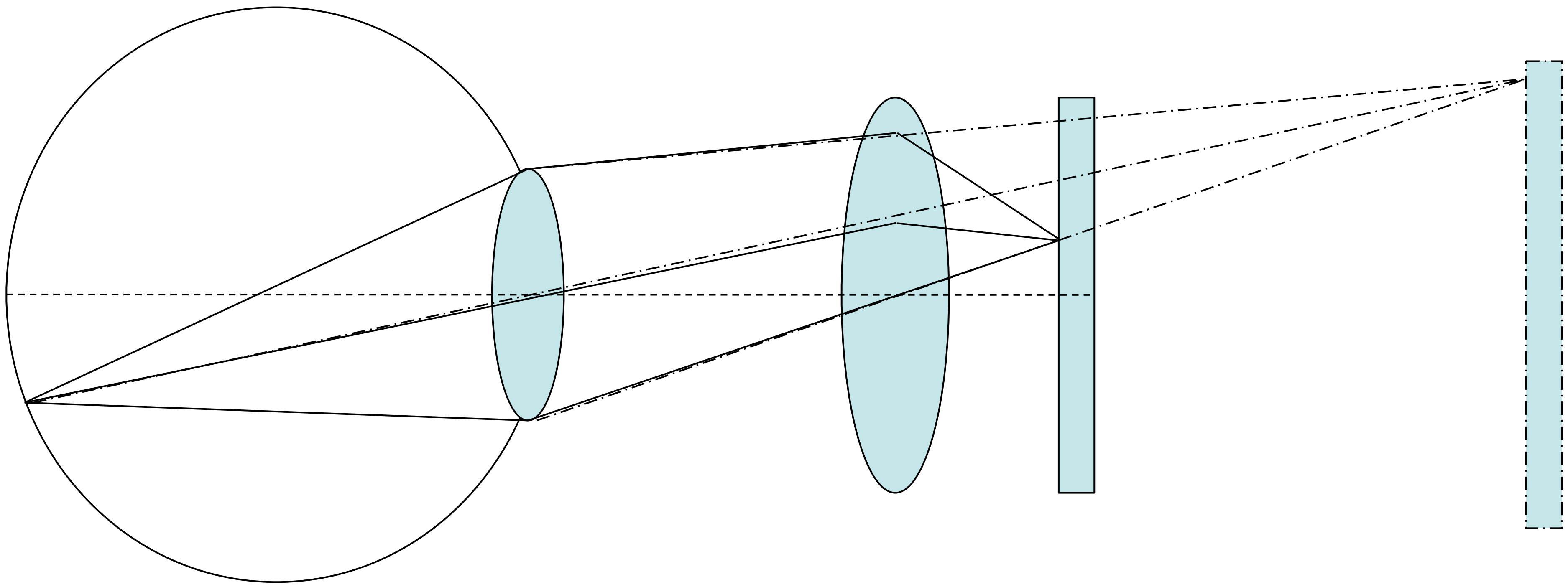
Ivan Sutherland‘s HMD



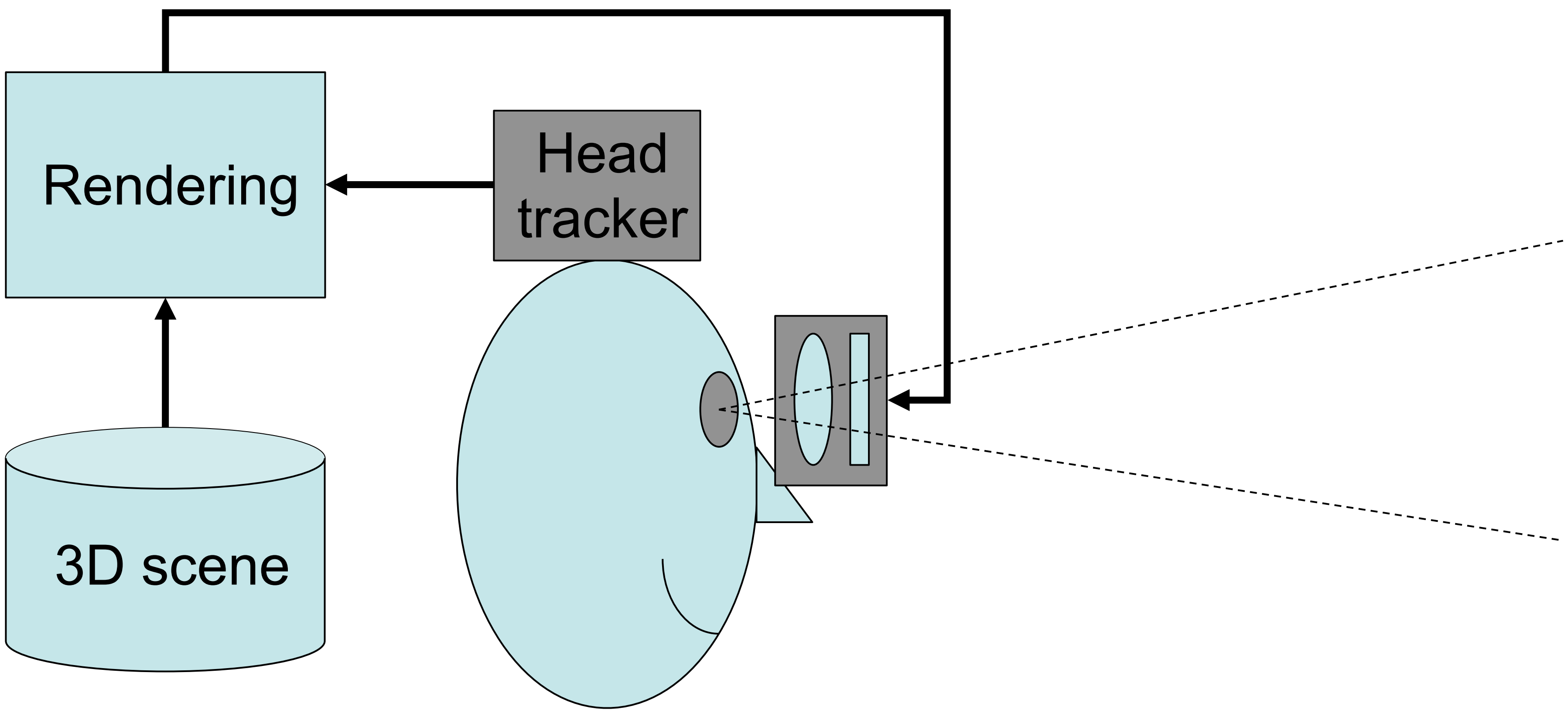
- Quelle: "A Head -Mounted Three-Dimensional Display," Sutherland, I.E. AFIPS Conference Proceedings, Vol. 33, Part I, 1968, pp. 757-764.

Principle: closed (video only) HMD

- Monitor is mounted very close to the eye
- Additional lens makes it appear distant
- ➔ all images appear at the same distance
  - –Usually at infinity or slightly less



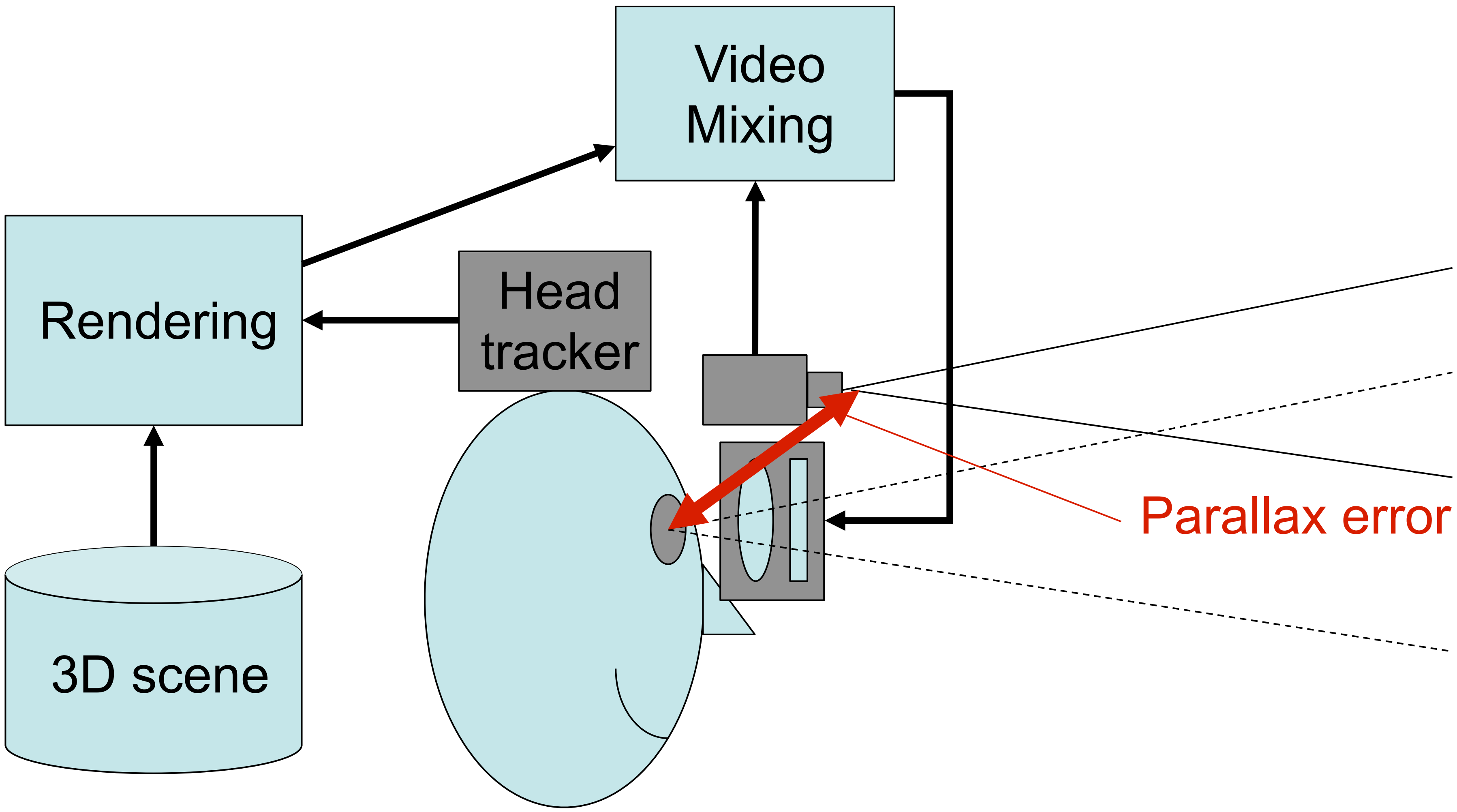
Creating VR with a HMD



Challenges with HMDs in VR

- Lag and jitter between head motion and motion of the 3D scene
  - Due to tracking → predictive tracking
  - Due to rendering → nowadays mostly irrelevant
- Leads to different motion cues from
  - Eye (delayed) and
  - Vestibular system (not delayed)
- Result: cyber sickness

Creating AR with video see-through HMDs



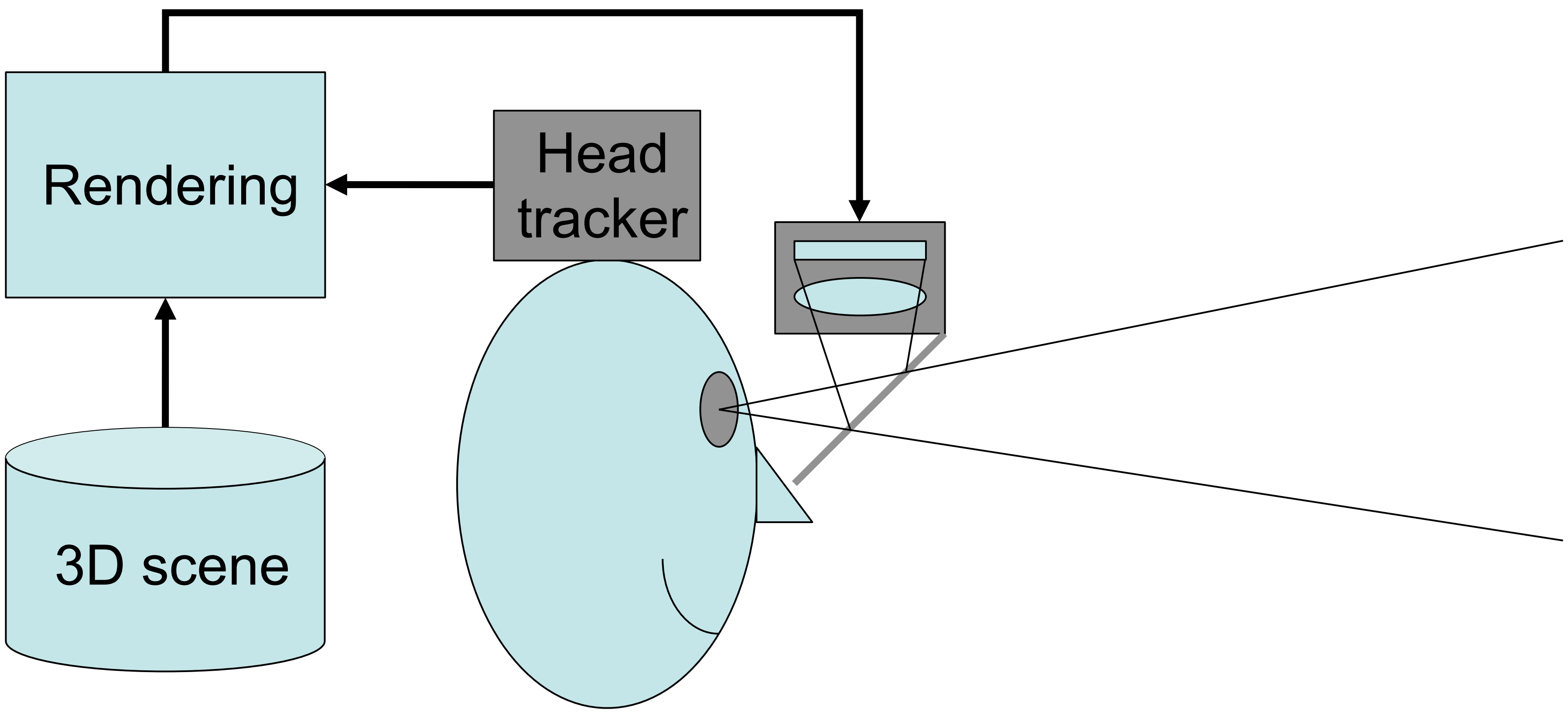
Advantages of video-based see-through

- Lag between physical and virtual image can be compensated
- Camera can be used for tracking as well
  - Physical image = raw tracking data
  - Perfect registration possible
- Video mixer can add or subtract light
  - Virtual objects can be drawn in black
  - Physical objects can be substituted
  - Virtual objects can be behind physical objects
- Just one image with a given focus distance

Challenges of video-based see-through

- Lag between physical and virtual image can be compensated
  - …by delaying the physical image
  - Leads back to the cyber sickness problem
- Parallax error can not be corrected electronically
  - Wrong stereo cues when used for stereo
- Richness of the world is lost
  - Video image just 0.5 megapixels
  - Resolution of human vision is much higher (>10x)

Creating AR with optical see-through HMDs

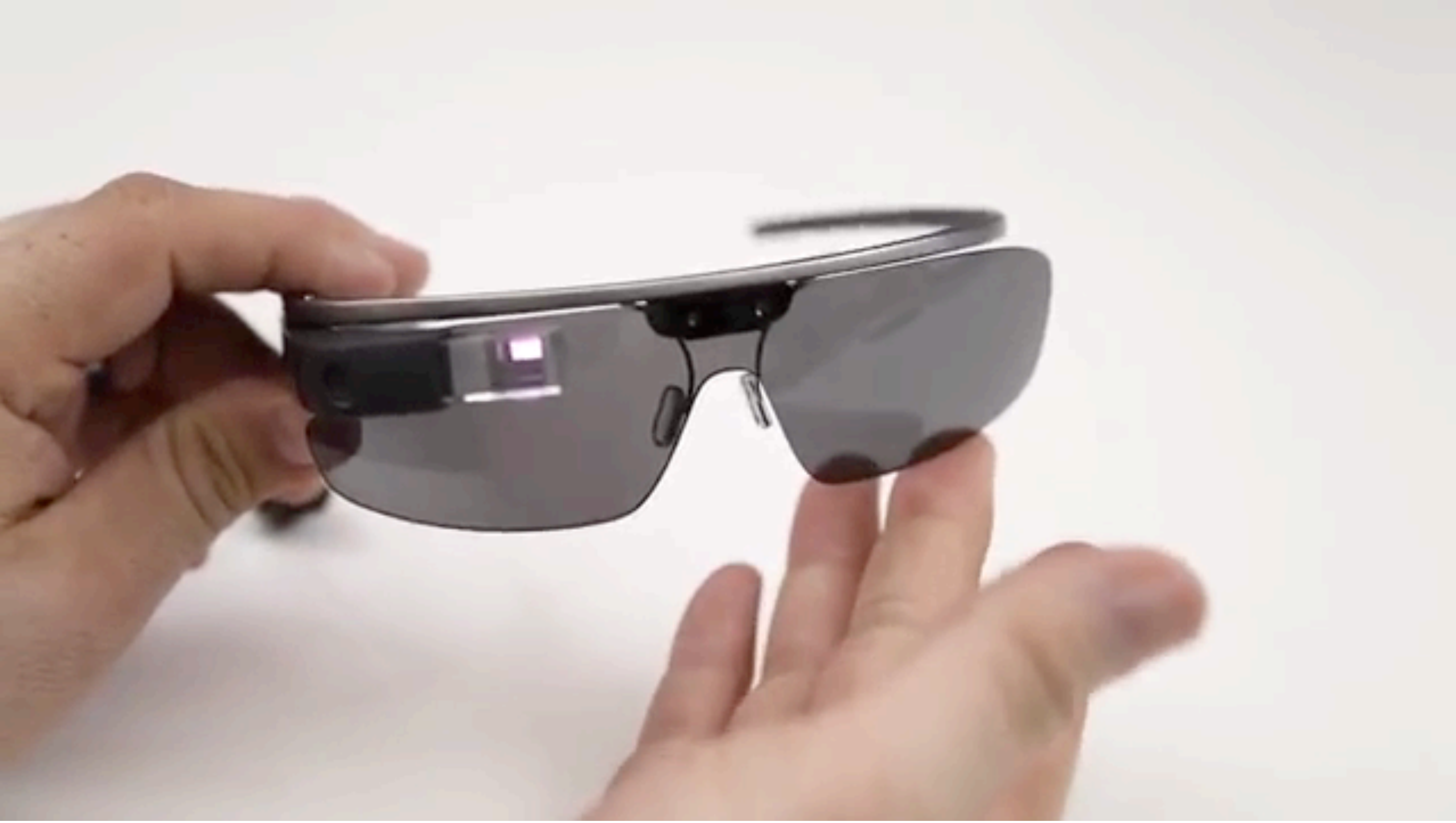


Advantages of optical see-through HMDs

- Preserve the richness of the world
  - Very high resolution of physical image
  - No lag between motion and phys. image
  - Physical objects can be focused at their correct distance

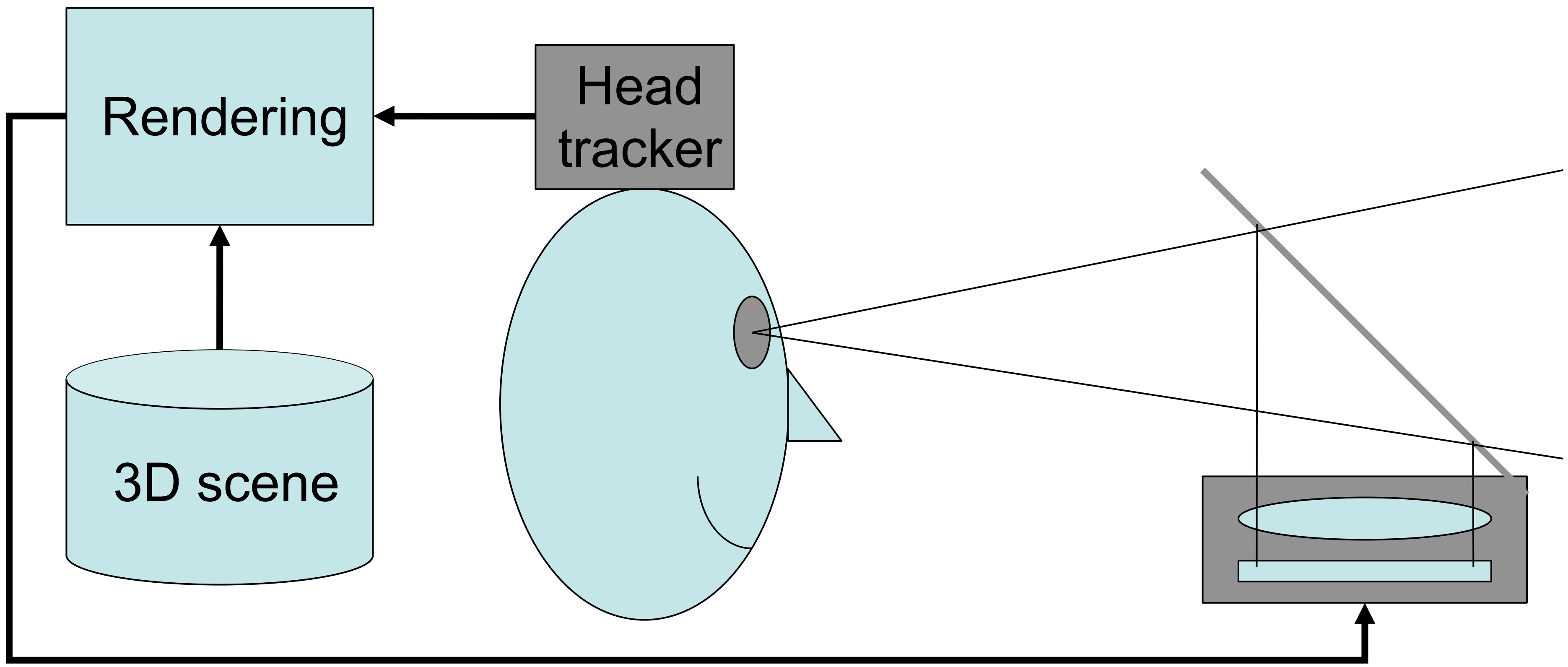
- Limitations:
  - can only add light, i.e. not cover things
  - lag of digital image very noticeable

Example: Google glass



http://www.youtube.com/watch?v=Ee5JzKbOAaw

Creating AR with Head-up Displays (HUDs)



Head-Up Display with 3D registration

- Currently mostly military use
- Fixed Display
- Very exact head or eye tracking needed
  - Easy for jet pilots
- High brightness and dynamics needed

HUD without 3D registration

- Optional Equipment in premium cars (image source: www.bmw.ch)
- easy: no tracking needed! -> not AR!

HUD app for iPhone

- can be bought from app store
- put iPhone under wind shield
- uses GPS and accell sensors to sense car motion
- can display speed, heading, ...

Tactile output

- Basics about tactile perception
- Vibrotactile output: actuators
- Example: Tesla Touch
- Example: Mudpad

Haptics: a word on Terminology

- Definition: Sense and/or motor activity based in the skin, muscles, joints, and tendons
- Two parts
  - Kinaesthesis: Sense and motor activity based in the muscles, joints, and tendons
  - Touch: Sense based on receptors in the skin
    - Thermal: sense of heat & cold
    - Tactile: mechanical stimulation of the skin
    - Pain: nociceptors, det. physical damage

http://images.inmagine.com/img/aspireimages/drk004/drk004802.jpg

Why Haptic Interaction?

- Has benefits over visual display
  - Eyes-free
  - no need to look
- Has benefits over audio display
  - Personal not public
  - Only the receiver knows there has been a message
- People have a tactile display with them all the time
  - Mobile phone

Tactile Technologies

- Vibration motor with asymmetric weight
  - Eccentricity induces vibrations
  - Speed controls vibration frequency
  - Precision limited (several ms startup time)

PMD 310 vibration motor

Tactaid VBW32 actuator

Phone vibration motor

C2 Tactor actuator

Actuators now in other kinds of devices

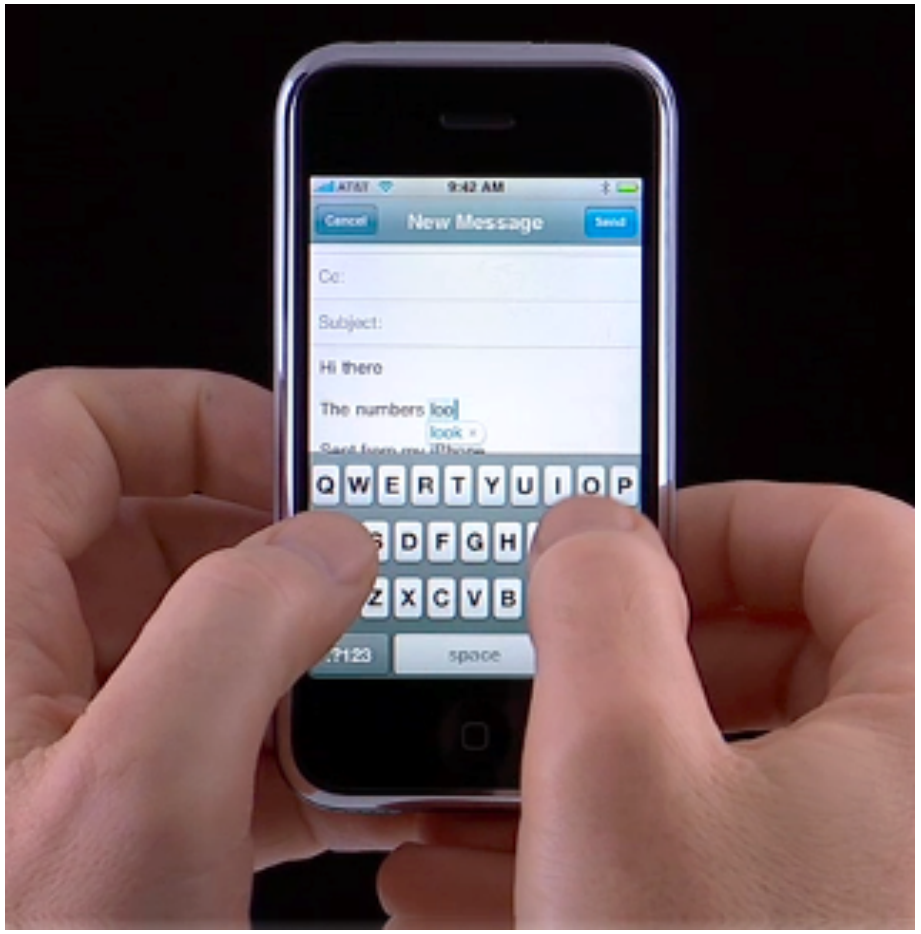
3 cell pin array

Example: Tactile Button Feedback

- Touchscreen phones have no tactile feedback for buttons
  – More errors typing text and numbers

- Performance comparison of physical buttons, touchscreen, and touchscreen+tactile
  – In lab and on subway

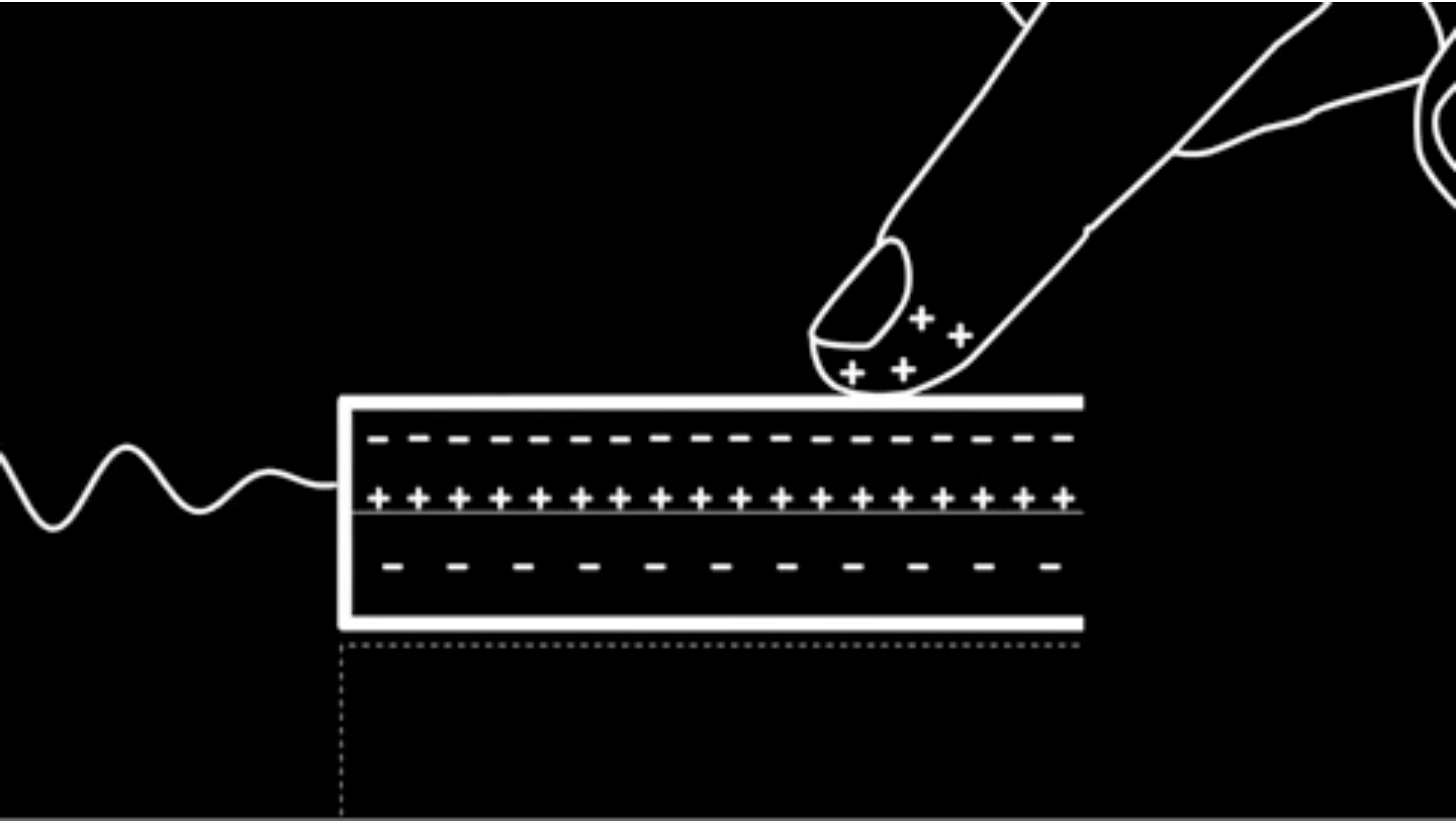
- Touchscreen+tactile as good as physical buttons
  – Touchscreen alone was poor



Brewster, Chohan, Brown: Tactile feedback for mobile interactions. CHI '07.

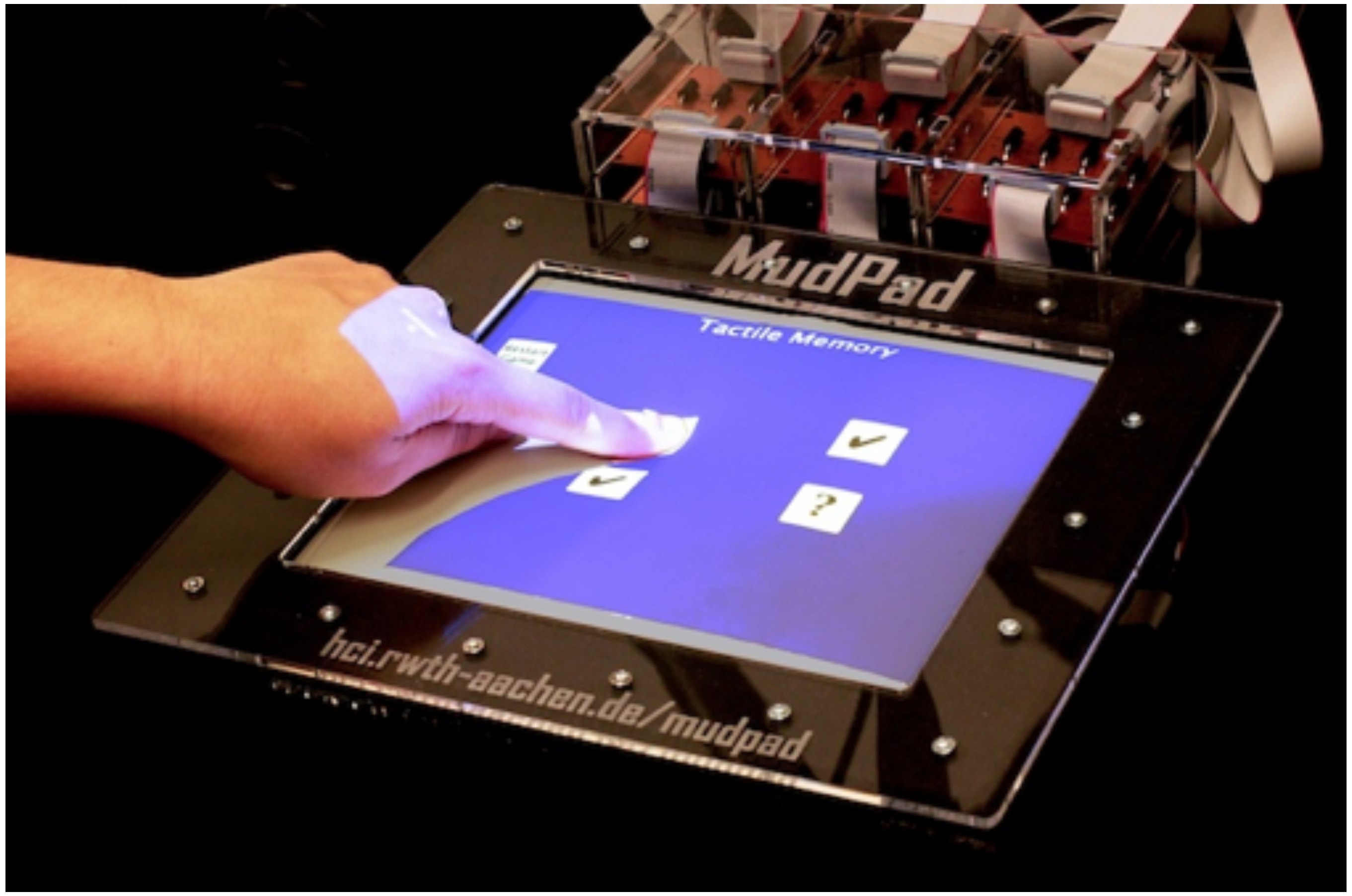
http://www.youtube.com/watch?v=3I3MDNZk-3I

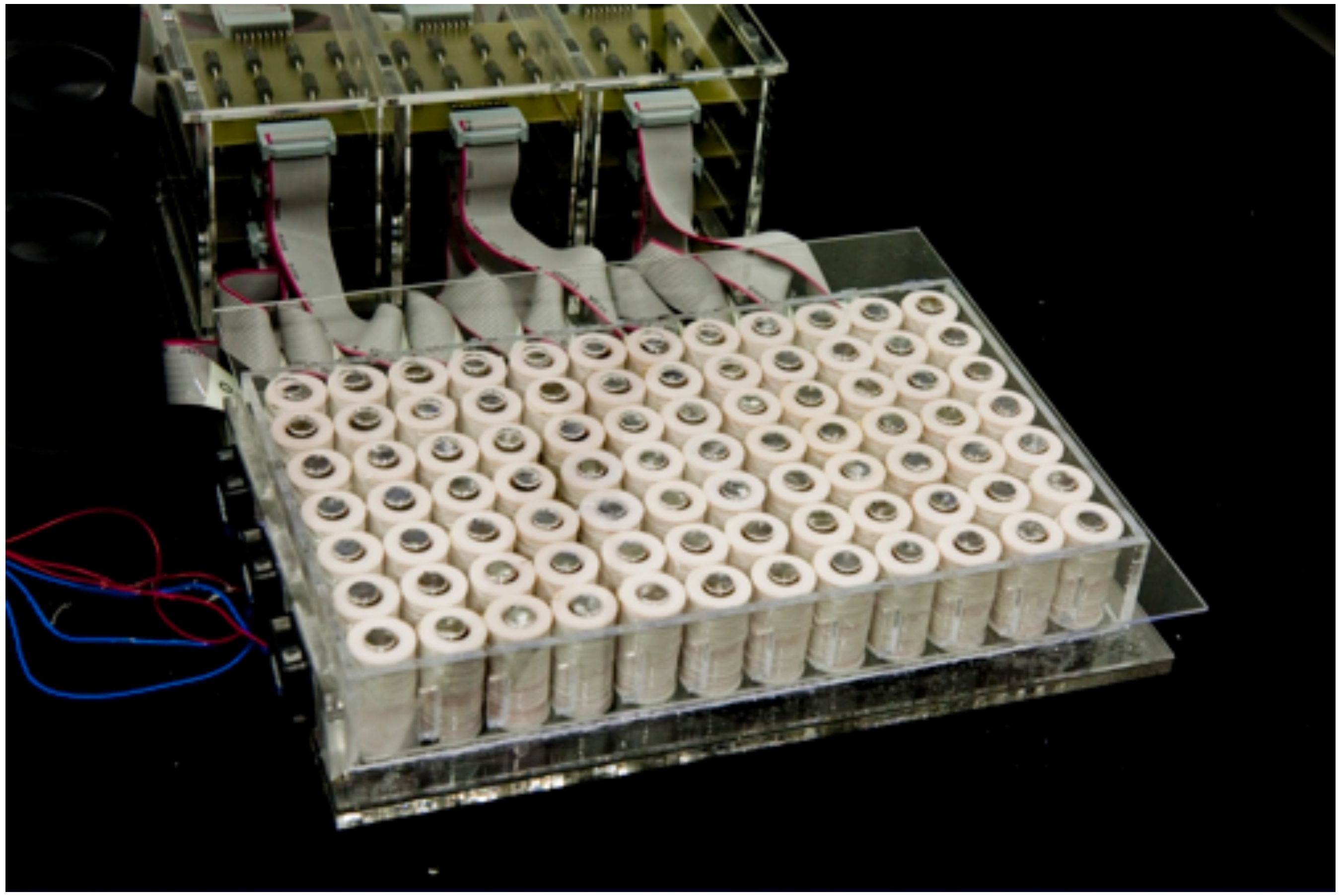
Example: TeslaTouch (Bau et al. UIST 2010)



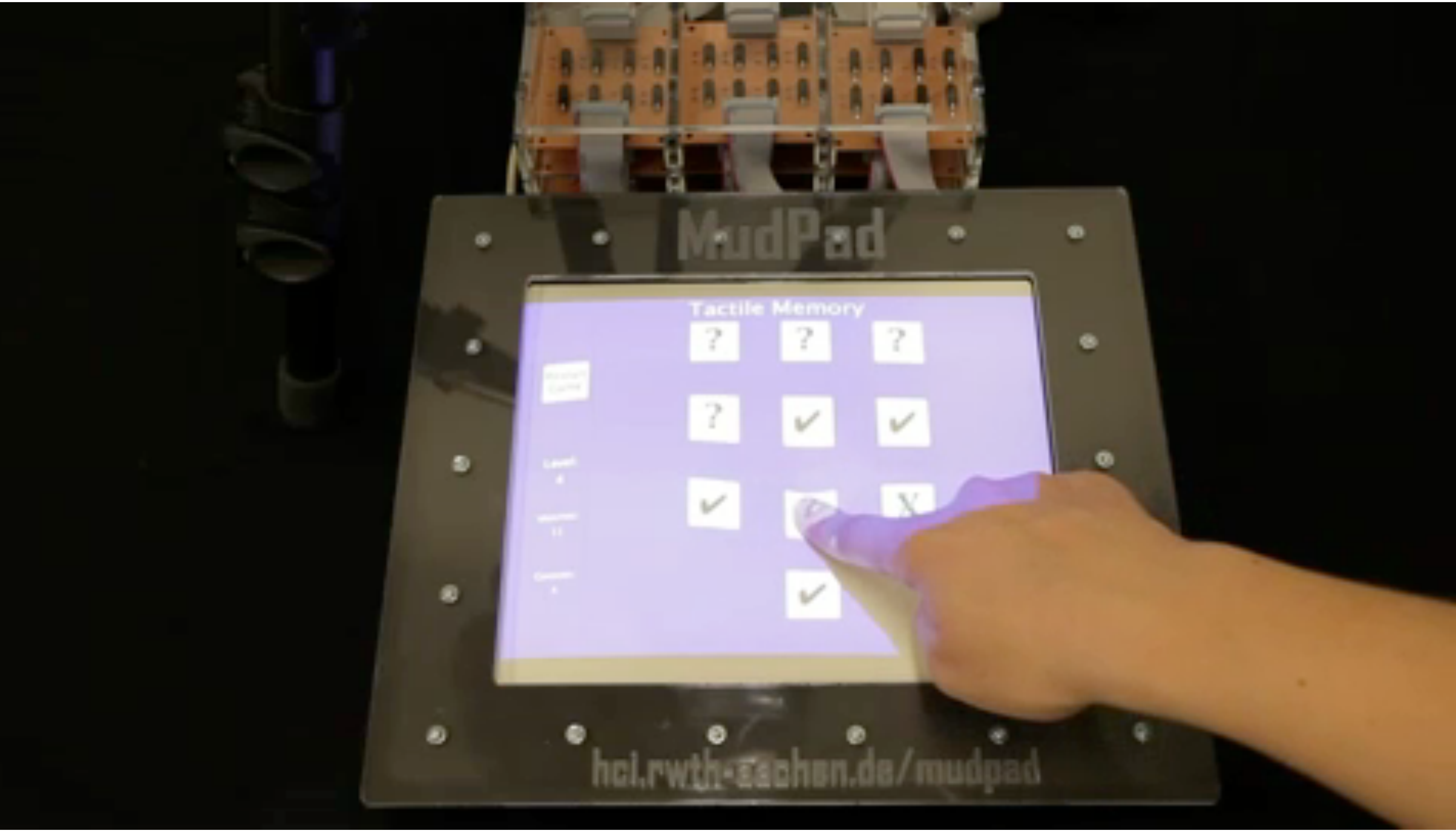
Example: Mudpad (Y. Jansen, CHI 2010)

- http://hci.rwth-aachen.de/mudpad
- overlay containing a ferromagnetic fluid
  - normally is fluid
  - turns stiff in magnetic field
- put electromagnets behind the screen
  - can control stiffness of the liquid in different locations





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



Take-home messages

- Visual output is not only possible on screens
  - HMDs
  - projectors (not even mentioned ;-)

- Think about other output media
  - haptic output (basics are available in every phone!)
  - acoustic output (not even discussed...)