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

Context-Aware Communication and Interaction

Albrecht Schmidt

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Overview

1. Introduction & Motivation
2. Example Systems/Applications
3. Defining Context
4. From Sensor to Context
5. Examples of off-the-shelf hardware and systems
6. Summary
7. Reference and Reading

1. Introduction & Motivation

Perception and context enables smart behavior

- Perception in Nature
  - Adaptation to the environment
  - Foundation for intelligent behavior
  - Acting and reacting in an appropriate way
- Sense is more then sensor – the whole process
  - reception of the stimulus
  - translation from stimulus to signal
  - signal transport
  - the processing/matching on several levels
- Different senses
  - Vision, Hearing, Smell, Taste, Touch, Temperature
  - Gravity and acceleration , Position and constellation of (body) parts
  - Magnetic fields, Electric fields

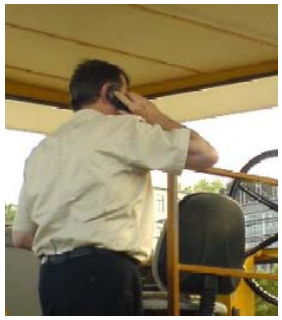
Sensing and perception

- Sensors already integrated in devices
  - Light sensor
  - GPS
  - Acceleration sensors
  - Touch and Temperature
  - Wireless (use for sensing)
- Sensors wirelessly linked
  - Step counter (e.g. Nike)
  - Physiological sensors (e.g. pulse)
- Processing power is available
  - Algorithms for context and activity recognition can be run on mobile devices
- Many sensors available

Devices are used everywhere – in Context

- Mobile and ubiquitous use

- Interaction with the mobile device is the secondary task



Context as key for efficient communication [Lenat98]

- Coding in context
  - Coding and representation chosen to fit the context
  - Obvious context information is not included in the coding (e.g. the question "*another drink?*" in the hotel bar at 2am implies: in this bar and now – not somewhere else or another day)
- Transport of the message
  - Media chosen appropriate for the current context (e.g. whispering with your neighbor during a lecture, shouting across the street to get the attention of a friend, drawing a sketch, etc.)
- Decoding of the message
  - Taking context information into account for decoding the message
  - Additionally to the explicitly transmitted message further context information is provided (e.g. surrounding situation, body language, form of the explicit representation)
  - Context is used to interpret the message

Mini-Exercise (60 seconds in pairs)

Phoning in the car

- Compare
  - hands-free phoning in the car
  - talking to a passenger on the front seat
  - talking with a child on the backseat
- What is safest?
- Why?

Context in Interactive Systems

- Use context for **adaptation** of
  - Application
  - Content
  - Presentation
  - Interaction modality
- Context as **content**
  - Tagging of media (e.g. location and time in photos)
  - Creating meta information
  - Context as the content (e.g. recording a walking track)
  - Real-time sharing of context (e.g. presence)
- **Rethink** user interface options
  - Output
  - Input
  - Communication

Rethink Output

- Make use of context
- Adjusting media quality
- Adapt media usages
- Choose the modality
- Adapt content and visual representation
- Timing of output / notification
  - Interrupt at “apprpriate” times

Rethink Input

- Easing input by using context knowledge
- Automate input
  - current time
  - who is in a meeting
  - tracking documents used
  - places visited…
- Provide context-dependent defaults
- Optimize input space to fit to current context
  - recognizer for handwriting/speech,
  - context-sensitive menus

… this is not easy!!!

Taking context of usage into account in the design of devices/applications

- At design time
  - Specifically designed for a certain context

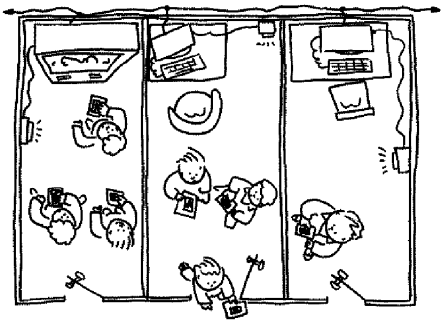
http://www.tgdaily.com/content/view/28552/145/

- At run time
  - Recognizes the context
  - Acts depending on the context

2. Example Systems/Applications

ParcTab Context-Aware Computing System [Schilit94]

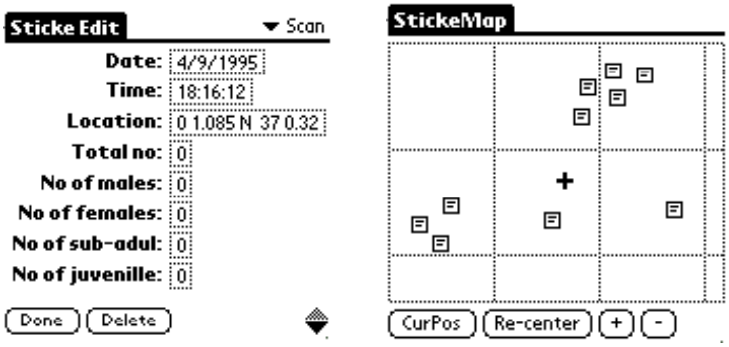
- Classification of applications using context-aware services
- Infrared location sensing
- Context as name-value pair
- Automatic behavior vs. manual interaction



Name	Room	Distance
caps	35-2200	200ft
claudia	35-2108	30ft
perfector	35-2301	20ft
snoball	35-2103	100ft

	manual	automatic
information	Proximate selection and contextual information	Contextual reconfiguration
command	Contextual commands	Context-triggered actions

Human-Computer-Giraffe Interaction: HCI in the Field [Pascoe98]

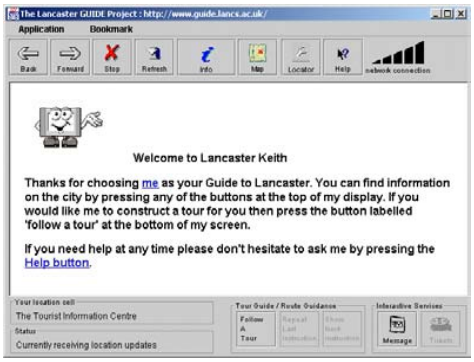


- Actions triggered by location
- Notes that are linked to contexts
- Time and Location as contexts
- GPS receiver attached to a PDA

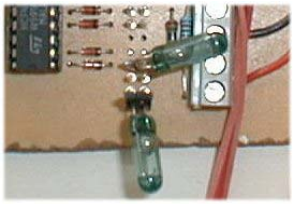
GUIDE – Towards Context in HCI

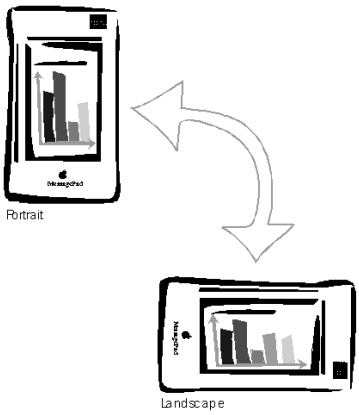
[Cheverst00]

- two classes of context were identified, namely personal and environmental context
- significant contexts
  - visitor's interests
  - current location
  - budget constraints,
  - Disabilities
- Cell Based Location (on WLAN)
- Support the user in creating a conceptual model



Physical context and device interaction [Schmidt99]





Extremely simple, but still it creates a new experience

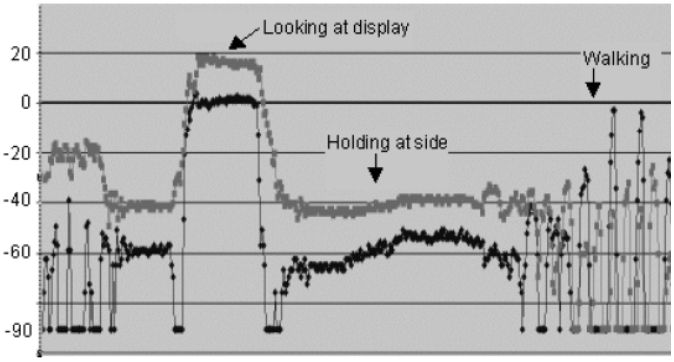
- 2-Bit Input
- Not an input device
- Very specific function

Mobile Phone that recognizes its interaction context [Schmidt99a]

Perception as key for smart devices

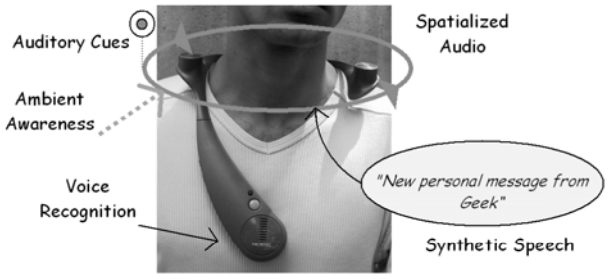
- Phone acts context dependent
- Sensors
  - Accelerometers
  - Microphone
  - Temperature
  - …
- Recognizes contexts
  - "in the user's Hand"
  - "on a surface"
  - "in a bag"
  - …
- Algorithms with minimal processing

Sensing Techniques for Mobile Interaction [Hinckley00]



Nomadic Radio [Sawhney00]

- Scalable Auditory Presentation
- Contextual Notification, depending on
  - Message priority
  - Usage level
  - Likelihood of Conversation



Silence	Ambient	Auditory	Summary	Preview	Full Body	Foreground
			"new voice msg. from Kathy."	*"Hi mom, its Kathy."*	*"Hi mom, its Kathy. Can you pick me up early from school today?"*	*"Hi mom, its Kathy. Can you pick me up early from school today?"*

Context Call [Schmidt00]

Sharing of context before the call is established

- **In real life we have social protocols for initiating conversation**
  - social skill – knowledge from both sites required!
  - trained from early childhood on

- **context matters - manly implicitly**
  - how important is it for me?
  - how convenient seams it for the other person?
  - relation between the communication partners?
  - what type of conversation will it be?
  - is it socially acceptable (topic/situation)?
- **To avoid situations like:**
  - "if I would have known that you are in a meeting I would not have called you."
  - "if I would have known that you are still at work I would not have called you."
  - …
  - "if I would have known that the phone is off and I can only leave a message I would not have called."

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Context Phonebook

[Schmidt01]

- **User experience vs. technology**
- **phone users can selectively share context**
  - information about the situation
  - information about availability
  - …
- **caller can decided**
  - knows her own constraints
  - has some information about the other side
  - can judge if the call will be appropriate
  - context matters - manly implicitly

3. Defining Context and Interaction in Context

Defining Context - Schilit, 1994: "exploiting the changing environment"

"Such context-aware software adapts according to the location of use, the collection of nearby people, hosts, and accessible devices, as well as to changes to such things over time. A system with these capabilities can examine the computing environment and react to changes to the environment." [Schilit94].

Defining Context - Brown, 1997: "context-aware" – driven by context

"Indeed you could argue that every application which takes some account of the user is a context-aware application. In practice, the adjective "context-aware" is attached to applications that are mainly driven by the user's context. They tend to be mobile applications […]." [Brown97].

Defining Context - Ryan, 1998: "context-awareness" – sense and act

"[…] 'context awareness', a term that describes the ability of the computer to sense and act upon information about its environment, such as location, time, temperature or user identity. This information can be used [...] to tag information [...] to enable selective responses [...] or retrieving information relevant [...]. [Ryan98].

Defining Context – Dey, 2000: Context - characterize the situation

"Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves." [Dey00]

"A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task." [Dey00].

Resulting Interaction Paradigm: Implicit Interaction

- Utilizing context for human computer interaction

"Implicit human computer interaction is an action, performed by the user that is not primarily aimed to interact with a computerized system but which such a system understands as input." [Schmidt00a]

4. From Sensor to Context

What is a Sensor?

- A sensor is a technological device or biological organ that detects, or senses, a signal or physical condition or chemical compounds.
- A electronic, electrical, micro-mechanic or electro-mechanical device that responds to a stimulus, such as heat, light, or pressure, and generates a signal that can be measured or interpreted.
- A function of time that returns a value (binary, number, vector, array) dependent on a measured parameter.
- Examples: light, temperature, sound, radiation, power, flow, movement, acceleration, vibration, orientation, proximity, chemical, biological, physiological, …

see http://en.wikipedia.org/wiki/Sensor

Information “Sensors”

- Sensors that are related to the device or system
  Examples
  - battery voltage,
  - RSSI,
  - real-time,
  - current packet loss,
  - current power consumption
  - location sensors
  - devices in vicinity

- Access to information over a network (e.g. WWW)
  - weather in New York
  - share price of GOOGLE

Bio-Sensors

- Sensors to measure physiological parameters in humans and animals
- Towards sensing emotions…

- Example
  - Galvanic skin response
  - Heard rate
  - Blood pressure
  - Blood oxygen saturation
  - EEG, ECG
  - …

Image from http://affect.media.mit.edu/

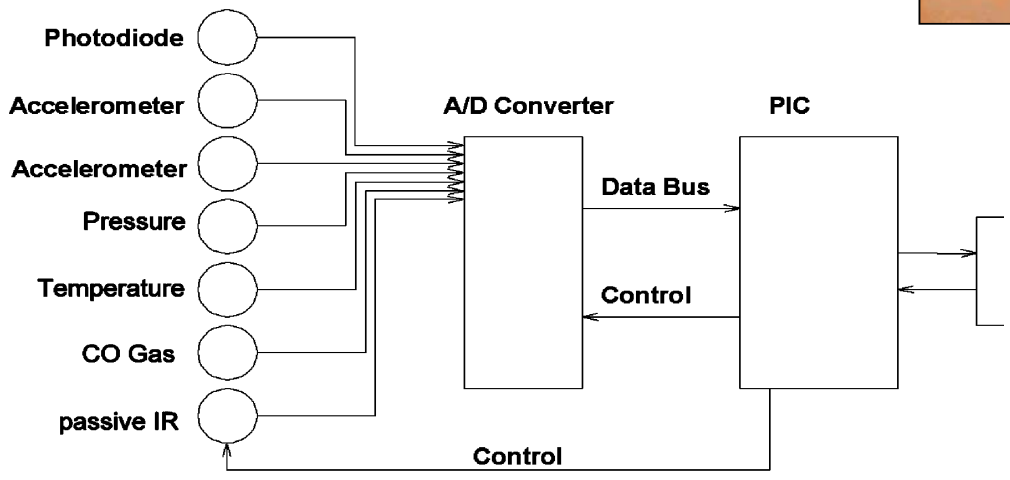
What can you measure? Some Examples

- Temperature Sensor
  - weather / temperature
  - human proximity and touch
  - device in operation
  - indoor / outdoor?
  - speed?
  - …
- Light Sensor
  - light level
  - light frequency (50Hz/60Hz)
  - indoor / outdoor?
  - movement?
  - usage of a environment
  - touch
  - …

- Accelerometer
  - tilt
  - vibration
  - acceleration
  - gestures
  - shock
  - position?
  - Interaction?
  - …

Dependent on the application a sensor can be used to measure different phenomena in the real world

Example of a technical setup



Sensors | AD - Conversion | Feature and context processing

Problems with Sensors

- Need for calibration
- Sensors are Inaccurate (within a given specification)
- Sensors are unreliable (within a given specification)
- Noise and false readings are common
- Timing between processor and sensor is often critical

- Mechanical Issues, casing
  "Sensor may need a hole to see the world"

Mini-Exercise (120 Seconds, in pairs)

- Assume a mobile device should be able to discriminate
  - Informal meeting
  - Presentation
  - Coffee break
  - Working alone
- Consider
  - What sensors can be used?
  - How do we describe the situations?
  - What trade-offs will we phase in the design?
  - What will obviously not work?

How to describe and match a Context/Situation?

- Descriptions differ depending on
  - Who (role) make a description
  - What the purpose of the description is
  - The individual creating the description
- Structure descriptions
  - Checklists
  - presence and absence of features
  - Sensor values
  - Perceived features
- Based on experience (learning)
  - Automated description depending on features

Modeling Context [Schmidt03]

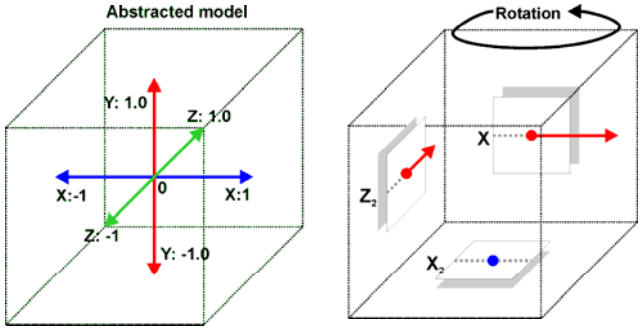
- Modeling the domain
- Alternative approaches
  - Top-down
    Situation → Context → Features → Sensors
  - Bottom-up
    Sensors → Features → Context → Situation
- Do not try to model the world…
  …model your application's world!

Parameters and requirements on Sensing for Context-Awareness [Schmidt,01]

- Design and Usability
- Energy Consumption
- Calibration
- Start-up Time
- Robustness and Reliability
- Portability, Size and Weight
- Unobtrusiveness, Social Acceptance and User Concern
- Price and Introduced Cost
- Precision and Openness

Arranging Sensors

- The position of sensors on a object or in the environment matters!
- Dependent on the position different phenomena will/can be measured
- The sensor in the “right” position can save processing and energy
- Embodiment – see robotics
- Example: placement of acceleration sensors in a interactive cube



Multiple Sensors

- Multiple sensors (of the same type) can ease recognition of certain phenomena
- Correlation of sensor readings
- Networked sensors and time stamped readings

- Example: detect the number of sound sources
  - very difficult with one microphone
  - much simpler with multiple distributed microphones

5. Examples of off-the-shelf hardware and systems

Mobile Phone: Nokia N95

- Mobile phone with
  - GPS
  - 3-axis Accelerometer
  - Network interfaces (Bluetooth, WLAN, GSM)
- Programmable
  - C
  - Python

- There are many more phones with different sensors and programming interfaces…

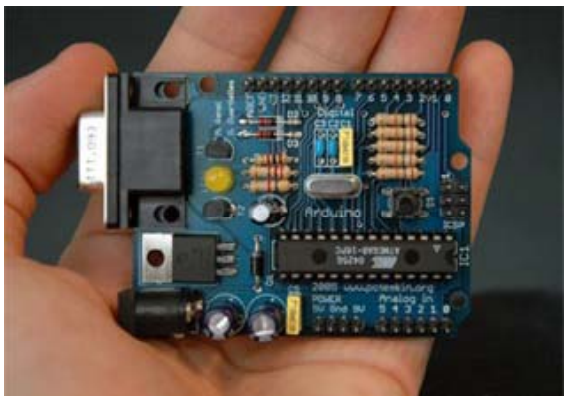
Physiological Sensing: NeXus-10

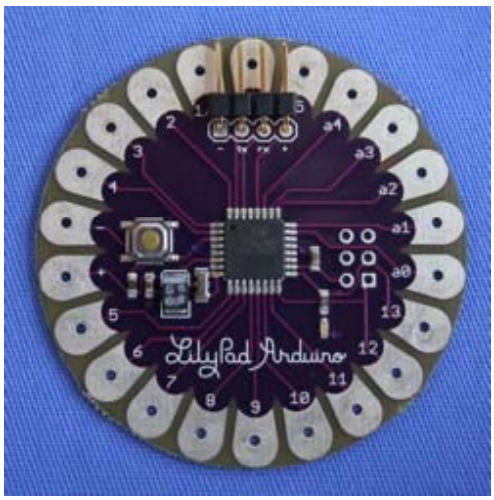
http://www.mindmedia.nl/german/nexus10.php

- 10 AD channels
- Variety of physiological sensors
- Mobile
- Bluetooth connectivity to PC/Laptop

Sensor Board: Arduino

http://www.arduino.cc/





- Variety of extensible and easy to use microcontroller boards
- Extensible with your own sensors

MPTrain (Video) [Oliver06]

- Hardware:
  - physiological sensors wirelessly connected
  - music player
- Software
  - the user defined exercise pattern (desired heart-rate)
  - System constantly monitors heart-rate and speeds and plays music with specific features that encourages the user to speed up, slow down or keep the pace

6. Summary

Summary

- Perception as a key to smart behavior
- Context awareness to
  - Adjusting the output to the context
  - Easing input by using context knowledge
  - Share context information
- Many interesting examples exist
  - Location enters the the real world
  - Context still waits in the lab
- Definitions of context
- Sensing → context → actions
- Off-the-shelf hardware and systems are available

Directions

- Location is in the market place
- Context in user generated content
- Use of context in end-user configuration/programming
- Context sharing in communication
- Context prediction and learning of behavior
- Privacy issues
- Implanted sensors?

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Questions!

7. References and Reading

References and Reading (1)

- [Lenat98] Doug Lenat. The Dimensions of Context-Space. CYCORP. October 28, 1998. http://www.cyc.com/doc/context-space.pdf
- [Pascoe98] Pascoe, J., Ryan, N. S., and Morse D. R., "Human Computer Giraffe Interaction: HCI in the Field", Workshop on Human Computer Interaction with Mobile Devices, University of Glasgow, United Kingdom, 21-23 May 1998, GIST Technical Report G98-1. 1998.
- [Cheverst00] Cheverst K., Davies N., Mitchell K., Friday A. and Efstratiou C., "Developing Context-Aware Electronic Tourist Guide: Some Issues and Experiences", Proceedings of CHI'2000, Netherlands, (April 2000), pp. 17-24.
- [Schilit94] Bill Schilit, Norman Adams, and Roy Want. Context-aware computing applications. In *Proceedings of IEEE Workshop on Mobile Computing Systems and Applications, pages 85-90, Santa Cruz, California,* December 1994. IEEE Computer Society Press.
- [Schmidt99] A. Schmidt, M. Beigl, H. Gellersen. There is more to context than location. Computers and Graphics, 23(6):893-901, 1999. http://www.comp.lancs.ac.uk/~albrecht/pubs/pdf/schmidt_cug_elsevier_12-1999-context-is-more-than-location.pdf
- [Hinckley00] Hinckley, K., Pierce, J., Sinclair, M., and Horvitz, E. 2000. Sensing techniques for mobile interaction. In *Proceedings of the 13th Annual ACM Symposium on User interface Software and Technology* (November 06 - 08, 2000). UIST '00. ACM, New York, NY, 91-100. DOI= http://doi.acm.org/10.1145/354401.354417
- [Schmidt99a] Schmidt, A., et al. 1999. Advanced Interaction in Context. In *Proceedings of the 1st int. Symposium on Handheld and Ubiquitous Computing* (September, 1999). LNCS, vol. 1707. Springer, 89-101. http://www.teco.edu/~albrecht/publication/huc99/advanced_interaction_context.pdf

References and Reading (2)

- [Schmidt00] Schmidt, A., Takaluoma, A. and Mntyjrvi, J., "Context-Aware Telephony over WAP", Springer-Verlag, London, Ltd., Personal Technologies, Volume 4, pages 225-229. Short paper presented at Handheld and Ubiquitous Computing (HUC2k), HP Labs, Bristol, UK, September 2000.
- [Schmidt01] A. Schmidt, T. Stuhr, and H.W. Gellersen, Context-Phonebook – Extending Mobile Phone Applications with Context., in Third Mobile HCI Workshop, Lille, France, 2001.
- [Sawhney00] N. Sawhney and C. Schmandt. Nomadic Radio: Speech and Audio Interaction for Contextual Messaging in Nomadic Environments. ACM Transactions on Computer-Human Interaction, Vol. 7, No. 3, September 2000, Pages 353–383.
- [Oliver06] Oliver, N. and Flores-Mangas, F. 2006. MPTrain: a mobile, music and physiology-based personal trainer. In *Proceedings of the 8th Conference on Human-Computer interaction with Mobile Devices and Services* (Helsinki, Finland, September 12 - 15, 2006). MobileHCI '06, vol. 159. ACM, New York, NY, 21-28. DOI= http://doi.acm.org/10.1145/1152215.1152221
- [Schmidt01a] A. Schmidt, and K. Van Laerhoven, How to Build Smart Appliances?, IEEE Personal Communications 8(4), August 2001 http://www.comp.lancs.ac.uk/~albrecht/pubs/pdf/schmidt_ieee_pc_08-2001.pdf
- [Schmidt03] Albrecht Schmidt. Ubiquitous Computing - Computing in Context. PhD-Thesis. Lancaster University 2003. http://www.comp.lancs.ac.uk/~albrecht/phd/

References and Reading (3)

- [Dey00] Dey, A., "Providing Architectural Support for Building Context-Aware Applications", Ph. D. Thesis Dissertation, College of Computing, Georgia Tech, December 2000. http://www.cc.gatech.edu/fce/ctk/pubs/dey-thesis.pdf
- [Ryan98] Ryan, N. S., Pascoe, J., Morse, D. R., "Enhanced Reality Fieldwork: the Context-aware Archaeological Assisstant", in V. Gaffney, M. van Leusen and S. Exxon (eds.) Computer Applications in Archaeology 1997, 1998. http://www.cs.ukc.ac.uk/projects/mobicomp/Fieldwork/Papers/CAA97/ERFldwk.html
- [Schmidt00a] Albrecht Schmidt, Implicit Human Computer Interaction Through Context. Personal technologies. 3,2000. Springer. http://www.teco.edu/~albrecht/publication/mobile99/impl_hci.pdf
- [Brown97] Peter J Brown, John D Bovey, Xian Chen. Context-aware applications: from the laboratory to the marketplace. 4 issue 5. IEEE Personal Communications (October 1997)

Further Reading

Wearable Computing

- Kristof Van Laerhoven and Cakmakci, O. 2000. What Shall We Teach Our Pants?. In Proceedings of the 4th IEEE international Symposium on Wearable Computers (October 18 - 21, 2000). ISWC. IEEE Computer Society, Washington, DC, 77. http://www.mis.informatik.tu-darmstadt.de/People/kristof/publications/iswc_2000.pdf
- P. Lukowicz, J. A. Ward, H. Junker, M. Stager, G. Troster, A. Atrash, and T. Starner, "Recognizing workshop activity using body worn microphones and accelerometers, " in Pervasive Computing: Proceedings of the 2nd International Conference. Springer-Verlag Heidelberg: Lecture Notes in Computer Science, Apr. 2004, pp. 18--22. http://www.atrash.com/old/publications/workshop.pdf

Context and Activity Recognition

- Ling Bao and Stephen S. Intille. Activity recognition from user-annotated acceleration data. . In Proceedings of Pervasive 2004: the Second International Conference on Pervasive Computing, volume 3001 of Lecture Notes in Computer Science, pages 1--17. Springer, 2004. http://web.media.mit.edu/~intille/papers-files/BaoIntille04.pdf
- Gellersen, H. W., Schmidt, A., and Beigl, M. 2002. Multi-sensor context-awareness in mobile devices and smart artifacts. Mob. Netw. Appl. 7, 5 (Oct. 2002), 341-351. DOI= http://dx.doi.org/10.1023/A:1016587515822
- Tapia, E.M., S.S. Intille, and K. Larson. 2004. Activity Recognition in the Home Setting Using Simple and Ubiquitous Sensors. In Proceedings of Pervasive 2004: the Second International Conference on Pervasive Computing, volume 3001 of Lecture Notes in Computer Science, pages 158–175. Springer-Verlag, 2004. http://web.media.mit.edu/~emunguia/presentations/Pervasive2004.pdf

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