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

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

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

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**Related 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

Side-of-Device Interaction: SideSight

Air + Touch

Mobile context and task theory interaction techniques

small screens touch precision

extend input vocabulary menu techniques

occlusion multi-device

in/output

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.

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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.

**Small screens**

**Touch precision**

**Extend input vocabulary**

**Menu techniques**

**Occlusion**

**Multi-device**

**In/output**

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.

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

![Graph showing total time for 2HS and 1HR conditions across stroke pairs.](image)

- does that result remind you of something?
Menu Techniques

• FastTap
• BezelTap
• Augmented Letters
• Two-handed Marking Menus
• Occlusion-aware interfaces
Occlusion-aware interfaces

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

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.

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Scalable Circle and Pivoting Rectangle Model

(a) Bézier spline
(b) Scalable Circle and Pivoting Rectangle Model
(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

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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](http://kenhinckley.wordpress.com/?s=bump)
Mobile context and task theory interaction techniques

small screens touch precision extend input vocabulary menu techniques occlusion

multi-device

in/output

- 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


“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.
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

Mobile Technologies

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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

\[ U_{y_3} = U_{y_4} = U_{x_2} + \frac{(U_{x_1} - U_{x_2}) \times R_2}{R_1 + R_2} = 0V + 5V \times \frac{1}{3} = 1.66V \]
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
Figure 3: Interactive table with an $8 \times 9$ 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
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!!
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
Capacitive Sensing (SFCS) is a non-invasive and inexpensive method for user identification. Since the AC signal always flows through the body, the impedance of the path of least resistance can be measured. The signal flows through the body, depending on the path and how it influences the impedance profile. By using recently proposed SFCS techniques, we are able to capture a multitude of electrical properties that can be coupled to users, especially available touchscreens.

Figure 2. Mean permittivity and resistivity of human body.

We created a proof-of-concept system using a commercial touchscreen, which consists of a 6.7" LCD panel, a 6.4" IR touch screen, and an Indium Tin Oxide (ITO) coated transparent substrate. The current of the sine wave is 0.5 mA, swept over a range of frequencies (e.g., EKG frequency range). The signal is sent over USB to a computer, and the true amplitude component is measured.

Figure 3. A cutaway view of the touchscreen layers, which are connected to a Touché sensor board. Here, a wire from the touch point goes to a sensor board, which is then communicated to the SVM classifier.

As shown in Figure 1 and seen in Figure 2, the true amplitude component is measured.

The current of the sine wave is 0.5 mA, swept over a range of frequencies (e.g., EKG frequency range). The signal is sent over USB to a computer, and the true amplitude component is measured. This also allows us to determine the frequency response (cloaking frequency) of the body, but this requires a greater amount of power than the scenario where the AC signal flows through the body, and it does not require user to wear an Indi Tin Oxide (ITO) coated transparent substrate.
Capacitive Fingerprinting
Exploring User Differentiation by Sensing Electrical Properties of the Human Body

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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
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?

- 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

The rapidly spinning inner wheel will maintain its direction in space if the outside framework changes.

\[ L = I \omega \]

Angular momentum
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