Tutorial Day at MobileHCI 2008, Amsterdam

Text input for mobile devices by Scott MacKenzie

Scott will give an overview of different input means (e.g. key-based, stylus, predictive, virtual keyboard), parameters relevant for designing and assessing mobile text input (e.g., writing speed, cognitive load) and issues related to the context of use (e.g., walking/standing).

Mobile GUIs and Mobile Visualization by Patrick Baudisch

Patrick will introduce different approaches for creating mobile graphical user interfaces. He will talk about the design process, prototyping and assessment of user interfaces, trade-offs related to the design of mobile GUIs and different possible interaction styles. As one specific topic in mobile GUIs he will address concept for mobile interactive visualization (e.g. maps).

Understanding Mobile User Experience by Mirjana Spasojevic

Mirjana will discuss different means for studying mobile user needs and evaluating the user experience. This includes explorative studies and formal evaluations (in the lab vs. in the field), including longitudinal pilot deployments. The lecture will discuss traditional HCI methods of user research and how they need to be adapted for different mobile contexts and products.

Context-Aware Communication and Interaction by Albrecht Schmidt

Albrecht will give an overview of work in context-awareness and activity recognition that is related to mobile HCI. He will discuss how sharing of context in communication applications can improve the user experience. The lecture will explain how perception and sensing can be used to acquire context and activity information and show examples how such information can be exploited.

Haptics, audio output and sensor input in mobile HCI by Stephen Brewster

Stephen will discuss the design space for haptics, audio output as well as sensor and gesture input in mobile HCI. Furthermore he will assess resulting interaction methods and implications for the interactive experience.

Camera-based interaction and interaction with public displays by Michael Rohs

Michael will introduce you camera based interaction with mobile devices; this includes a assessment of optical markers, 2D-barcodes and optical flow as well as techniques related to augmented reality. In this context he will address interaction with public displays, too.

Spetember 2nd 2008

Haptics, audio output and sensor input in mobile HCI

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Research group

- Multimodal Interaction Group
- Key area of work is *Multimodality*
- More human way to work
  - Not everyone has all senses
  - May not always be available all of the time
- No one sense can do everything on its own
  - Need flexible forms of interaction to suit different users, tasks and contexts

Overview of tutorial

- Problems with interaction in a mobile world
- Non-speech audio
  - Why use audio?
  - Earcons, auditory icons and sonification, examples
- Haptics
  - Why use haptics?
  - Definitions, hardware, examples
- Sensor input
  - Why sensor input?
  - Definitions, hardware, gestures for input

Interaction problems

- Mobile interaction takes place in the real world
  - Users involved in other tasks
  - On the move
  - Contexts very varied
  - Users need effective ways to interact with sophisticated new applications and services
- Current interfaces can make interaction difficult

Screen is limited

- Screen space small
- Eyes heavily used when mobile
- Using up too much visual attention is dangerous
- Hard to design good graphical interfaces for use on the move

Input is limited

- Keyboards and pens hard to use when mobile
  - Buttons are small
  - Input difficult and error prone
  - Requires much visual attention
  - Two hands
- Touchscreen phones lose important tactile features
  - Requires more visual attention

Multimodal interaction

- Need interactions that allow people to get on with their lives whilst using the technology
  - 'Eyes-free' or 'Hands-free'
- Need to develop new interaction techniques that suit real environments of use
  - Non-speech sounds + tactile displays for output
  - Sensors for gestural input for input
  - Multimodal interaction

Non-speech audio interaction

- Music, structured sound, sound effects, natural sound
- Icons vs text, non-speech vs speech
- Why use audio?
  - Good for rapid non-visual feedback
  - Trends, highly structured information
  - Works well with speech and graphical displays
  - Omni-directional / attention grabbing
  - Reduced need for visual display, good for visually-impaired users

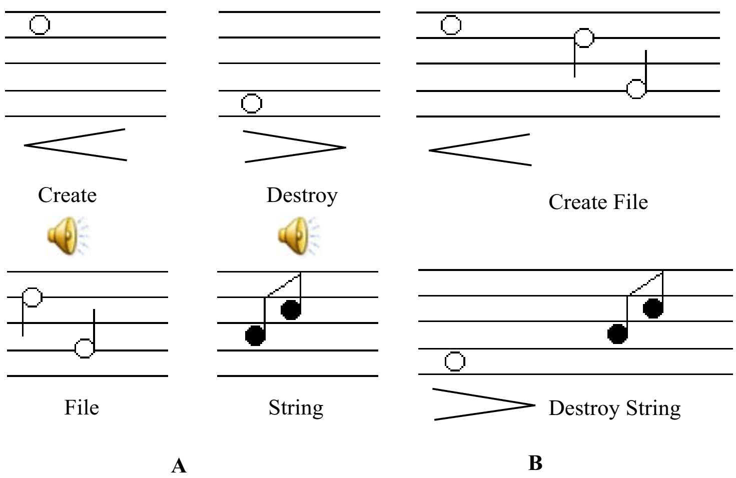
Main types of non-speech audio

- Simple beeps
- Earcons (Blattner): musically structured, abstract sounds *(abstract)*
- Auditory Icons (Gaver): natural, everyday sounds *(representational)*
- Sonification: visualisation using sound, mapping data parameters to audio parameters *(abstract)*

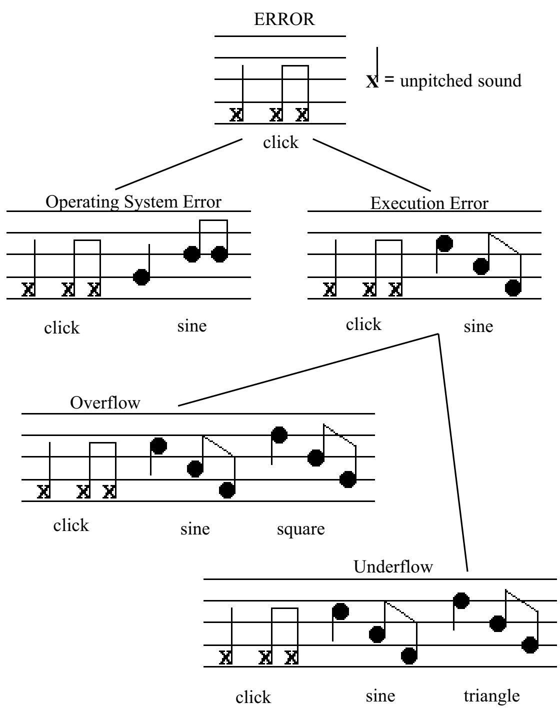
Earcons

- Structured audio messages based on abstract sounds
  - Created by manipulation of sound properties: timbre, rhythm, pitch, tempo, spatial location (stereo, 3D sound), ...
- Composed of motives
- Can be *compound*
  - Sub-units combined to make messages
- Or *hierarchical*
  - Sounds manipulated to make complex structures

Earcons



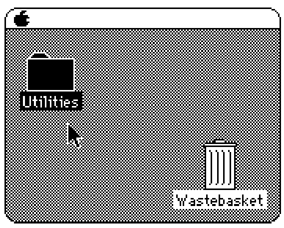
Hierarchical Earcons



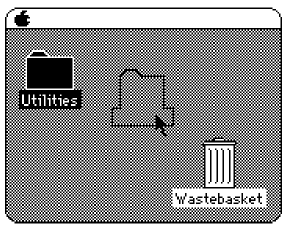
Auditory Icons

- Everyday, natural sounds represent objects and actions in the interface
- Sounds have an intuitive link to what they represent
- Sounds are multi-dimensional
- The SonicFinder
  - Selecting, copying, dragging

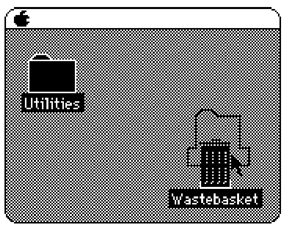
Auditory Icons



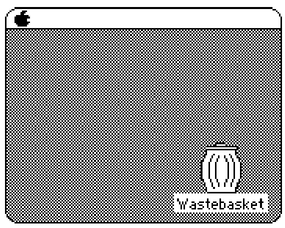
A) Papery tapping sound to show selection of folder.



B) Scraping sound to indicate dragging folder.



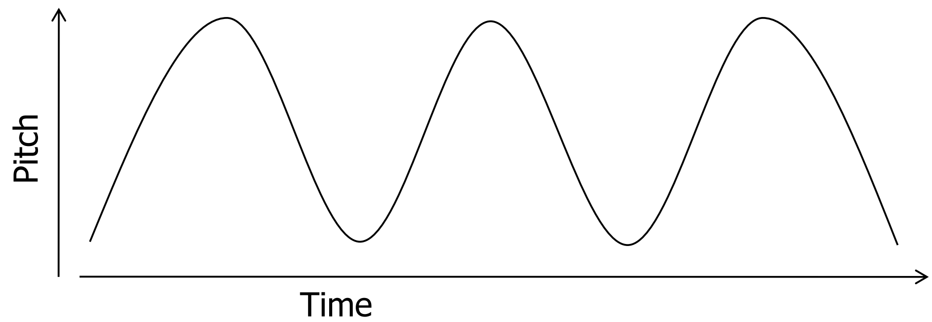
C) Clinking sound to show wastebasket selected



D) Smashing sound to indicate folder deleted.

Sonification

- Mapping of data values to auditory parameters
  - Most commonly x-axis to time, y-axis to pitch
  - Demo



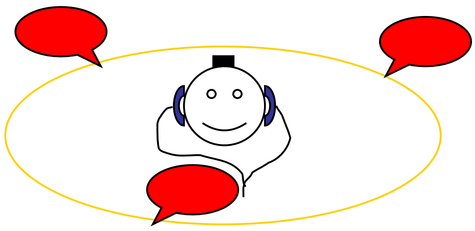
Sound in interaction

- Simple sounds for targeting can increase usability in stylus/button interface by 25% when mobile
  - Reduce size of on-screen targets
- Used for many other interaction improvements
  - Scrollbars, menus, progress bars, …

www.icad.org for many good audio examples

Example:3D audio interaction

- Need to increase the audio display space
  - Deliver more information
  - Quickly use up display space
- 3D audio
  - Provides larger display area
  - Monitor more sound sources
  - Planar sound (2.5D)
- 'Audio windows'
  - Each application gets its own part of the audio space (Cohen)



3D audio interaction techniques

- How do we use spatial audio?
  - Progress indicator (Walker, PUC)
  - Diary / NomadicRadio (Schmandt, TOCHI)
- Pie Menus (Brewster, CHI03, Marentakis, CHI06)
  - Audio menu items placed around the head
  - Cardinal points or front 180°
  - Users can select audio menu items with head gestures when on the move

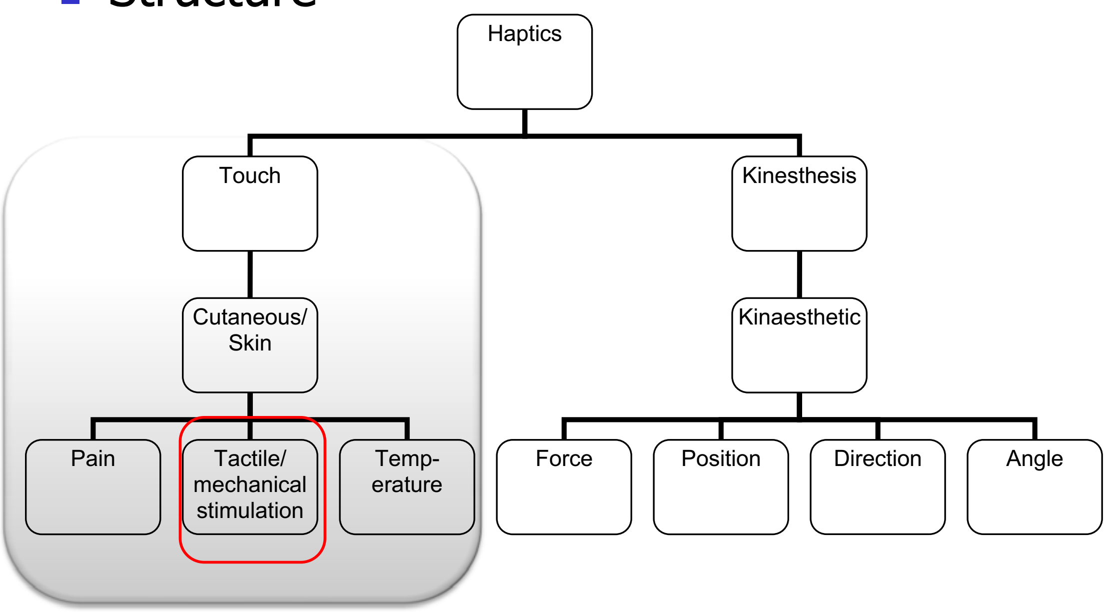
Haptics

- Definition
  - *Haptics*: 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
    - *Tactile:* mechanical stimulation to the skin

From new ISO Tactile/Haptic standard 9241-910

Haptics

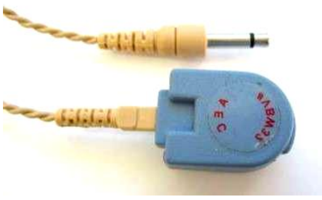
- Structure



Why haptic interaction?

- Has benefits over visual display
  - Eyes-free
- 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



Tactaid VBW32 actuator

Phone vibration motor

C2 Tactor actuator

3 cell pin array

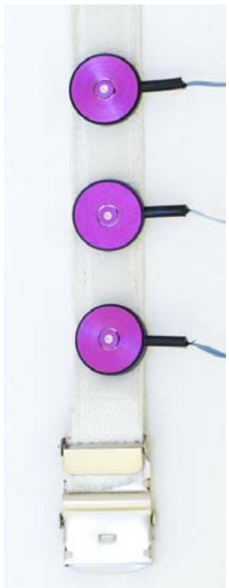
Actuators now in other kinds of devices

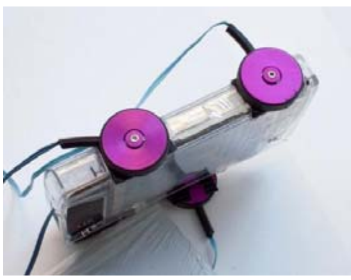
Design of Tactons

- Tactons – tactile icons
  - Structured, abstract messages that can be used to communicate non-visually (Brown, 2005)
  - Tactile equivalent of Earcons
- Vibrotactile feedback
- Encode information using parameters of cutaneous perception
  - Waveform
  - Duration/rhythm
  - Body location

Tacton parameters

- Spatial location (on forearm, waist, hand) very effective
  - Good performance with up to 4 locations
  - Wrist and ankle less effective, especially mobile





Tacton parameters

- Rhythm very effective
  - Easily identified with three levels
- Waveform
  - Carefully designed sine, square and sawtooth waveforms very effective (*tuned* to capabilities of actuator)
- Intensity
  - Two levels
  - Hard to use and may need to be controlled by user

Brown, MobileHCI 05, 06

Crossmodal audio and tactile interactions

- Train people in one modality and use in another
  - Useful when one modality may be unusable
  - Trained with Earcons and tested with Tactons
  - Trained with Tactons and test with Earcons
  - Trained and tested in same modality
- Results very positive – training transferred well both ways
  - Equal to training within same modality

Hoggan, ACM ICMI, 2007

Example: tactile button feedback

- Touchscreen phones have no tactile feedback for buttons
  - More errors typing text and numbers
- Compared performance of real buttons to touchscreen and touchscreen+tactile
  - In lab and on subway
- Touchscreen+tactile as good as real buttons
  - Touchscreen alone was poor

Brewster, CHI 2008

Example: tactile navigation

- Non-visual interface for GPS + compass
- Belt of 4 actuators
  - Placed North, South, East, West
- Vibrations gave direction and distance
- Users could follow paths accurately without a screen

Sensor input

- Definition: *Sensors convert a physical signal to an electrical one that can be manipulated symbolically within a computer*
- Why sensor input?
  - Input in new ways, new form factors
  - Discrete vs continuous, rich, natural movements
  - Very engaging for users
  - Interaction on the move
  - Context sensing
  - Input for users with disabilities

Chapter 10, HCI Handbook, 2nd Edition

Sensor types

- Common types include
  - Microphone
  - Camera (front and back), light sensor
  - Accelerometer (change in motion with respect to gravity)
  - GPS receiver for large scale movements
  - Touchscreen / multitouch
- Less common
  - Magnetometer
  - Gyroscope
  - Pressure
  - RFID tag reader
  - Physiological sensors (heart rate)
  - Contact microphone

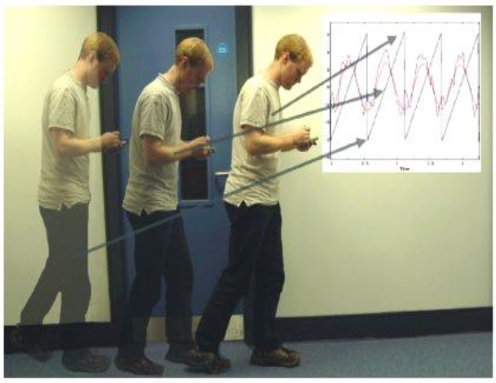
Example: SHAKE sensor pack

- SHAKE
  - Accelerometer, magnetometer, gyro, capacitive touch sensor, (RFID)
  - Bluetooth connection to host device

www.dcs.gla.ac.uk/research/shake/

Uses for sensor input

- Gesture interaction
- Context awareness
- Can sense gait and phase
  - Walking, running, standing, …
  - Results show that users tap more and are more accurate in some parts of gait phase



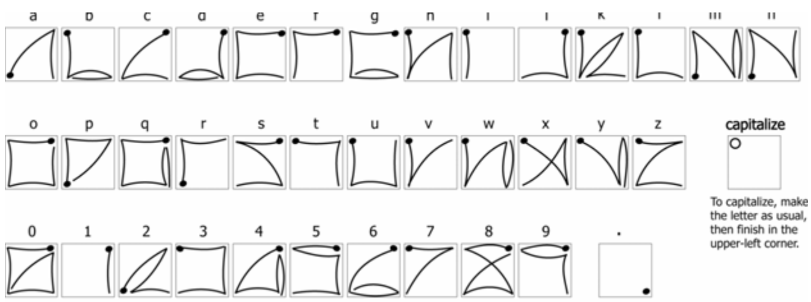
Crossan, 2007

Why gestures for input?

- Kinaesthetic perception means gestures can be ‘eyes free’
- Can use many different parts of the body
  - Fingers, hands, head, or device
  - Can be one handed, no handed
  - Good if users are involved in something else, e.g. carrying bags, operating machinery
- Self-contained, no screen or surface needed
  - Can easily be used on the move
- Popular with users – Nintendo Wii

Touchscreen gestures

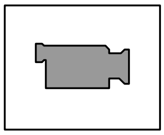
- iPhone rotate/zoom - Multitouch
- Metaphorical gestures (Pirhonen, CHI 2002)
  - Sweeps and taps to control music player
- Writing gestures
  - EdgeWrite (Wobbrock)



Gesturing with a device

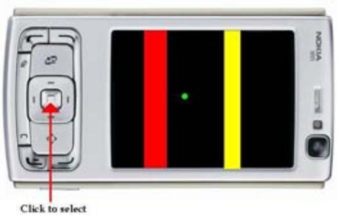
- Use the device itself to gesture or point
  - One-handed interaction
- "Tilt to Scroll"
  - (Oakley, 2005, Strachan, 2007)
  - Natural but problematic in bright light

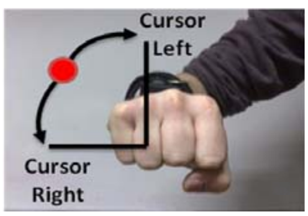
- Can use other points on body to act as holders of information
  - BodySpace (Strachan, 2007)



Wrist gestures

- Can rotate wrist to control a cursor
  - Discreet form of input whilst holding a bag
- Investigated whether users could select targets using wrist
- Very effective
  - 90% accuracy for 9° targets
  - Mobile recognition techniques are challenging





Crossan, MobileHCI 2008 / www.gaime-project.org

Future

- Audio
  - Better quality 3D sound on mobiles
- Haptic
  - Higher quality tactile actuators (Luk, CHI06)
  - Pressure, temperature
  - Force-feedback displays??
- Sensors and gesture
  - Investigation of new body locations
  - Develop multitouch
  - Gesture recognition techniques robust to noise of real world movements

Conclusions

- Screens and keyboards are hard to use when mobile
  - Limit our mobile interactions
- Multimodal interaction
  - Sound and tactile feedback 'eyes free'
  - Gestures good as input can be 'hands-free'
  - Improve performance when mobile
- New multimodal interaction techniques provide new opportunities for applications and services

Haptics, audio output and sensor input in mobile HCI

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Resources - audio

- Audio
  - www.icad.org – audio conference series
  - Brewster, S.A. 2008. *Chapter 13: Nonspeech auditory output.* In The Human Computer Interaction Handbook 2nd Edition (Lawrence Erlbaum Associates, USA), pp 247-264. ISBN 978-0-8058-5870-9
  - Blattner, M., Sumikawa, D. & Greenberg, R. (1989). Earcons and icons: Their structure and common design principles. *Human Computer Interaction*, 4(1), pp. 11-44.
  - Brewster, S.A., Wright, P.C. & Edwards, A.D.N. (1992). A detailed investigation into the effectiveness of earcons. In Auditory display, sonification, audification and auditory interfaces. The Proceedings of the First International Conference on Auditory Display: Addison-Wesley, pp. 471-498.
  - Gaver, W. (1986). Auditory Icons: Using sound in computer interfaces. *Human Computer Interaction*, 2(2), pp. 167-177
  - Gaver, W. (1989). The SonicFinder: An interface that uses auditory icons. *Human Computer Interaction*, 4(1), pp. 67-94
  - Sawhney, N. and Schmandt, C. (2000) Nomadic radio: speech and audio interaction for contextual messaging in nomadic environments. ACM TOCHI 7(3), pp 353-383
  - Sonification report: http://www.icad.org/node/400
  - Cohen, M. & Ludwig, L.F. (1991). Multidimensional audio window management. *International Journal of Man-Machine Studies*, 34, pp. 319-336
  - Walker, A. and Brewster, S.A.(2000). Spatial audio in small display screen devices. *Personal Technologies,* 4(2), pp 144-154.
  - Brewster, S.A., Lumsden, J., Bell, M., Hall, M. and Tasker, S. *Multimodal 'Eyes-Free' Interaction Techniques for Wearable Devices.* ACM CHI 2003. ACM Press, Addison-Wesley, pp 463-480
  - Marentakis, G.N. and Brewster, S.A. *Effects of Feedback, Mobility and Index of Difficulty on Deictic Spatial Audio Target Acquisition in the Horizontal Plane.* ACM CHI 2006, ACM Press Addison-Wesley, pp 359-368.

Resources - haptics

- Haptics
  - ISO Tactile/Haptic standard 9241-910 – coming out shortly
  - www.hapticsymposium.org
  - www.eurohaptics.vision.ee.ethz.ch
  - IEEE Transactions on Haptics – new journal
  - www.roblesdelatorre.com/gabriel/hapticsl/ - haptics email list
  - Jones, L., Sarter, N. (2008) Tactile Displays: Guidance for Their Design and Application. Human Factors, 50(1), pp 90-111
  - Klatzky, R. and Lederman, S. (2003) Chapter 6: Touch. In Handbook of Psychology, Vol. 4: Experimental Psychology. John Wiley and sons.
  - Brown, L.M., Brewster, S.A. and Purchase, H.C. *A First Investigation into the Effectiveness of Tactons.* In Proceedings of WorldHaptics 2005 (Pisa, Italy). IEEE Press, pp 167-176
  - Brewster, S.A. and King, A. *An Investigation into the Use of Tactons to Present Progress Information.* In Proceedings of Interact 2005 (Rome, Italy), pp 6-17
  - Hoggan, E. and Brewster, S.A. (2007) *Designing Audio and Tactile Crossmodal Icons for Mobile Devices.* In ACM International Conference on Multimodal Interfaces (Nagoya, Japan). ACM Press, pp 162-169
  - Leung, Maclean, Bertelsen, Saubhasik (2007). Evaluation of haptically augmented touchscreen gui elements under cognitive load. ACM International Conference on Multimodal Interfaces. ACM Press, pp 374-381
  - Luk, Pasquero, Little, Maclean, Levesque and Hayward (2006) A role for haptics in mobile interaction: initial design using a handheld tactile display prototype. ACM CHI 2006, pp 171-180
  - Hoggan, E, Brewster, S.A. and Johnston, J. *Investigating the Effectiveness of Tactile Feedback for Mobile Touchscreens*. In Proceedings of ACM CHI2008 (Florence, Italy). ACM Press Addison Wesley, pp 1573-1582

Resources - sensors and gestures

- Sensors and gestures
  - http://www.gw2009.de – workshop series on gesture
  - Wilson, A. 2008. *Chapter 10: Sensor- and recognition-based input for interaction.* In The Human Computer Interaction Handbook 2nd Edition (Lawrence Erlbaum Associates, USA), pp 177-199. ISBN 978-0-8058-5870-9
  - Hinckley, K. (2008). *Chapter 9: Input technologies and techniques.* In The Human Computer Interaction Handbook 2nd Edition (Lawrence Erlbaum Associates, USA), pp 161-176. ISBN 978-0-8058-5870-9
  - Mitra, S. and Acharaya, T. (2007) Gesture recognition: A survey. *IEEE Transactions on Systems, Man and Cybernetics – Part C: Applications and Reviews*. 37(3), p 311 – 324
  - Oakley, I and O'Modhrain, S. Tilt to scroll: evaluating a motion based vibrotactile mobile interface. In WorldHaptics 2005 (Pisa, Italy). IEEE Press, 40-49.
  - S. Strachan, R. Murray-Smith, S. O'Modhrain, *BodySpace: inferring body pose for natural control of a music player*, Extended abstracts of ACM SIG CHI Conference, San Jose, 2007.
  - Crossan, A., Murray-Smith, R., Brewster, S.A. and Musizza, B. *Instrumented Usability Analysis for Mobile Devices.* Handbook of Mobile HCI (Lumsden, J. ed), The Ideas Group Inc. 2007
  - Pirhonen, A., Brewster, S.A. and Holguin, C. (2002). Gestural and Audio Metaphors as a Means of Control for Mobile Devices. *In ACM CHI2002* (Minneapolis, MN), ACM Press Addison-Wesley, pp 291-298.
  - Wobbrock, J., Myers, B. and Kembel, J. (2003) EdgeWrite: a stylus-based text entry method designed for high accuracy and stability of motion. ACM UIST 2003 (Vancouver, Canada), ACM Press, pp 61-70
  - Crossan, A., Williamson, J., Brewster, S.A. and Murray-Smith, R. *Wrist Rotation for Interaction in Mobile Contexts.* MobileHCI 2008 (Amsterdam, Holland).