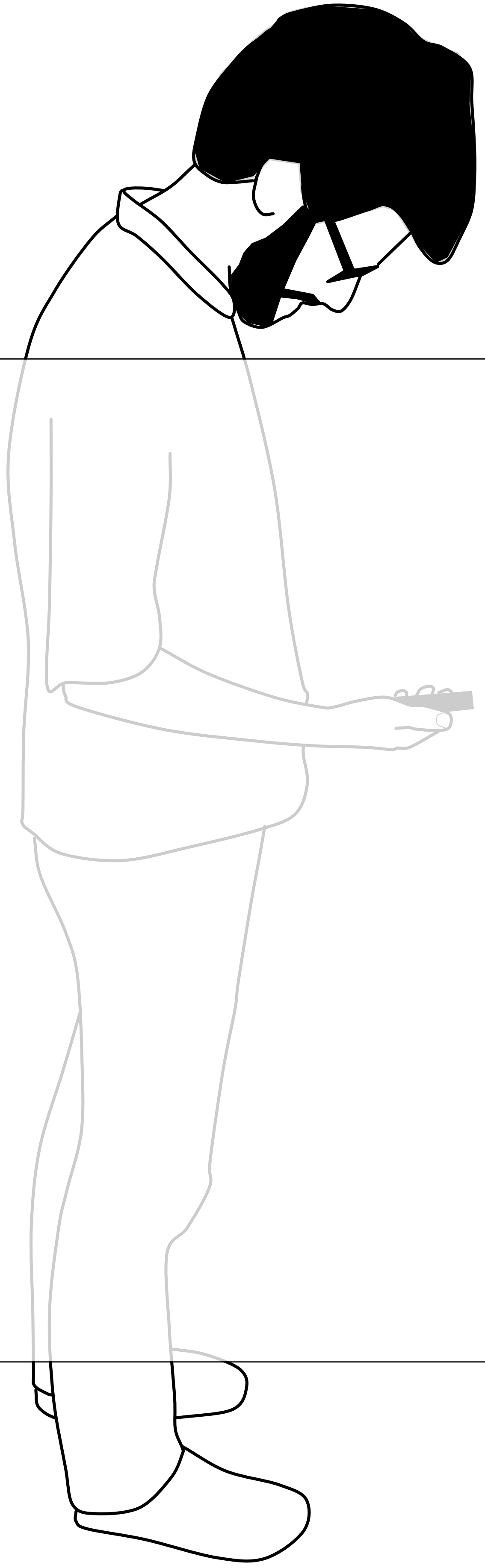
Mobile Technologies



context and task

theory

interaction techniques

in/output technologies

Repetition

- Precision input techniques
  - Offset Cursor / Shift
  - Tap Tap / MagStick
  - back-of device
- Enlarge input vocabulary
  - MicroRolls
  - BezelSwipe
- Forgot last week (after XPaand):
  - Bend gestures

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.

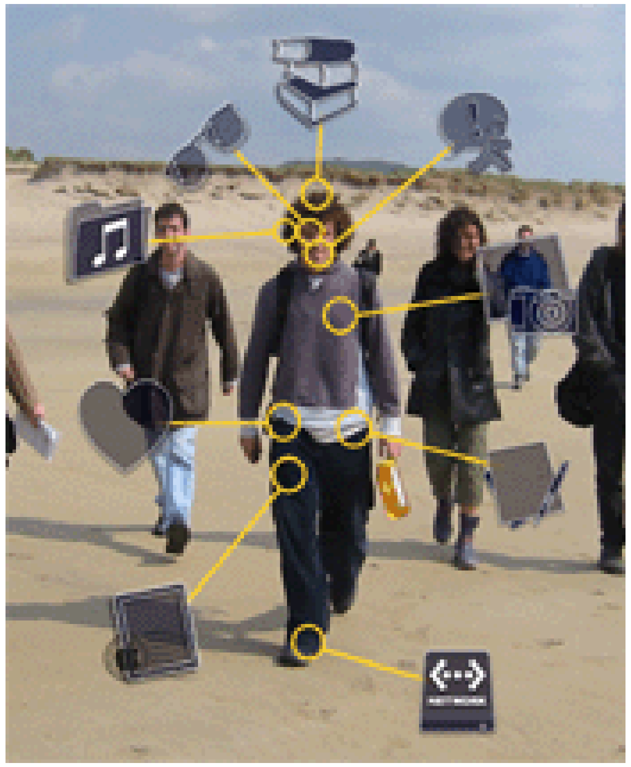
Extending Input Vocabulary

- ...by using the space around the body and the screen
  - BodySpace
  - Virtual Shelf
  - Around-Body Interaction
  - SideSight
  - Air+Touch

Literature: Cao, x. et al.:

BodySpace

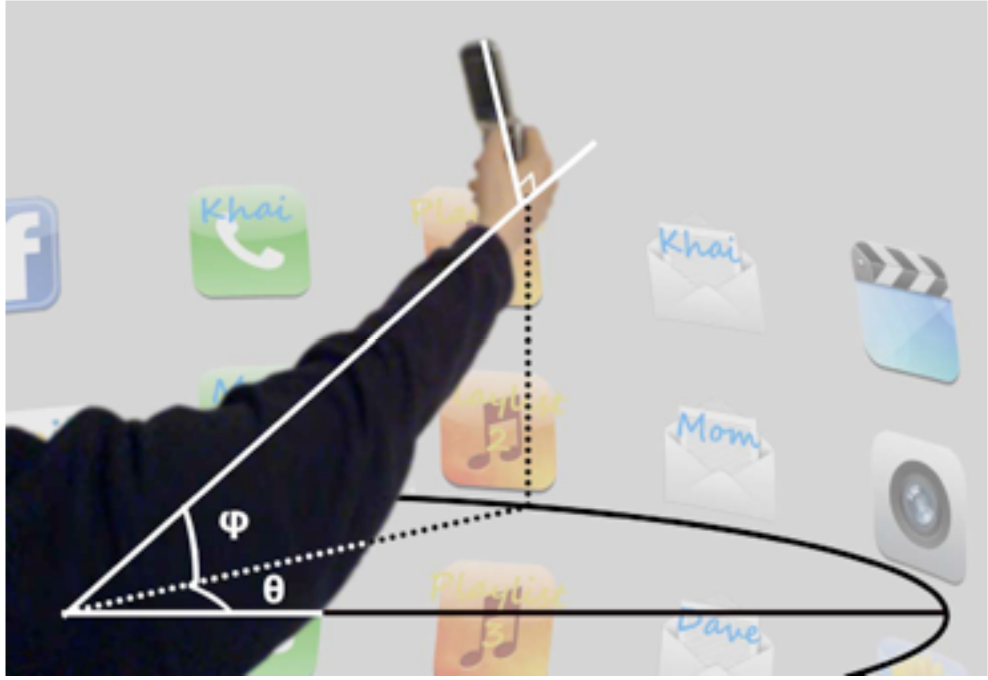
- uses inertial sensing and basic pattern recognition to allow gestural control
- control by placing the device at different body parts
  - magnetometer
  - accelerometer
  - gyroscope

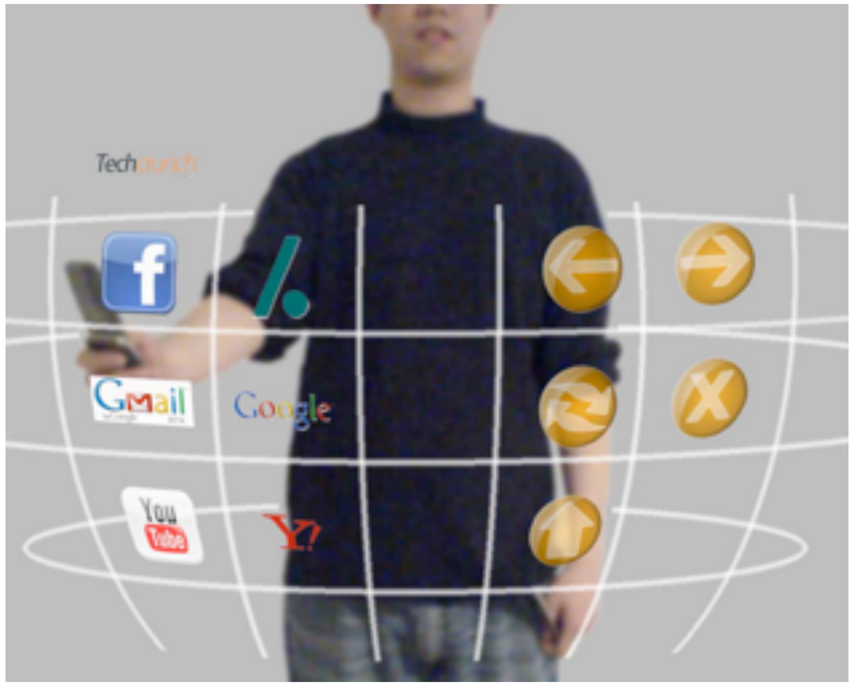


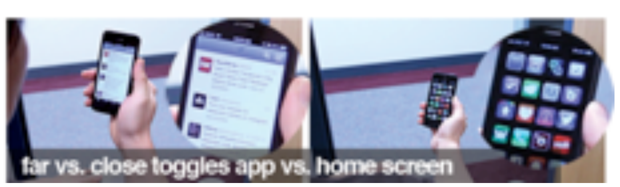
Literature: Strachan, S. et al.: BodySpace: Inferring body pose for natural control of a music player , CHI'07

Virtual Shelf

- access programmable shortcuts on mobile phone by pointing to a body-relative location around the body
  - especially interesting for visual impaired users
- shortcuts are arranged in an imaginary sphere.

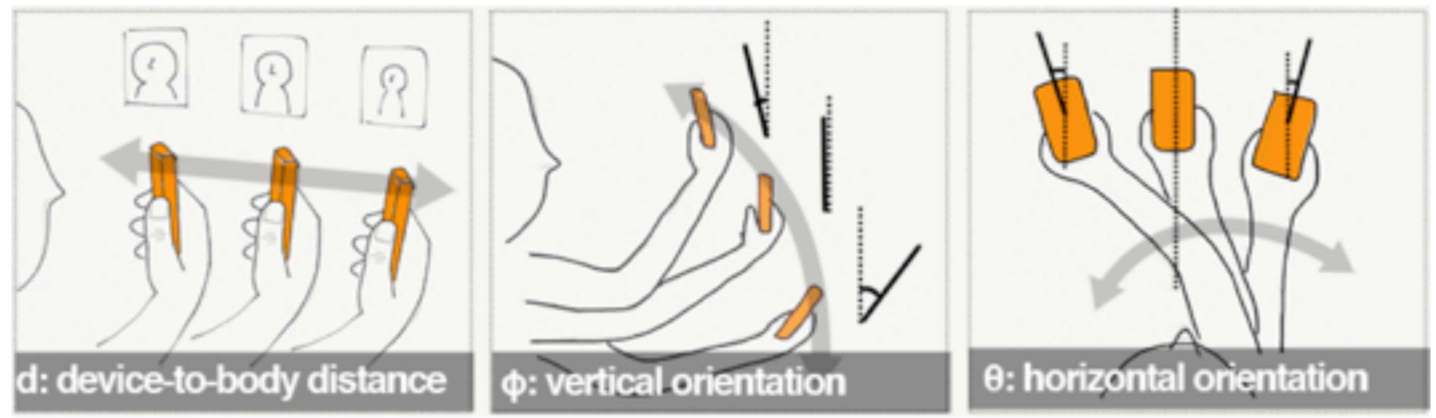






Around-body interaction

- phone's 3D location tracking: front camera, accelerometer and inertia measurement units

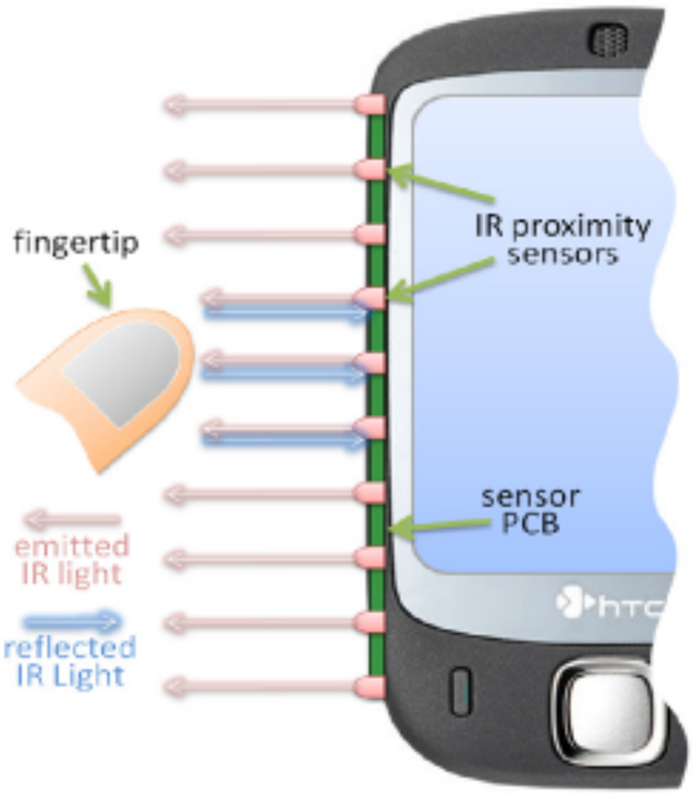


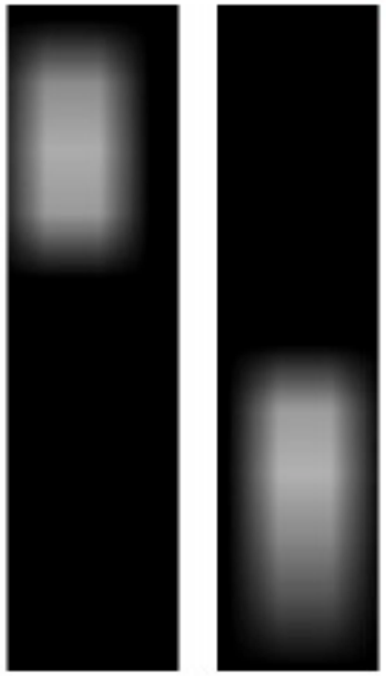
- three level of around body interaction:
  – canvas: expand interaction area beyond the screen boundaries (e.g. place UI element in space, which is larger than screen)
  – modal: switch between different applications or modes within a given application.
  – context: device's spatial relationship to the user

Literature: Chen, x. et al.: Around-Body Interaction: Sensing & Interaction Techniques for proprioception-enhanced input with mobile devices, MobileHCI'14

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





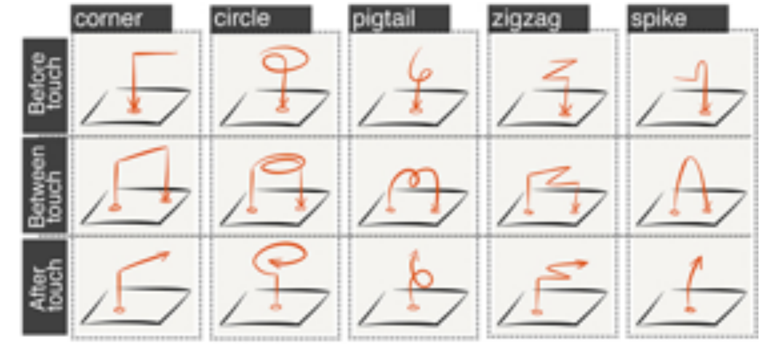
Left and right “depth” images

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.

Air + Touch



Literature: Chen, x. et al.: Air+Touch: Interweaving Touch & In-Air Gestures, UIST'14

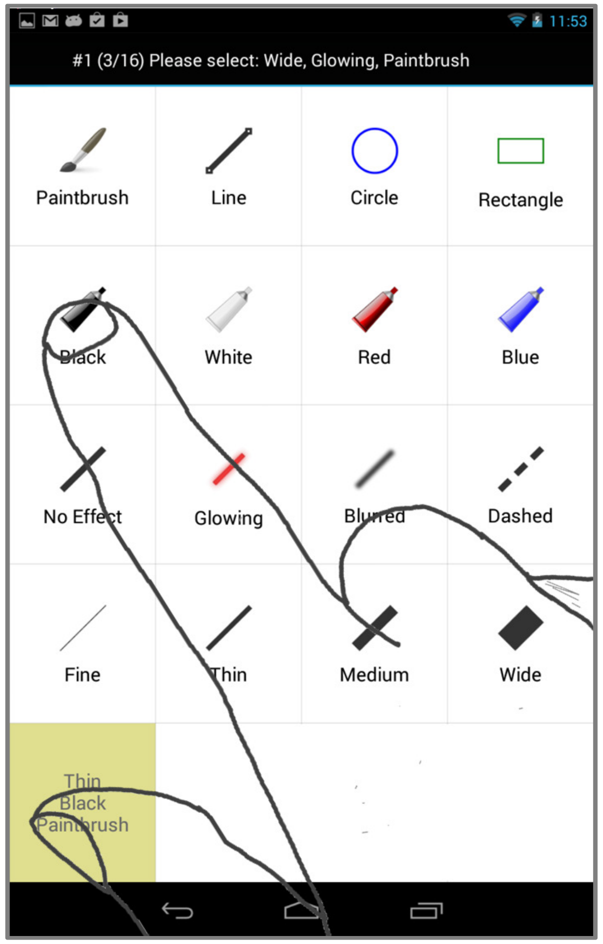
Menu Techniques

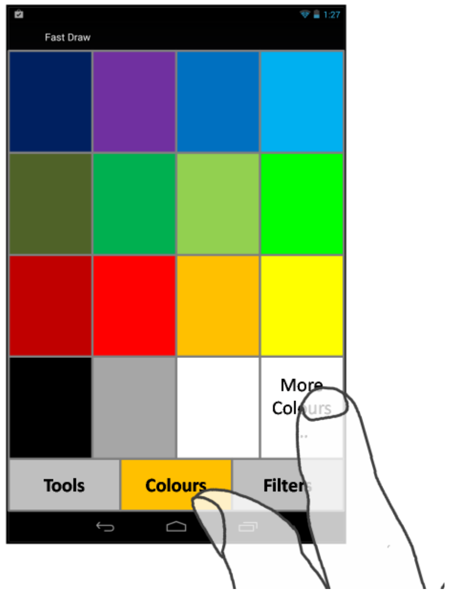
- FastTap
- BezelTap
- Augmented Letters
- Two-handed Marking Menus

Literature: Cao, x. et al.:

FastTap: Command selection on tablets

- rapid command execution technique
- modal access to a grid of command buttons (quasimode)
- selection mechanism identical for novices and experts
- takes advantage of spatial memory to teach command shortcuts.

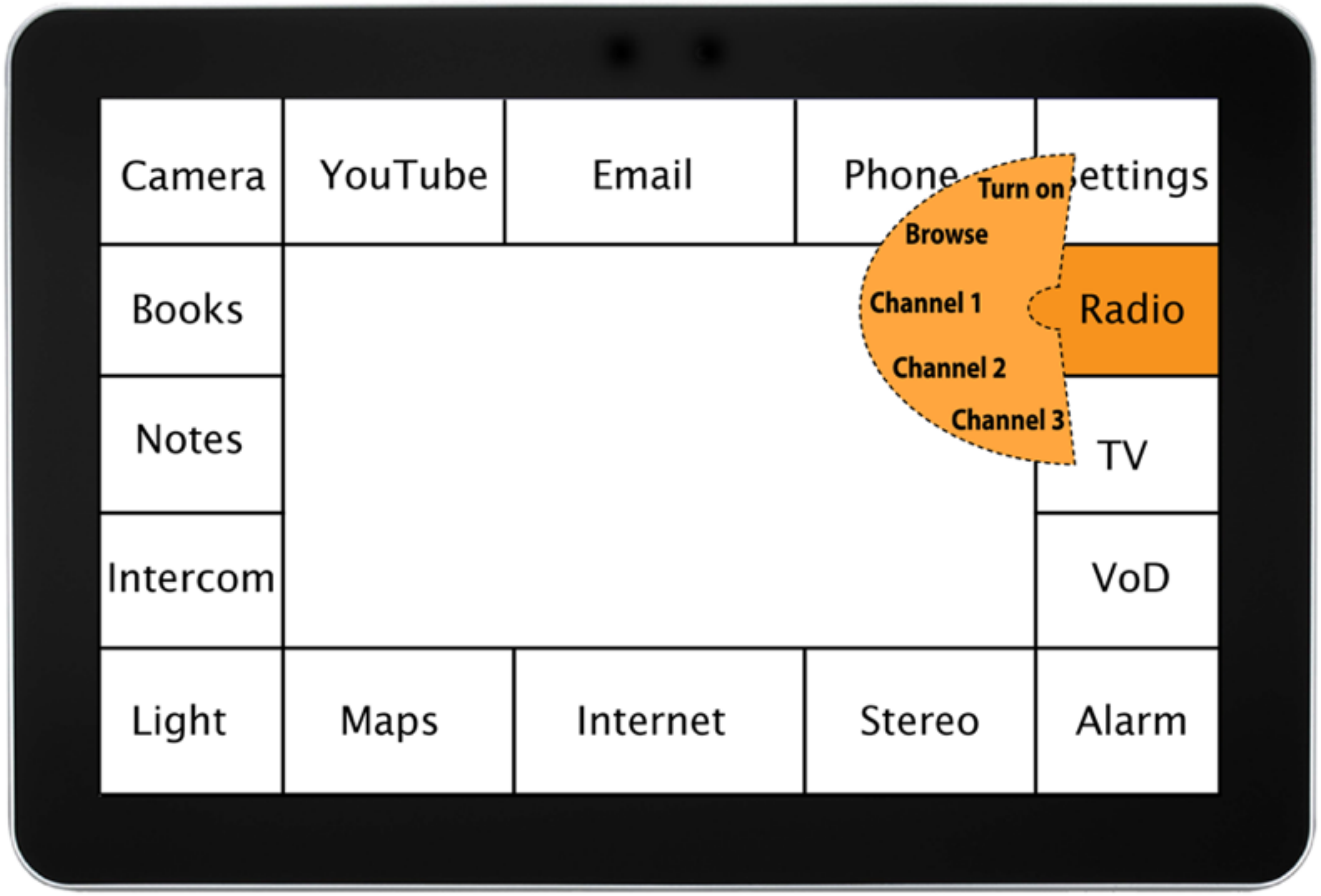




Literature: Gutwin, C. et al.: Faster Command Selection on Tablets with FastTap, CHI'14

Bezel Tap

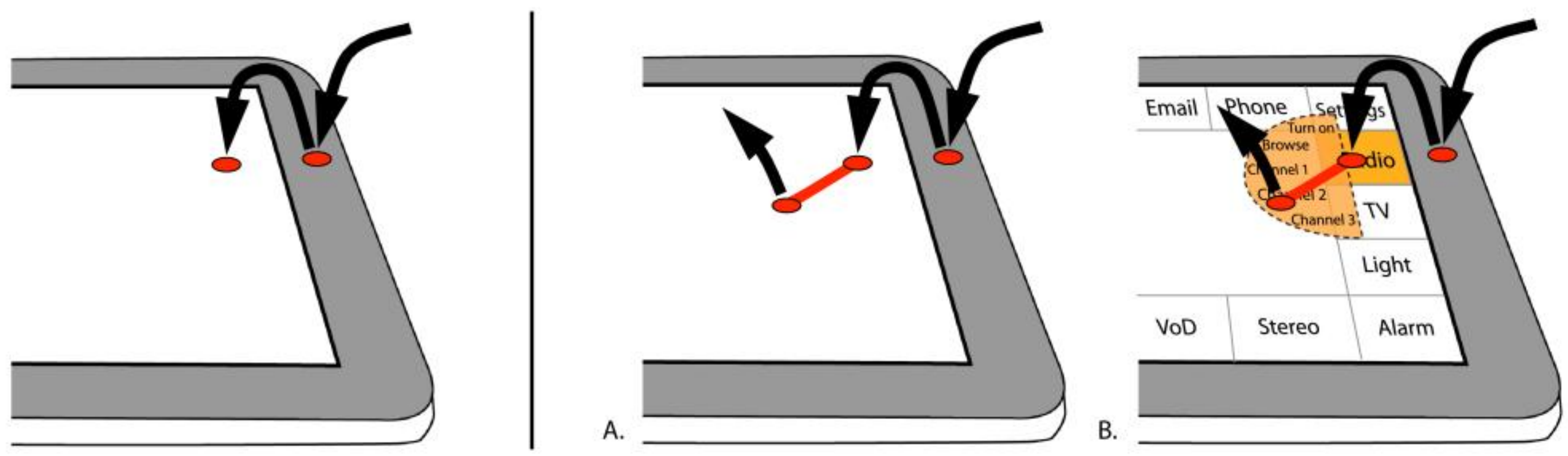
- usually: wake up tablet + unlock + navigate to command
- immediate interaction on handheld tablets
  - bezel tap + screen contact



Literature: Serrano, M. Bezel-Tap Gestures: Quick Activation of Commands from Sleep Mode on Tablets, CHI'13

Bezel Tap

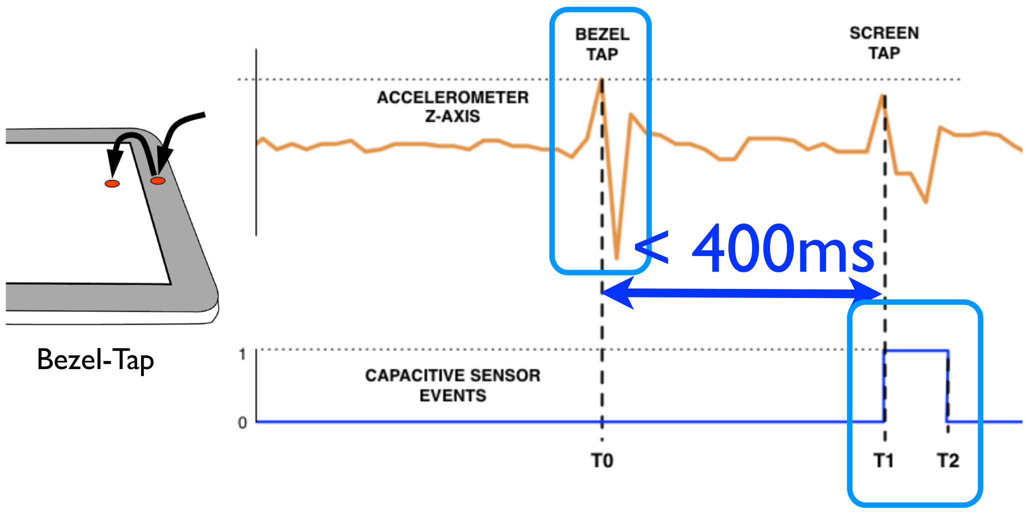
- feedforward : designed to transition from novice to expert user.



Literature: Serrano, M. Bezel-Tap Gestures: Quick Activation of Commands from Sleep Mode on Tablets, CHI'13

Bezel Tap Technique

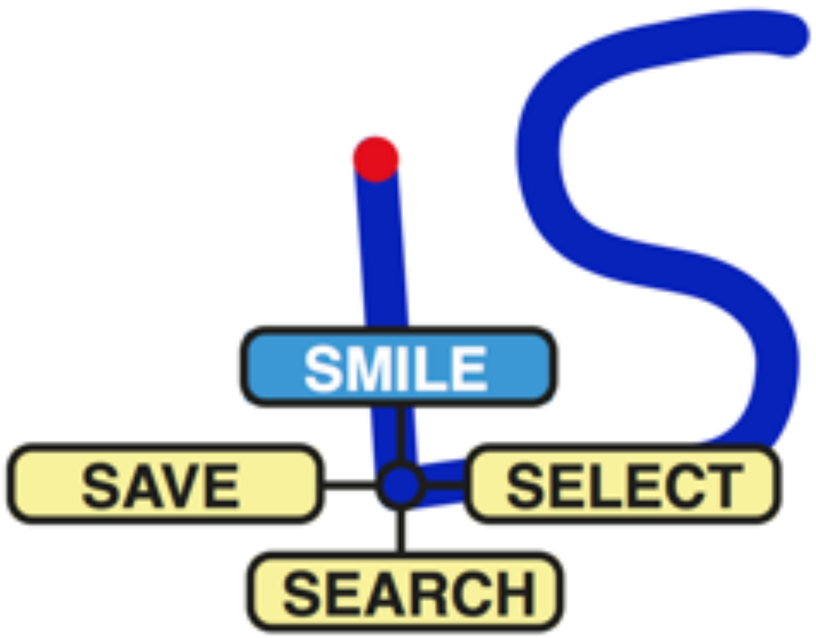
- Field study result:
  - no cross talk with everyday activities.



Literature: Serrano, M. Bezel-Tap Gestures: Quick Activation of Commands from Sleep Mode on Tablets, CHI'13

Augmented Letters

- mnemonic association to command names.
  - used the $1 recognizer for the unistroke letter.
- flattening command hierarchy
- tail to discriminate between commands starting with the same name.
- seamless transition between novice and expert.



Literature: Roy, Q. et al.: Augmented Letters: Mnemonic Gesture-Base Shortcuts, CHI'13

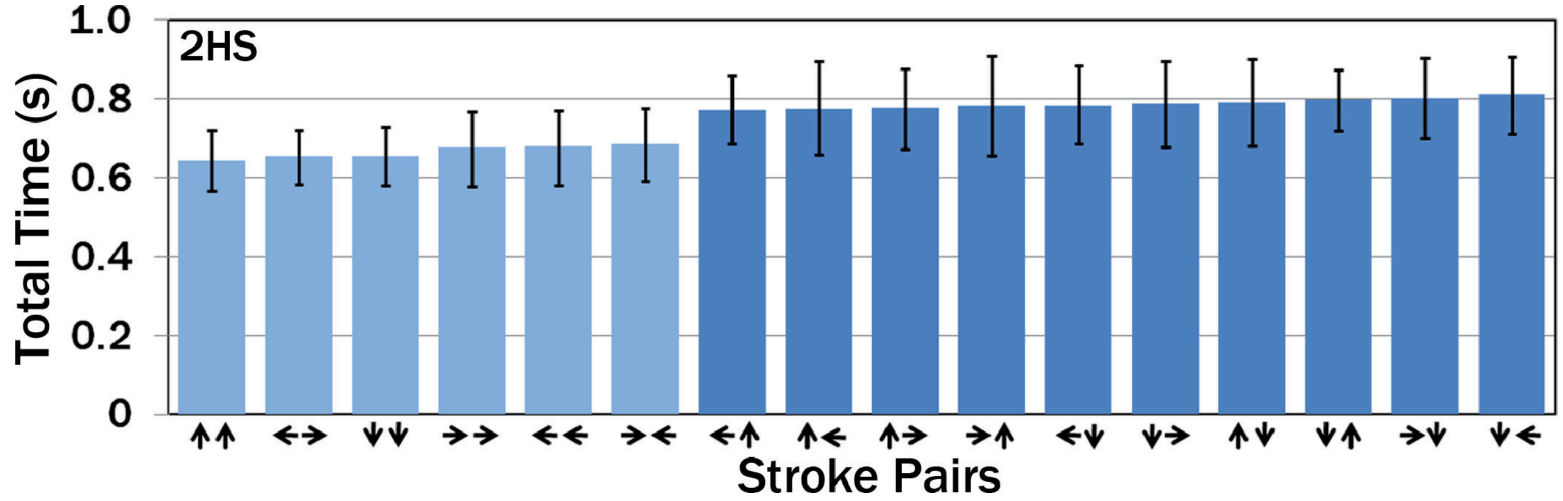
Two-handed Marking Menus

- Two-handed simultaneous: draw two strokes at the same time.
- Two-handed Ordered: alternate the hand used to draw each stroke.

Literature: Kin, K. et al.: Two-handed marking menus for multitouch devices, ToCHI'11

one performance finding

- two-handed simultaneous: symmetric or similar direction pairs perform faster



- does that result remind you of something?

Menu Techniques

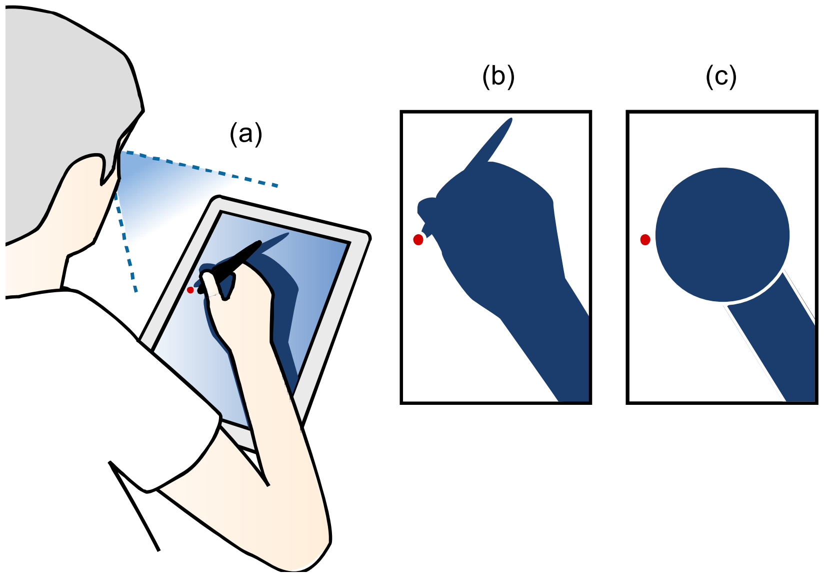
- FastTap
- BezelTap
- Augmented Letters
- Two-handed Marking Menus

- Occlusion-aware interfaces

Literature: Cao, x. et al.:

Occlusion-aware interfaces

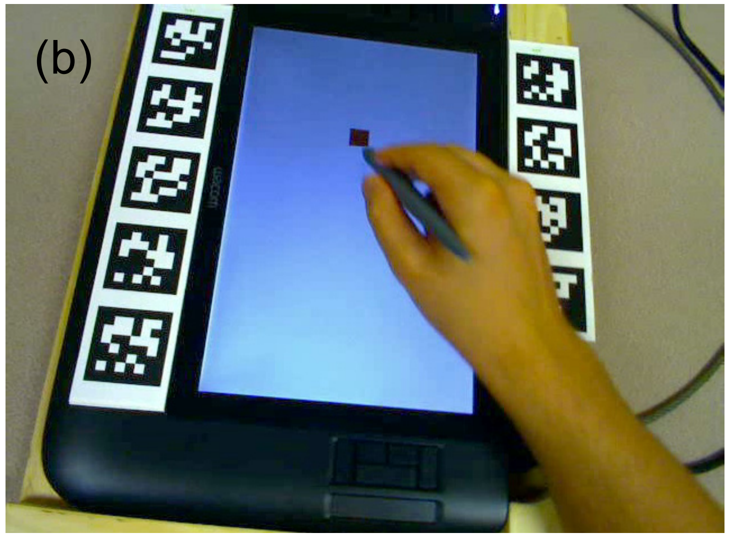
- problem: system generated messages may be positioned under the user's hand.



Literature: Vogel, D. et al. (2009). *Hand Occlusion with Tablet-sized Direct Pen Input,* CHI'09

Occlusion-aware interfaces

- one approach: experimental study using a novel combination of video capture, augmented reality marker tracking, and image processing techniques to capture *occlusion silhouettes*.



Literature: Vogel, D. et al. (2009). *Hand Occlusion with Tablet-sized Direct Pen Input,* CHI'09

Mobile

context and task

theory

interaction techniques

small screens

touch precision

extend input vocabulary

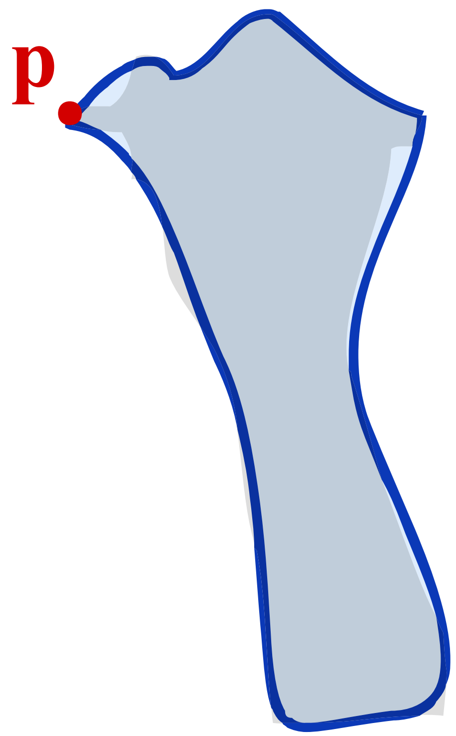
menu techniques

occlusion

multi-device

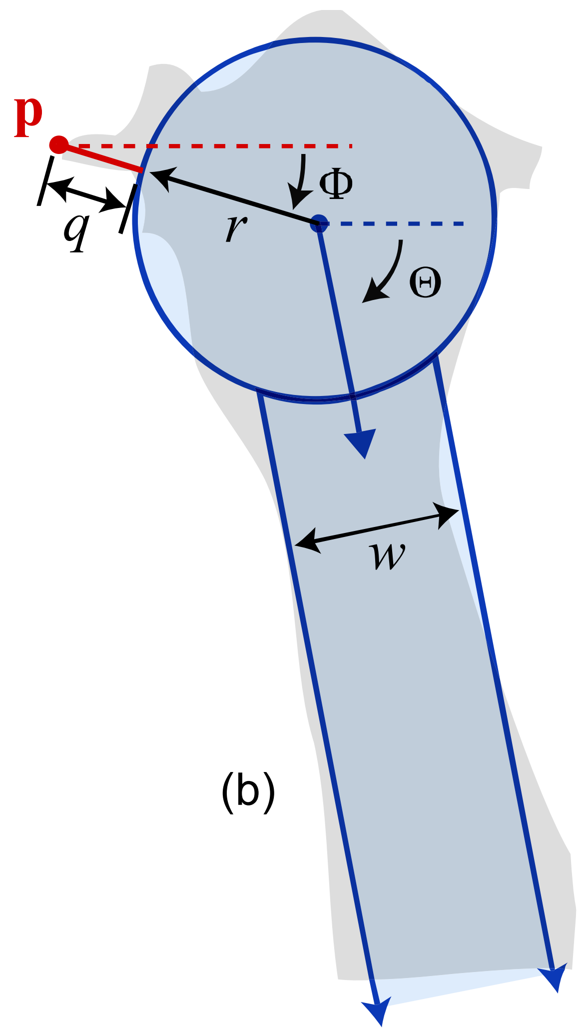
in/output

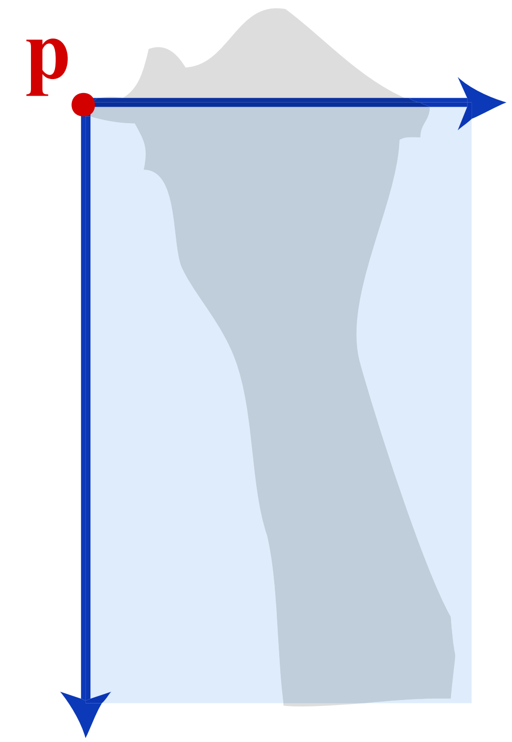
Scalable Circle and Pivoting Rectangle Model



(a)

Bézier spline

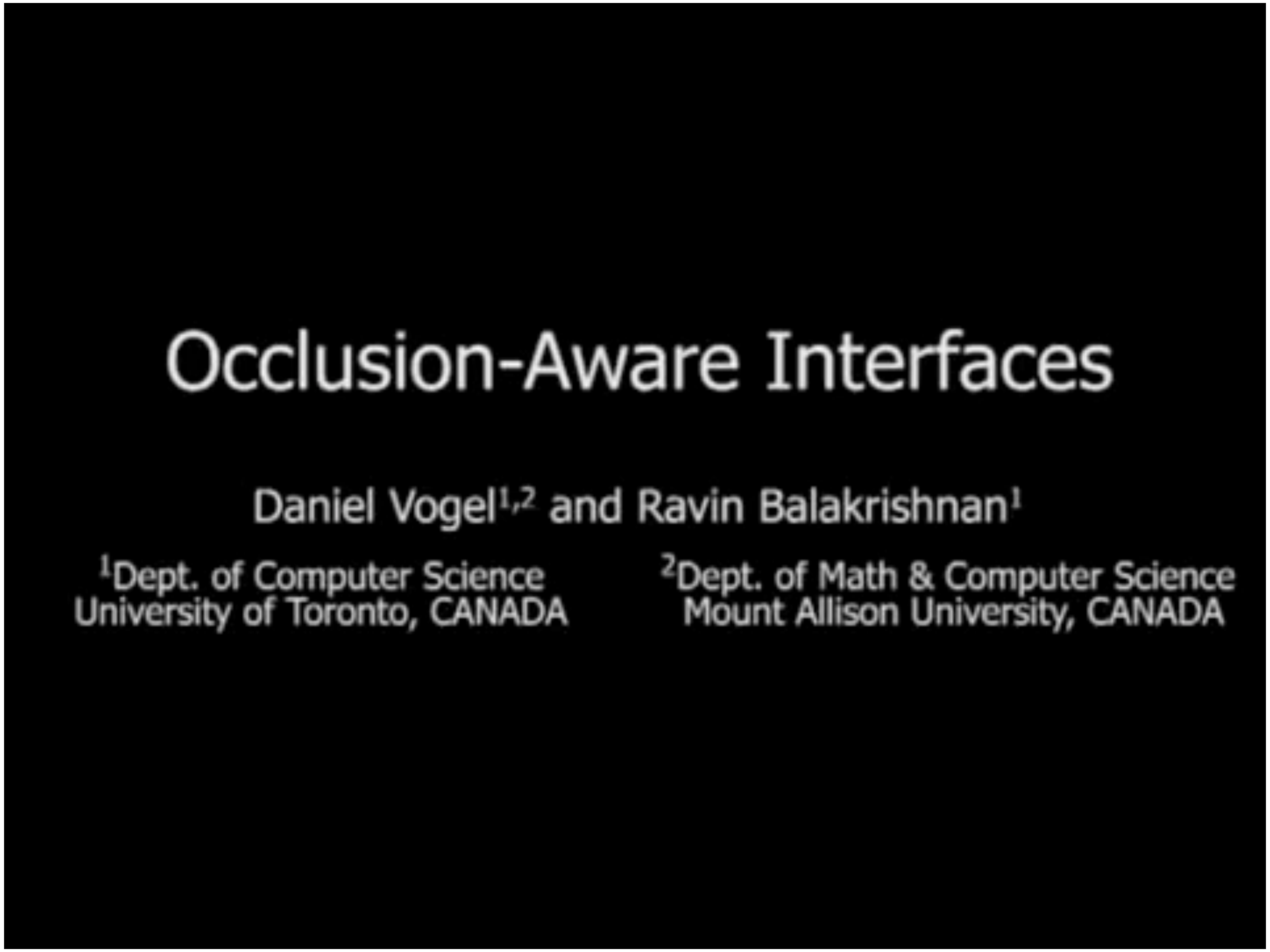




(c)

bounding rectangle model

Occlusion-aware techniques

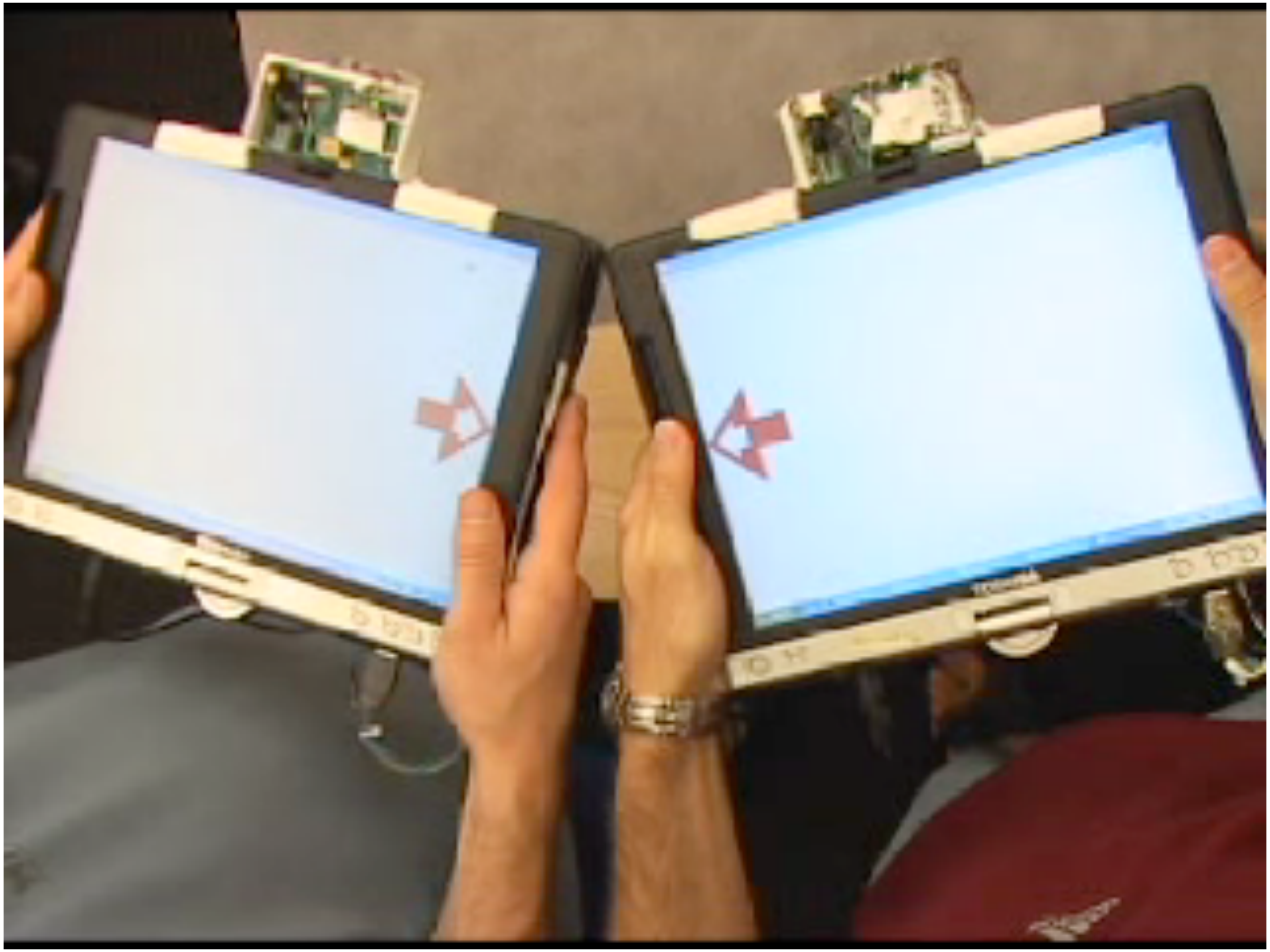


http://www.youtube.com/watch?v=4sOmlhEJ2ac

Interaction between mobile & other screens

- Bumping & stitching
- Pick & drop
- Augmented surfaces
- Touch projector

Bumping



- Hinckley, K., Bumping Objects Together as a Semantically Rich Way of Forming Connections between Ubiquitous Devices. UbiComp 2003
- http://kenhinckley.wordpress.com/?s=bump

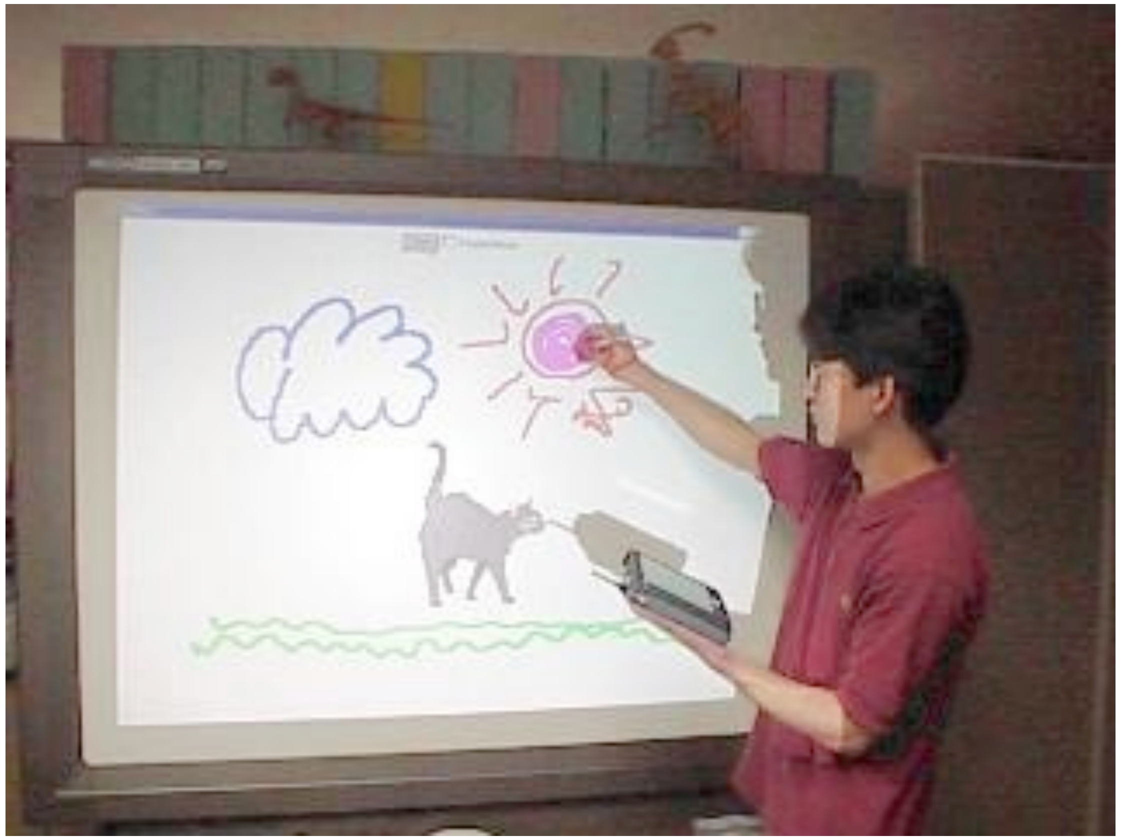
Stitching

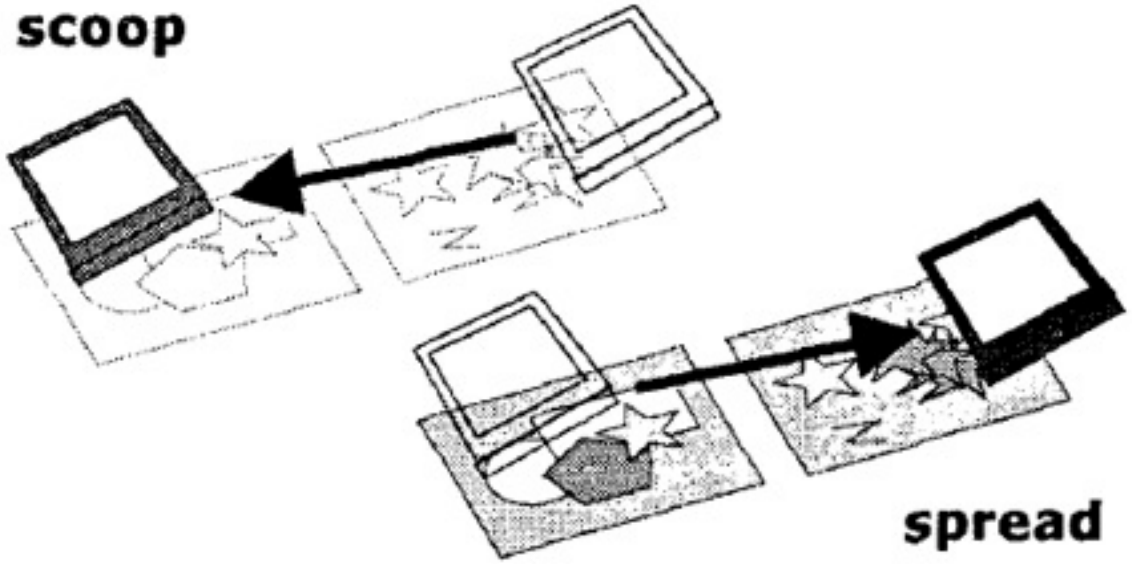
- Hinckley, K., Ramos, G., Guimbretiere, F., Baudisch, P., and Smith, M. Stitching: pen gestures that span multiple displays. In Proc. AVI 2004
- http://kenhinckley.wordpress.com/?s=stitch

"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

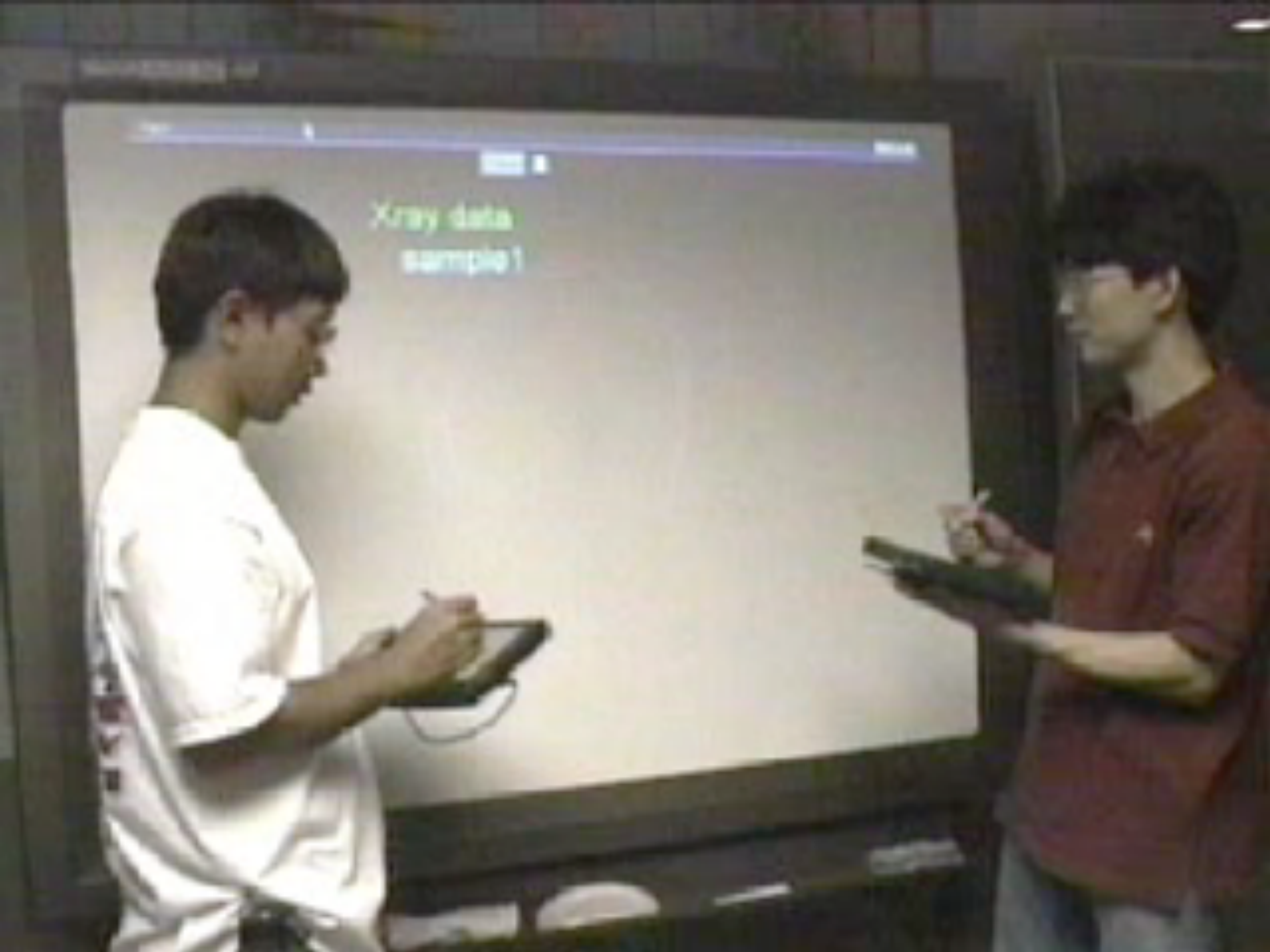
- Hyper Palette
  - PDA as interaction device for table
  - Electromagnetic 6D trackers
  - Scoop-and-spread: tilting plus movement





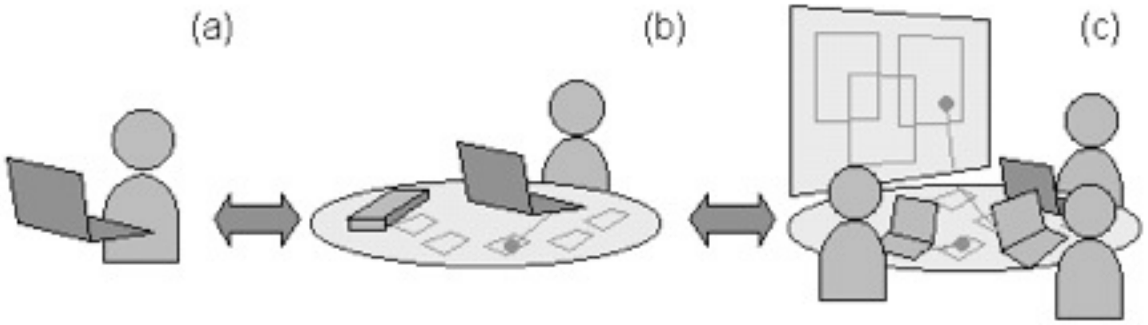
Rekimoto. Pick-and-drop: a direct manipulation technique for multiple computer environments. UIST '97.

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

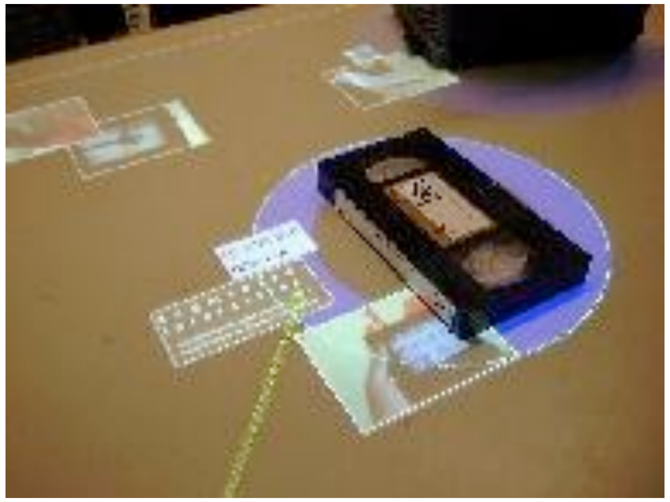

Xray data
sample1

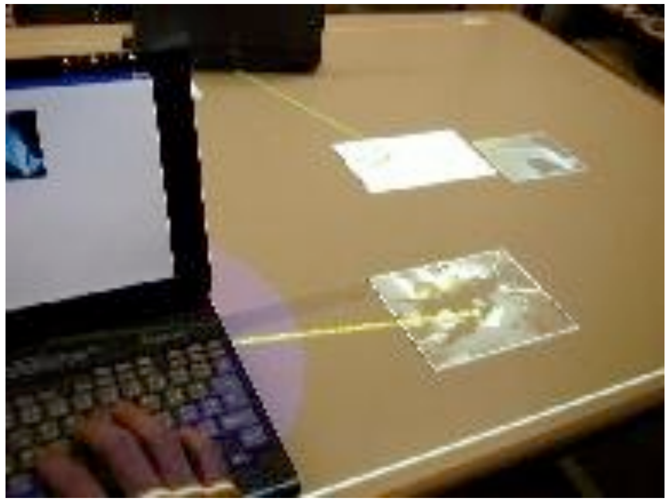
Augmented Surfaces

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

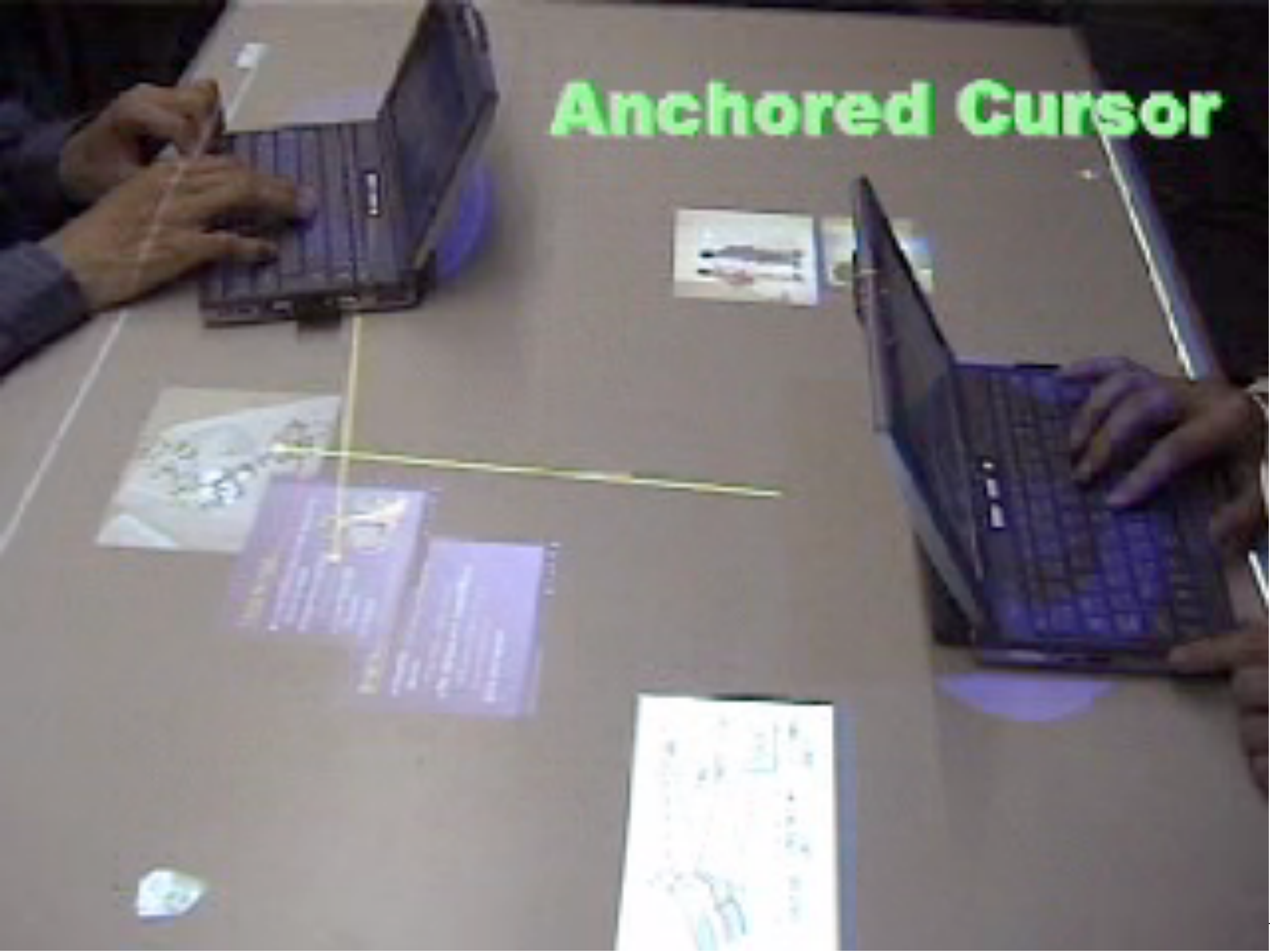


- Hyperdragging
  - Move information across boundary of devices and surfaces





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


Anchored Cursor

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

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

Touch Projector

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

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

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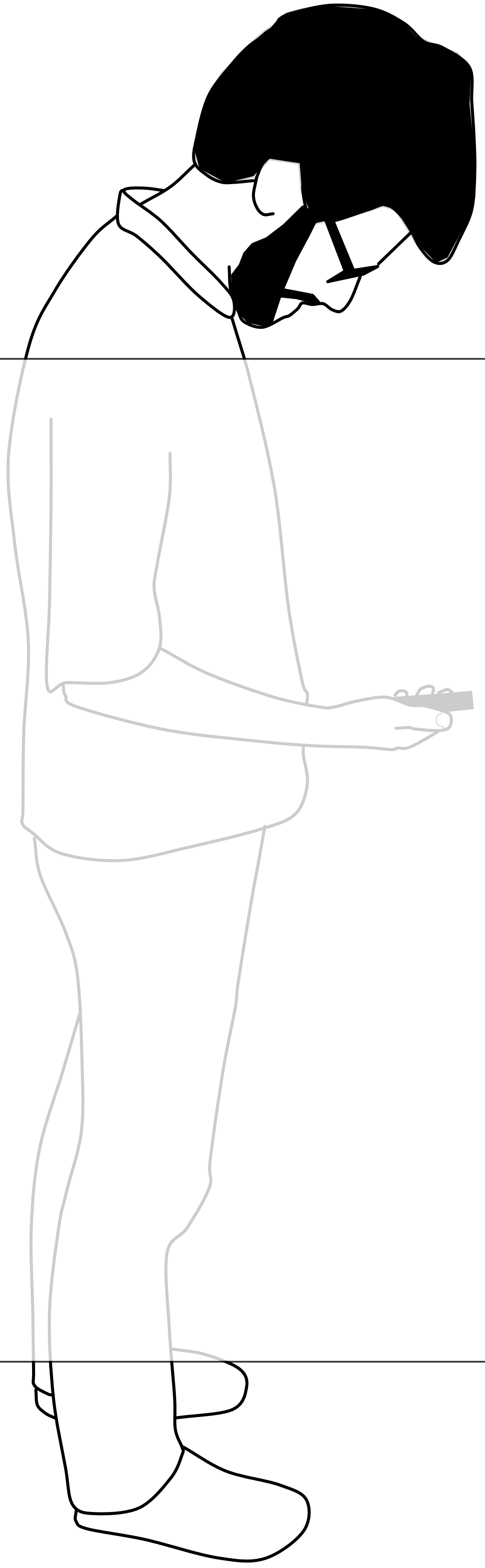
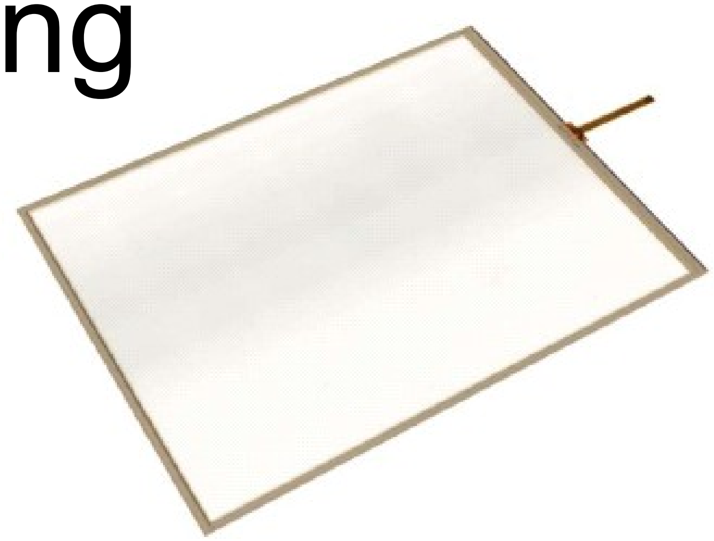
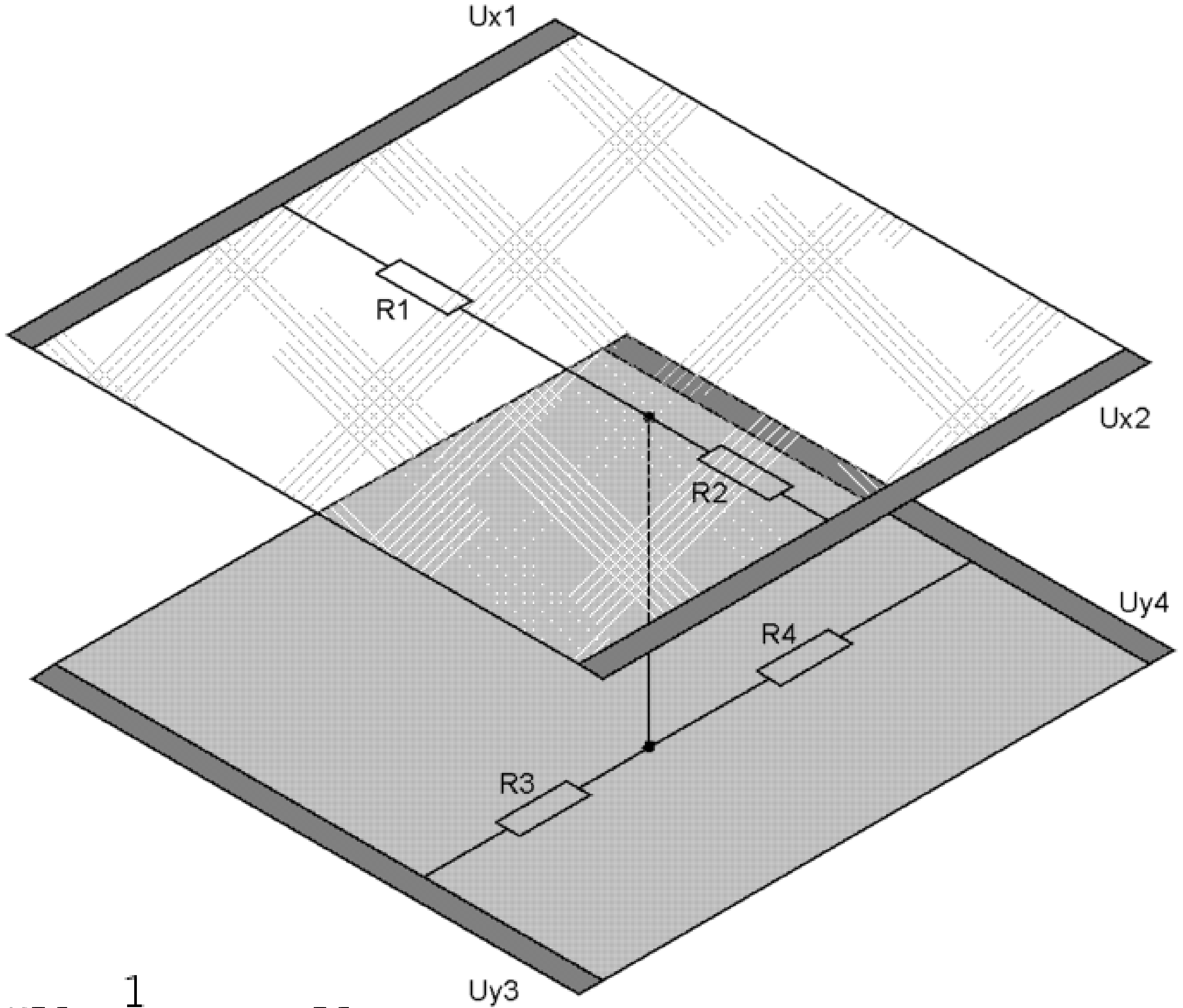


Classical (resistive) Touch Sensing

[http://de.wikipedia.org/wiki/Touchscreen]



- Two sheets of conductive, transparent material
- Connected by finger or pen pressure
- Resistance measurements
  - Between X electrodes
  - Between Y electrodes



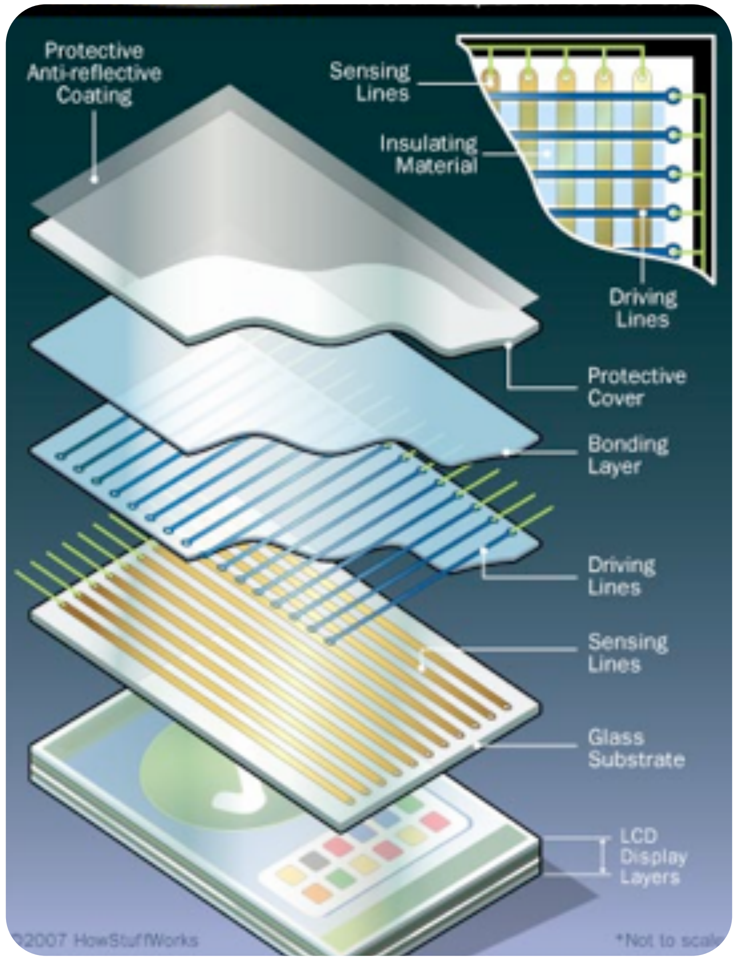
$$Uy_3 = Uy_4 = Ux_2 + \frac{(Ux_1 - Ux_2) * R_2}{R_1 + R_2} = 0V + 5V * \frac{1}{3} = 1,66V$$

Capacitive Touch Sensing

- Layer of conductive material holds charge
- Finger approaching the surface changes the amount of charge
- requires grid of driving and sensing lanes
- OR individual electrodes embedded in one layer

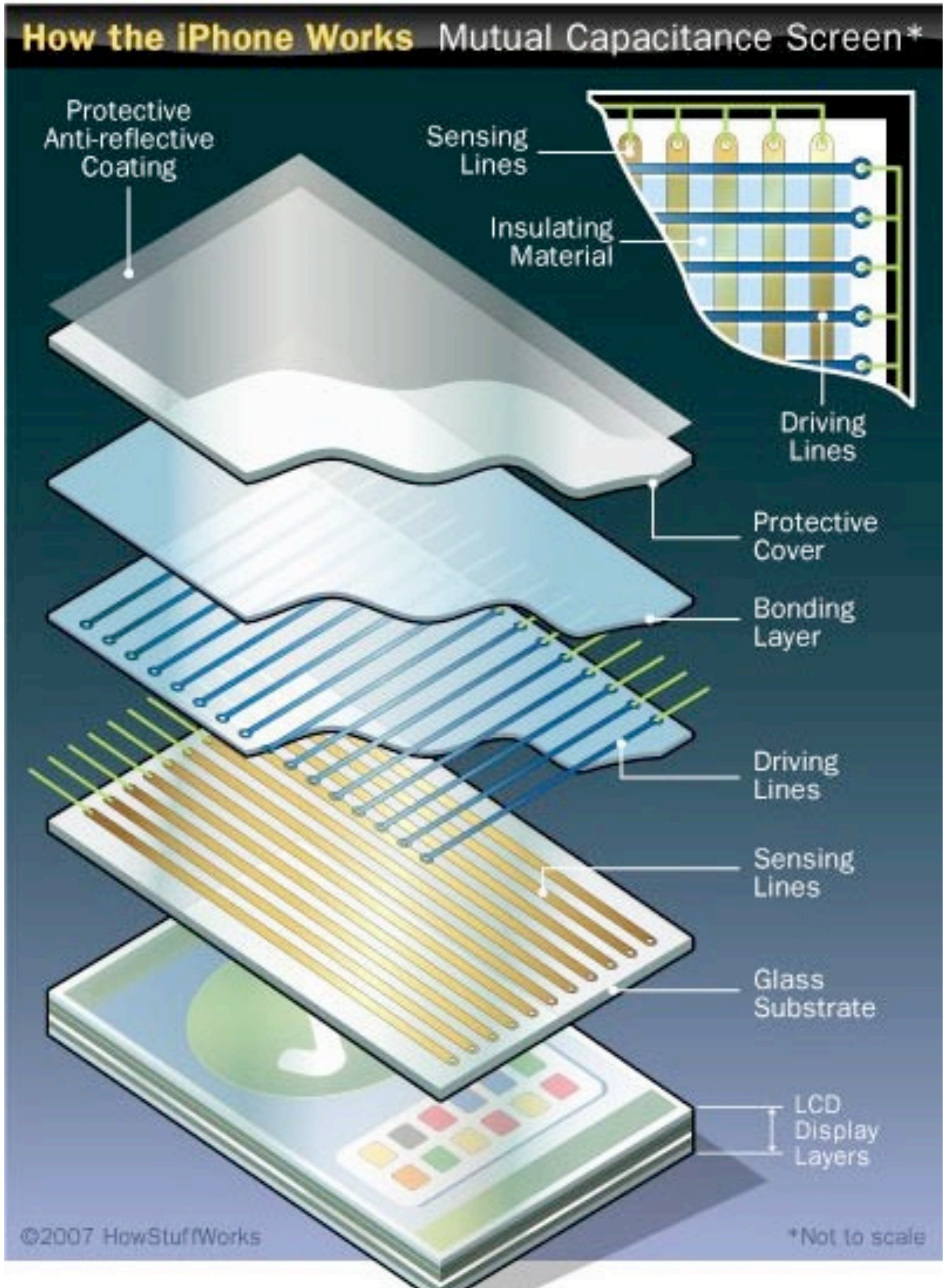
[Dietz Leigh'01]

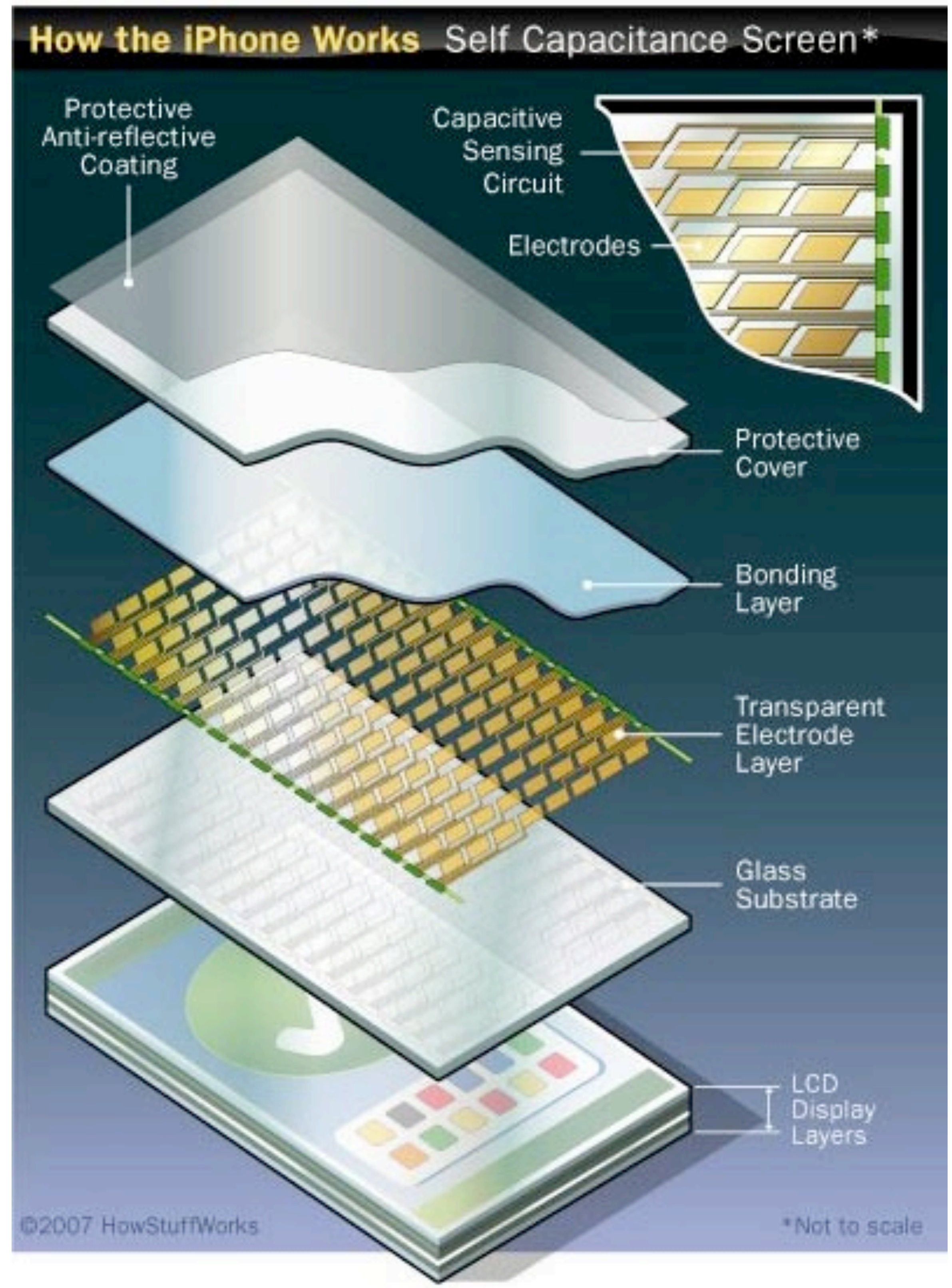
[Rekimoto'02]



Projected Capacitive Touch: iPad + iPhone

http://electronics.howstuffworks.com/iphone2.htm





Capacitive Sensing: Sony SmartSkin

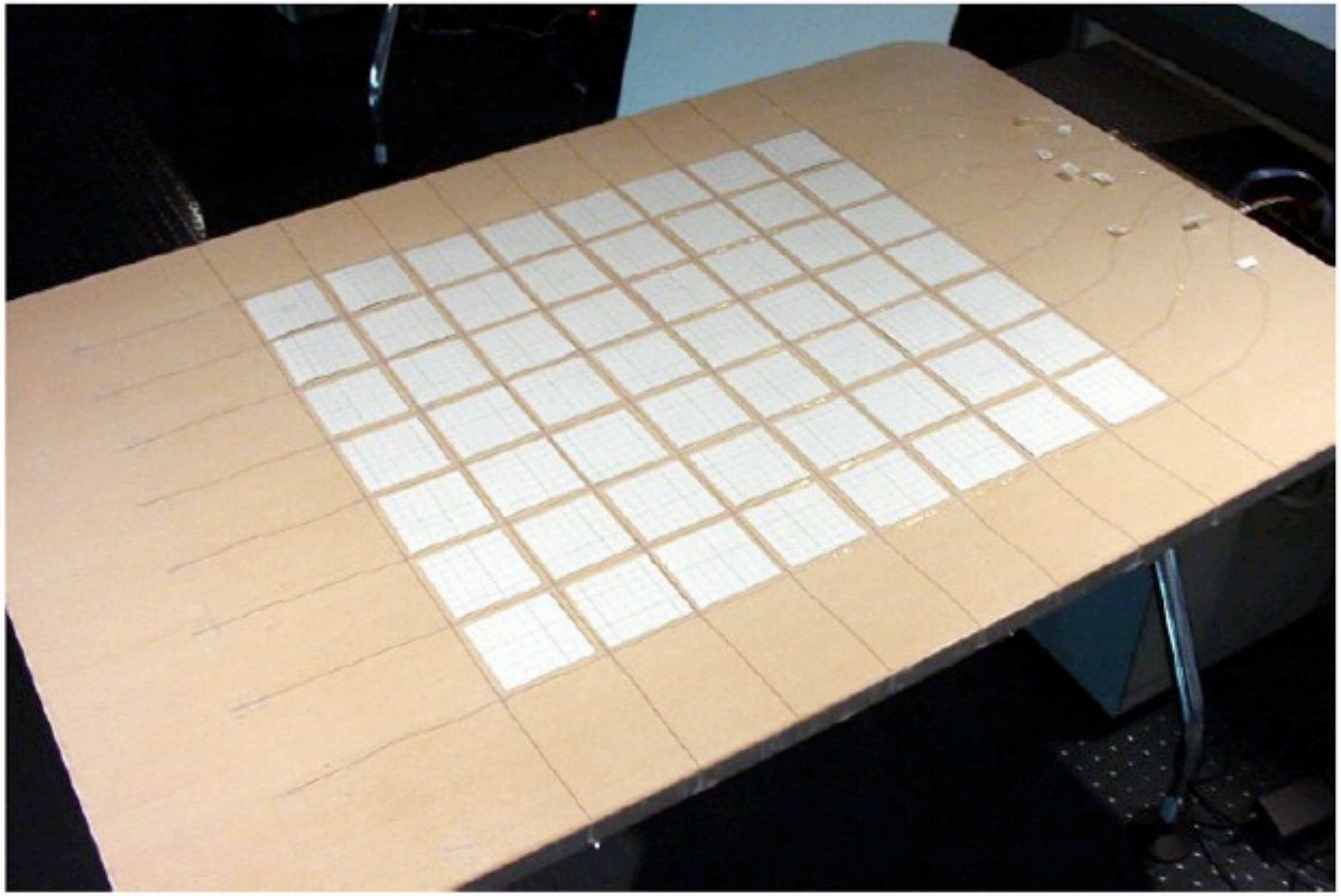
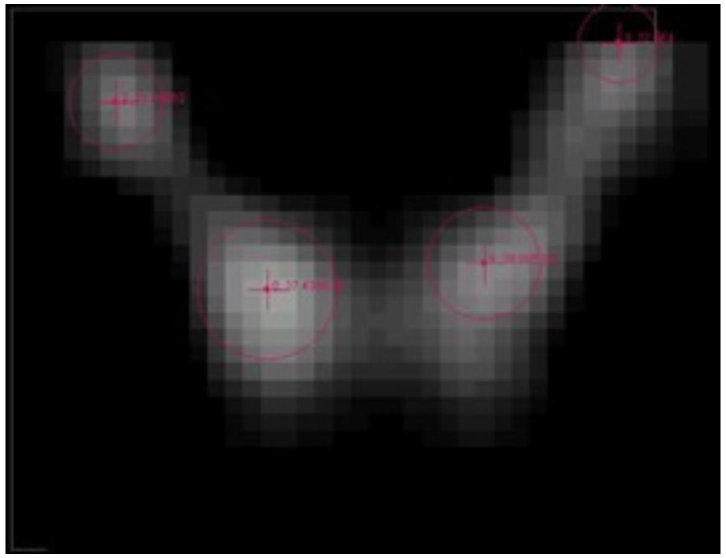


Figure 3: Interactive table with an 8 × 9 SmartSkin sensor: A sheet of plywood covers the antennas. The white squares are spacers to protect the wires from the weight of the plywood cover.



Capacitive Sensing: Sony SmartSkin

- finger only changes capacitive coupling in grid

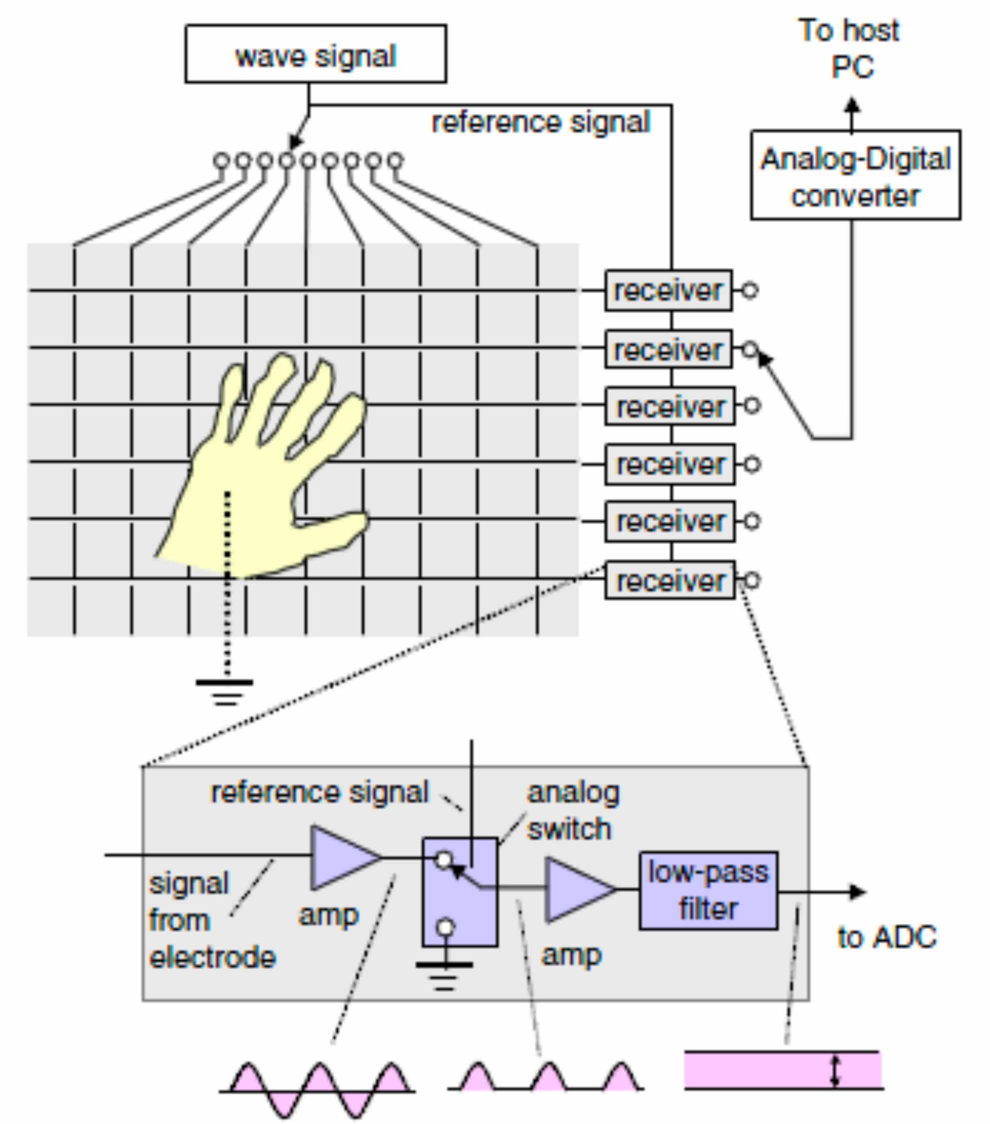


Figure 2: The SmartSkin sensor configuration: A mesh-shaped sensor grid is used to determine the hand's position and shape.

Capacitive Sensing: MERL DiamondTouch

- finger acts as one electrode of the capacitor
- connection e.g., through the chair
- different users send different signals
- finger identification solved!!

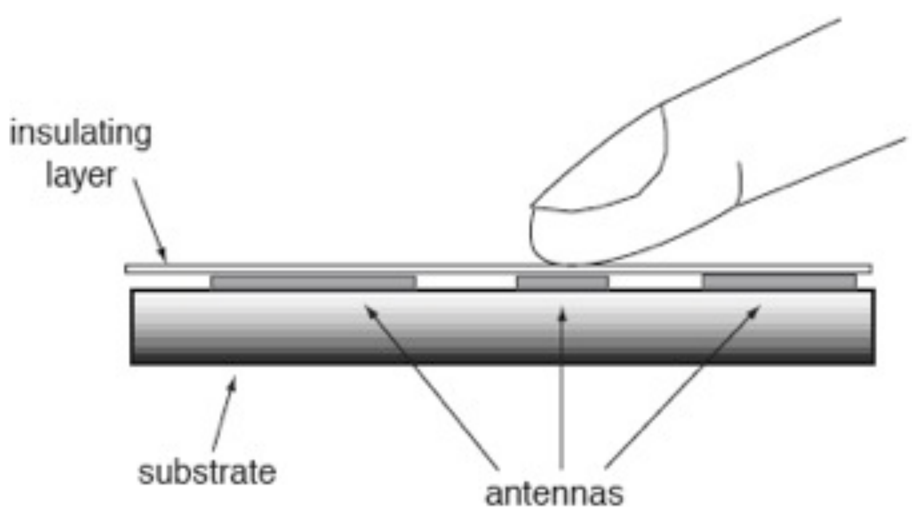
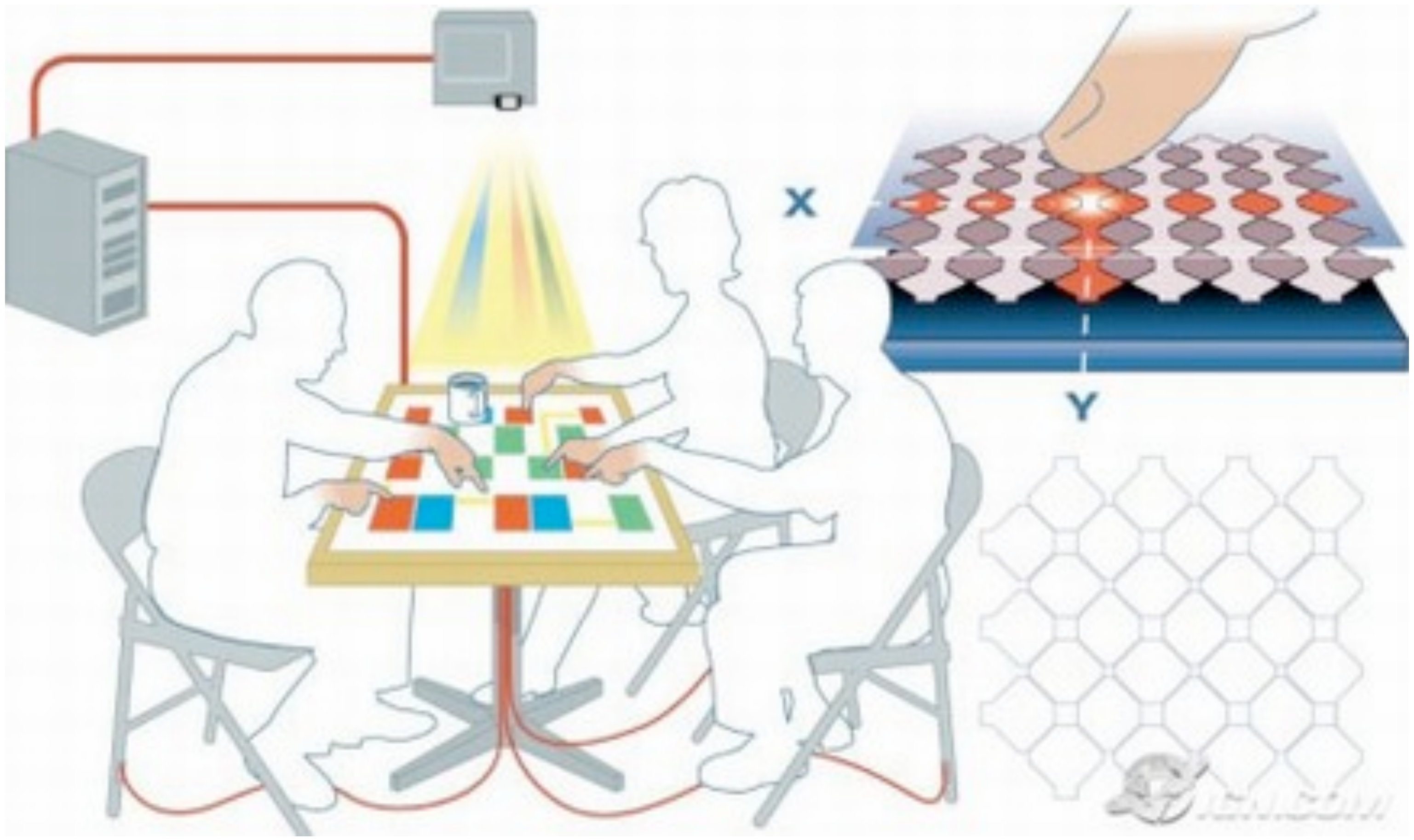


Figure 3: A set of antennas is embedded in the table-top. The antennas are insulated from each other and from the users.



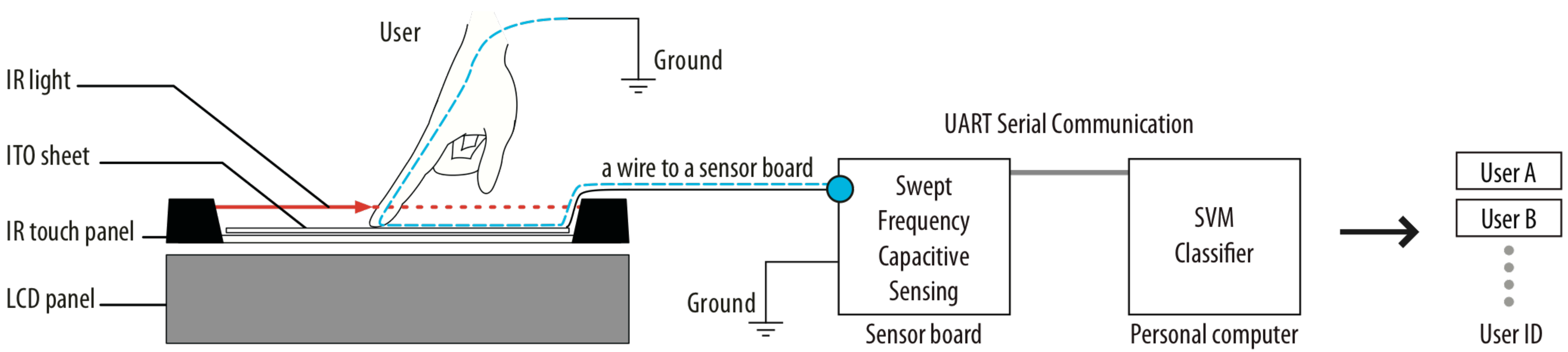
Capacitive Fingerprinting

- identify user with Swept Frequency Capacitive Sensing
  - measure the impedance of a user to the environment (i.e. ground) across a range of alternating (AC) frequencies
  - user differentiation approach without instrumentation of user or environment.
- people differ in bone densities, muscle mass, wear different footwear, and other biological/anatomical factors
  - unique electrical properties
- limitations:
  - distinguishes a small set of users.
  - users can only touch sequentially, not simultaneously
  - not robust enough yet for real-world use

Literature: Harrison, C. et al.: Capacitive Fingerprinting: Exploring User Differentiation by sensing electrical properties of the human body, UIST'12

approach

- estimate impedance profiles of users at different frequencies
  - instrument devices by single electrode and wire.
  - e.g. at 1 kHZ bone has resistivity of approximately 45 Ωm, 1 MHz is approx. 90 Ωm
- AC signal takes path with least impedance. sweep over a range of frequencies to direct current through various paths inside body.
- signal's amplitude and phase changes differently at different frequencies.
- measure and build a frequency-to-impedance profile


User
Ground
IR light
ITO sheet
IR touch panel
LCD panel
a wire to a sensor board
UART Serial Communication
Swept
Frequency
Capacitive
Sensing
Sensor board
Ground
SVM
Classifier
Personal computer
User A
User B
User ID

Capacitive Fingerprinting

Exploring User Differentiation by Sensing Electrical Properties of the Human Body

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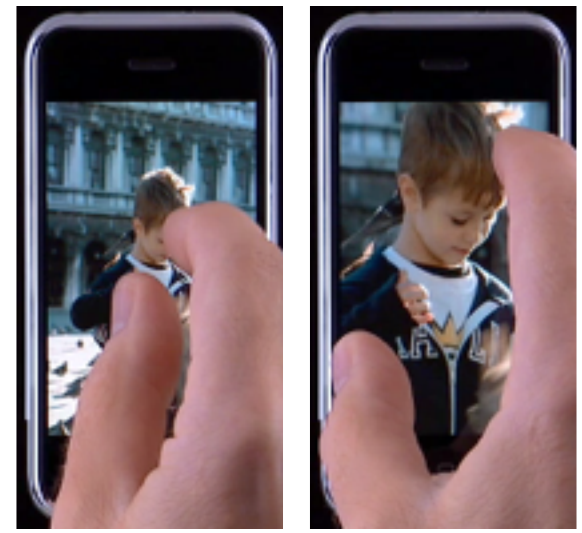
Disney Research
Pittsburgh

Sensors in Current Mobile Devices

- Multi-touch display
- GPS sensor (location)
- Accelerometer (orientation)
- Magnetometer (heading)
- Distance sensor (proximity)
- Ambient light sensor (brightness)
- RFID/NFC readers (tags)
- Camera



Multi-touch sensor

GPS Receiver

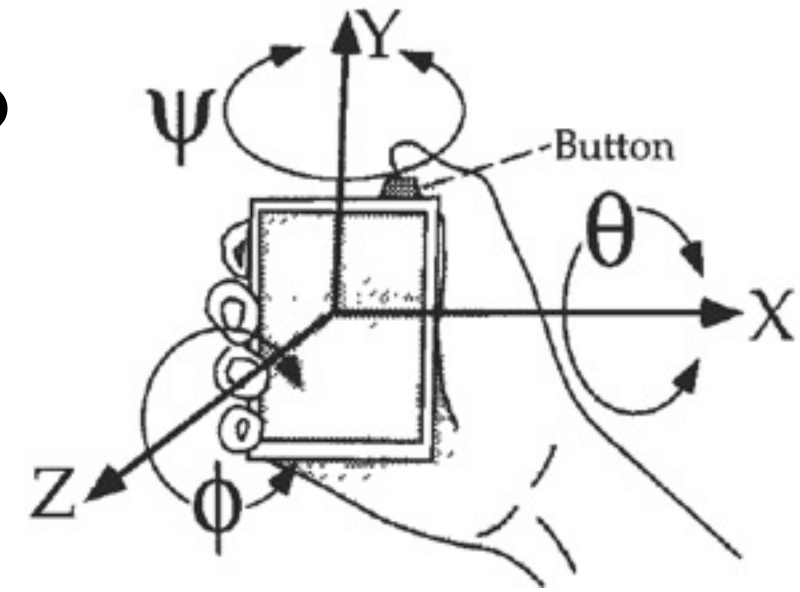
Accelerometer

Magnetometer

Sensors that Might be Used in Mobiles

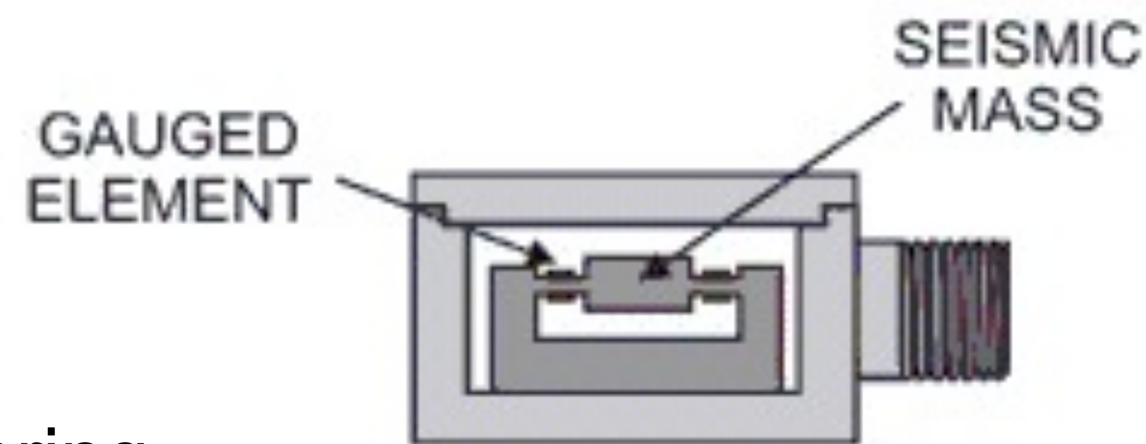
- Motion sensors
  - Accelerometer
  - Magnetometer (compass)
  - Gyroscope (rotation)
  - Tilt sensor
- Force / pressure / strain
  - Force-sensing resistor (FSR)
  - Strain gauge (bending)
  - Air pressure sensor
  - Microphone
- Position
  - Infrared range sensor (proximity)
  - Linear and rotary position sensors
- Light sensors
- Temperature sensor
- Humidity sensor
- Gas sensor

How do Accelerometers work?



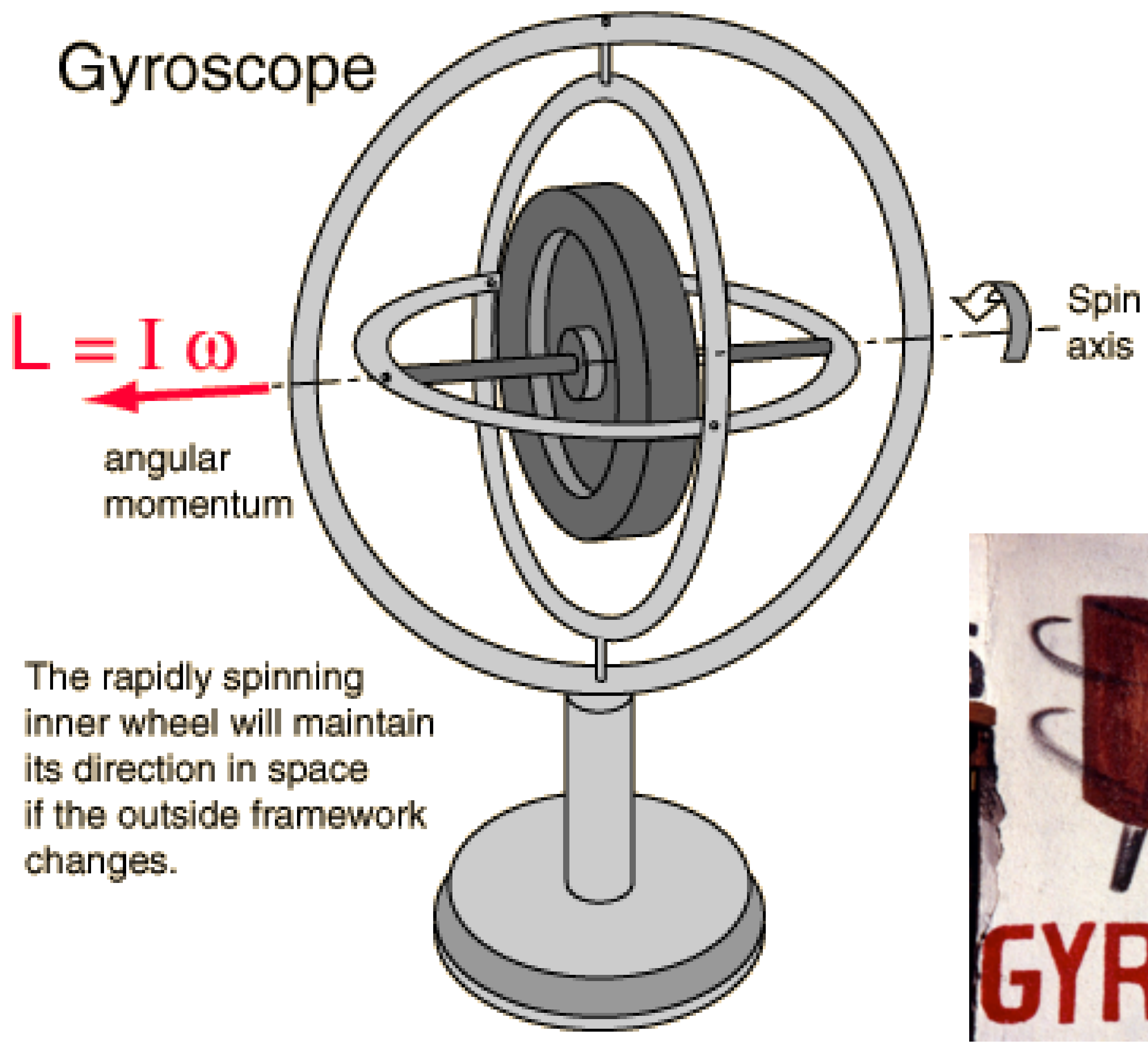
Source: Rekimoto: Tilting Operations for Small Screen Interfaces, 1996

- Measure acceleration
  - Change of velocity
- Causes of acceleration
  - Gravity, vibration, human movement, etc.
- Typically three orthogonal axes
  - Gravity as reference



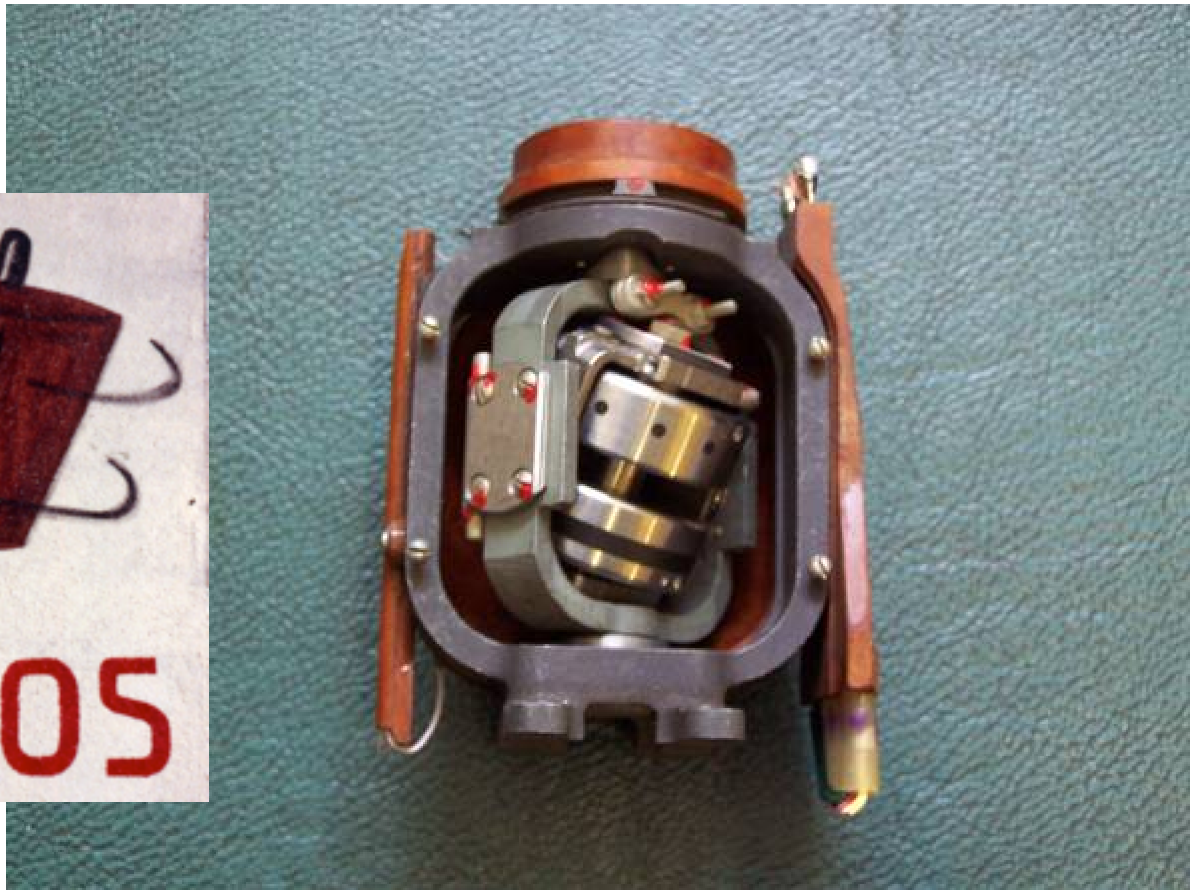
- Operating principle
  - Conceptually: damped mass on a spring
  - Typically: silicon springs anchor a silicon wafer to controller
  - Movement to signal: Capacitance, induction, piezoelectric etc.
- Derive position by integration
  - Problem: drift

Gyroscope


Gyroscope
L = I ω
angular momentum
Spin axis
The rapidly spinning inner wheel will maintain its direction in space if the outside framework changes.

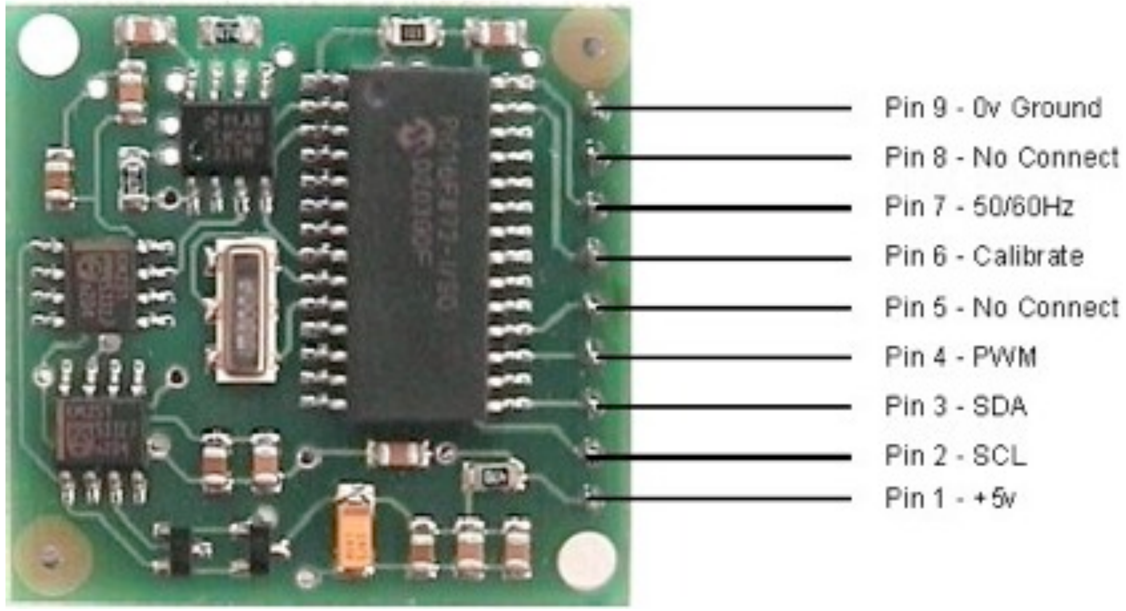

InterSense
Wireless
InertiaCube3™
Receiver
InterSense
Wireless
InertiaCube3™


GYROS



How do Magnetometers work?

- Measure strength and direction of magnetic field
  - Have to be calibrated
- Causes of magnetic fields
  - Earth's magnetic field (varies from place to place)
  - Electro magnetic interference (EMI)
- Typically three orthogonal axes
  - Magnetic north as reference
- Operating principle
  - Rotating coil, hall effect, etc.
- Technical parameters
  - Sensitivity to EMI
  - Update rate



KM51 Magnetic Field Sensor